



CISCO NETWORKING ACADEMY PROGRAM

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思科网络技术学院教程 (第一、二学期) (第三版) (英文版)

Cisco Networking Academy Program
CCNA 1 and 2
Companion Guide
Third Edition

The only authorized textbook for the
Cisco Networking Academy Program



[美]

Cisco Systems 公司
Cisco Networking Academy Program

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内容提要

思科网络技术学院 (Cisco Networking Academy) 课程是Cisco Systems公司在全世界范围推出的一个主要面向初级网络工程技术人员的培训项目, 其培训内容与CCNA类似。

本书为思科网络技术学院第一、二学期的配套书面教程, 主要内容包括: 网络入门、网络基础、网络介质、线缆测试与局域网和广域网布线、以太网基础、以太网技术和以太网交换、TCP/IP协议集和IP寻址、路由选择基础和子网、TCP/TP传输层和应用层、广域网和路由器、路由器基础、路由器配置、了解邻近和远程设备、管理Cisco IOS软件、路由选择和路由选择协议、距离矢量路由选择协议、TCP/IP差错控制消息、路由器排障基础、中级TCP协议、访问控制列表等。每章的最后还提供了复习题。附录A介绍了结构化布线的内容; 附录B是每章结尾复习题的答案; 附录C包含了本书中使用的所有关键词的术语表。

本书为新的思科网络技术学院教学计划的第一、二学期的书面教材, 编写本书的目的是为了帮助学生准备CCNA认证考试, 并帮助他们掌握必要的网络知识。

为实施人才强国战略贡献力量(代序言)

在《思科网络技术学院教程》(第三版)影印版出版之际,我谨代表思科系统网络技术有限公司,感谢各位学员朋友对思科网络技术学院的厚爱,感谢人民邮电出版社长期以来的合作与支持,感谢编辑及所有人为此付出的努力。

思科公司总裁兼首席执行官钱伯斯认为,互联网和教育,作为推动社会经济发展的两个核心动力,将深刻改变国家、企业和个人在未来时代的核心竞争力。现在,这一理念已经得到越来越多的认同和支持。

回首 1997 年,作为互联网和教育相结合的产物,思科系统公司启动了思科网络技术学院这一非赢利性的全球网络技术教育项目。到目前为止,思科公司为该项目的投入已达 2 亿美元,在全球 150 多个国家建立了 1 万余所思科网络技术学院。来自全球大学、职业技术学校、中学、团体机构和其他教育组织的 45 万学员正在学习。在中国,第一所思科网络技术学院 1998 年于复旦大学成立。短短 6 年时间,已经在全国建立了 200 所思科网络技术学院,培养超过 2 万名毕业生。最近,思科公司又与教育部签署协议,面向全国 35 所示范性软件学院提供全面的基于思科网络技术学院的网络技术课程体系,以帮助中国培养一大批兼通网络技术的复合型软件人才。

在思科网络技术学院,参加学习的学员不仅来自经济发达省份,也来自西部欠发达地区;既有在校的大学生甚至中学生,也有已经处于重要岗位的在职人员。2000 年 6 月,钱伯斯第三次访华之际,思科向 30 所西部高校捐建了思科网络技术学院,希望网络能为东西部地区协调发展做出贡献,得到了西部地区的热烈响应。2001 年 10,江泽民主席在第九界亚太经合组织会议(APEC)上宣布发起“人力资源能力建设促进项目”。作为该计划的积极参与者,思科系统公司在此后的三年中,为 APEC 各成员国选派的 400 名学员提供思科 CCNA、CCNP 培训及认证。此外,联合国开发计划署(UNDP)、国际电信联盟(ITU)也分别与思科合作,在贫困和欠发达地区成立思科网络技术学院,用以缩小地区间的数字鸿沟。

展望未来,网络还有更大的潜能等待着我们一起发掘。在国家高瞻远瞩地提出人才强国战略之今天,思科将一如既往地发挥自己特有的网络技术优势,尤其是通过思科网络技术学院这一非盈利性的全球教育项目,帮助中国的人才资源能力建设,最终发动更多的人投身到网络经济大潮去,为消除数字鸿沟、发展国民经济贡献力量!



杜家滨

思科系统公司全球 副总裁
思科系统(中国)网络技术有限公司 总裁

2004 年 12 月

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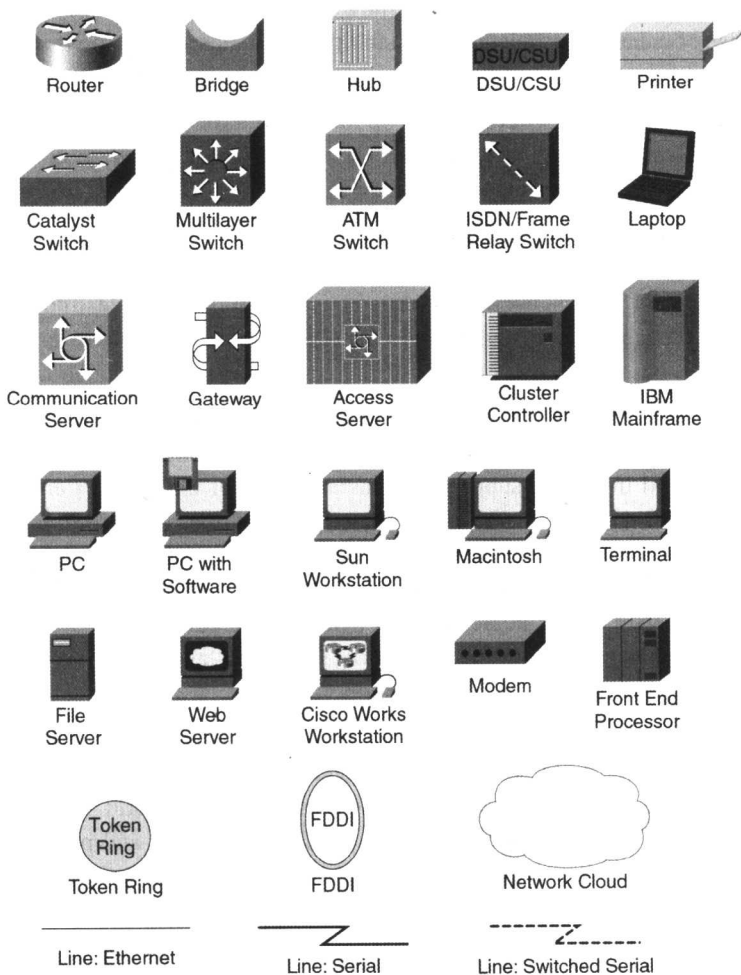
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Antoon W. Ruff is a networking professional who retired from the United States Air Force in June 2000. During his 29 years in the Air Force, Tony worked on systems that varied from the Titan II Intercontinental Ballistic Missile systems to current state-of-the-art Meteorological and Navigational networks. Since retirement, Tony has worked for ECPI College of Technology, a Virginia-based-for-profit college. He is currently the Director of Continuing Education at the Newport News Campus of ECPI.

Tony holds an AS degree from the Community College of the Air Force in electronic engineering technology. He has a BS degree from Southern Illinois University in industrial technology and a MS degree from University of Maryland, University College in information technology. Tony is a certified CCNA, holds the CompTIA network + certification, and has passed the Advanced Routing and Remote Access certifications toward the CCNP certification.

Cisco Systems Networking Icon Legend

Cisco Systems uses a standardized set of icons to represent devices in network topology illustrations. The following icon legend shows the most commonly used icons that you might encounter throughout this book.



Command Syntax Conventions

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

- 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.
- **Boldface** indicates commands and keywords that are entered exactly as shown.
- *Italic* indicates arguments for which you supply values.

Foreword

Throughout the world, the Internet has brought tremendous new opportunities for individuals and their employers. Companies and other organizations are seeing dramatic increases in productivity by investing in robust networking capabilities. Some studies have shown measurable productivity improvements in entire economies. The promise of enhanced efficiency, profitability, and standard of living is real and growing.

Such productivity gains aren't achieved by simply purchasing networking equipment. Skilled professionals are needed to plan, design, install, deploy, configure, operate, maintain, and troubleshoot today's networks. Network managers must assure that they have planned for network security and for continued operation. They need to design for the required performance level in their organization. They must implement new capabilities as the demands of their organization, and its reliance on the network, expands.

To meet the many educational needs of the internetworking community, Cisco Systems established the Cisco Networking Academy Program. The Networking Academy is a comprehensive learning program that provides students with the Internet technology skills essential in a global economy. The Networking Academy integrates face-to-face teaching, web-based content, online assessment, student performance tracking, hands-on labs, instructor training and support, and preparation for industry-standard certifications.

The Networking Academy continually raises the bar on blended learning and educational processes. The Internet-based assessment and instructor support systems are some of the most extensive and validated ever developed, including a 24/7 customer service system for Networking Academy instructors. Through community feedback and electronic assessment, the Networking Academy adapts the curriculum to improve outcomes and student achievement. The Cisco Global Learning Network infrastructure designed for the Networking Academy delivers a rich, interactive, and personalized curriculum to students worldwide. The Internet has the power to change the way people work, live, play, and learn, and the Cisco Networking Academy Program is in the forefront of this transformation.

This Cisco Press title is one of a series of best-selling companion titles for the Cisco Networking Academy Program. Designed by Cisco Worldwide Education and Cisco Press, these books provide integrated support for the online learning content that is made available to Academies all over the world. These Cisco Press books are the only authorized books for the Networking Academy by Cisco Systems, and provide print and CD-ROM materials that ensure the greatest possible learning experience for Networking Academy students.

I hope you are successful as you embark on your learning path with Cisco Systems and the Internet. I also hope that you will choose to continue your learning after you complete the Networking Academy curriculum. In addition to its Cisco Networking Academy Program titles, Cisco Press also publishes an extensive list of networking technology and certification publications that provide a wide range of resources. Cisco Systems has also established a network of professional training companies—the Cisco Learning Partners—who provide a full range of Cisco training courses. They offer training in many formats, including e-learning, self-paced, and instructor-led classes. Their instructors are Cisco certified, and Cisco creates their materials. When you are ready, please visit the Learning & Events area on Cisco.com to learn about all the educational support that Cisco and its partners have to offer.

Thank you for choosing this book and the Cisco Networking Academy Program.

Kevin Warner

Senior Director, Marketing

Worldwide Education

Cisco Systems, Inc.

Introduction

The *Cisco Networking Academy Program CCNA 1 and 2 Companion Guide*, Revised Third Edition, supplements your classroom and laboratory experience with version 3.1 of the CCNA curriculum within the Cisco Networking Academy Program.

Successful completion of the course results in a basic understanding of networking, routers, and routing and begins your preparation toward the Cisco Certified Network Associate (CCNA) certification exam. This textbook closely follows the style and format that Cisco Systems has incorporated into the Cisco Networking Academy Program curriculum.

This material extends your knowledge and practical experience with the design, configuration, and maintenance of local-area networks (LANs). The concepts covered in this book enable you to develop experience in cabling, routing, IP addressing, routing protocols, and network troubleshooting. This book introduces the OSI model, and discusses collisions and segmentations, Ethernet technologies, and Ethernet switching. This *Companion Guide* also features enhanced chapters on IOS, TCP/IP, and access control lists.

In addition to the CCNA Certification exam objectives, this book covers several topics to enhance your overall understanding of the networking industry. These topics are listed at the beginning of each chapter as “Additional Topics of Interest” and are generally set apart as sidebars within the chapter noted as “More Information.” This additional material covers important topics that are relevant to career success in the information technology industry and should be considered no less important to anyone learning about the networking field than any of the other sections pertaining to the CCNA exam.

Goal of This Book

The goal of this book is to educate you about Cisco supported networking technologies, and to help you understand how to design and build networks and to configure Cisco routers. It is designed for use in conjunction with the Cisco Networking Academy Program online curriculum.

Audience for This Book

This book’s main audience is students interested in networking technologies. In particular, it is targeted toward students in the Cisco Networking Academy Program. In the classroom, this book can serve as a supplement to the online curriculum.

This book is also appropriate for corporate training faculty and staff members, as well as general users. The book’s user-friendly, nontechnical approach is ideal for readers who prefer to stay away from technical manuals.

Book Features

Many of this book’s features help facilitate a full understanding of the networking and routing covered in this book:

- **Objectives**—Each chapter starts with a list of objectives that should be mastered by the end of the chapter. The objectives provide a reference of the concepts covered in the chapter and generally correlate to the CCNA exam objectives covered in that chapter. Formatted as questions, the chapter objectives can also serve as guide to approach the material in the chapter to learn the answers.
- **Key terms**—Each chapter includes a list of defined key terms that will be covered in the chapter. The key terms are then highlighted in color throughout the chapter where they are used in context. Definitions are provided in a comprehensive glossary to serve as a study aid to help you understand the chapter material before you move on to new concepts.
- **Figures, examples, and tables** —This book contains figures, examples, and tables that explain theories,

concepts, commands, and setup sequences by helping you to visualize the content covered in the chapter.

- **Chapter summaries**—At the end of each chapter is a summary of the concepts covered in the chapter. It provides a synopsis of the chapter and serves as a study aid focusing on the key objectives.
- **Check Your Understanding questions**—Review questions, presented at the end of each chapter, serve as an assessment and help test your understanding before you move on to new chapters. The answers are provided in an appendix.
- **Lab Activity references**—Throughout this book are references to lab activities that can be found in *Cisco Networking Academy Program CCNA 1 and 2 Lab Companion*, Revised Third Edition. These labs help you make a connection between theory and practice. References to the labs are marked with the following icon:



- **CD Activity references**—Throughout this book are references to Interactive Media Activities, PhotoZooms, and Videos found on this book's accompanying CD-ROM. These activities supplement the material found within this book to solidify your understanding of hardware components and networking concepts. References to these activities are marked with the following icon:



How This Book Is Organized

This book is divided into 22 chapters, 11 each for the CCNA 1 and CCNA 2 material, as well as 3 appendixes.

CCNA 1 Material

- **Chapter 1, “Introduction to Networking,”** presents the basics of connecting to the Internet. It also introduces different number systems and the processes used to convert a number from one number system to another.
- **Chapter 2, “Networking Fundamentals,”** introduces some of the terminology used by networking professionals and various types of computer networks. It also describes how the OSI reference model networking scheme supports networking standards. In addition, this chapter describes the basic functions that occur at each layer of the OSI model. Finally, this chapter describes various network devices and networking topologies.
- **Chapter 3, “Networking Media,”** introduces the basic theory of electricity, which provides a foundation for understanding networking at the physical layer of the OSI model. This chapter also discusses different types of networking media that are used at the physical layer, including shielded twisted-pair cable, unshielded twisted-pair cable, coaxial cable, and fiber-optic cable, as well as wireless media.
- **Chapter 4, “Cable Testing,”** describes issues related to the testing of media used for physical layer connectivity in local-area networks (LANs). Networking media is literally and physically the backbone of a network. Inferior quality of network cabling results in network failures and in networks with unreliable performance. The equipment used to perform these tests involves certain electrical and mathematical concepts and terms, such as signal, wave, frequency, and noise. Understanding this vocabulary is helpful when learning about networking, cabling, and cable testing.
- **Chapter 5, “Cabling LANs and WANs,”** describes issues related to cabling a WAN and cabling a LAN. Although each LAN is unique, many design aspects are common to all LANs. For example, most LANs follow the same standards and the same components. This chapter presents information on elements of Ethernet LANs and common LAN devices. Several WAN connections are available today. They range from dialup to broadband access, and differ in bandwidth, cost, and required equipment. This chapter presents information on the various types of WAN connections.

- **Chapter 6, “Ethernet Fundamentals,”** discusses the operation of Ethernet, Ethernet framing, error handling, and the different type of the collisions on Ethernet networks. In addition, this chapter introduces the collision domains and broadcast domains. Finally, this chapter describes segmentation and the devices used to create the network segments.
- **Chapter 7, “Ethernet Technologies,”** introduces Layer 2 bridging and switching techniques. It introduces the Spanning-Tree Protocol (STP), tells how STP works, and covers the STP switch port states. This chapter provides details about the most important types of Ethernet. The goal is to help you understand what is common to all forms of Ethernet. This chapter also covers the standards for Gigabit Ethernet, which has emerged in only 3 years. An even faster Ethernet version—10-Gigabit Ethernet—is now widely available, and still faster versions are being developed.
- **Chapter 8, “Ethernet Switching,”** introduces the concepts related to Ethernet switching. Bridges were developed to help correct performance problems that arose from increased collisions. Switches evolved from bridges to become the main technology in modern Ethernet LANs. This chapter also explores the effects of collisions and broadcasts on network traffic and then describes how bridges/switches and routers are used to segment networks for improved performance.
- **Chapter 9, “TCP/IP Protocol Suite and IP Addressing,”** presents an overview of the TCP/IP protocol suite. It starts with the history and future of TCP/IP, compares the TCP/IP protocol model to the OSI model, and identifies and describes each layer of the TCP/IP protocol suite.
- **Chapter 10, “Routing Fundamentals and Subnets,”** covers the topics related to the Internet Protocol (IP). This chapter also discusses the difference between routing and routed protocols, and tells how routers track distance between locations. Finally, this chapter introduces the distance vector, link-state, and hybrid routing approaches, as well as how each resolves common routing problems.
- **Chapter 11, “TCP/IP Transport and Application Layers,”** covers the issues related to the transport layer and how it uses the services provided by the network layer, such as best path selection and logical addressing, to provide end-to-end communication between source and destination. This chapter describes how the transport layer regulates the flow of information from source to destination reliably and accurately.

CCNA 2 Material

- **Chapter 1, “WANs and Routers,”** introduces WAN devices, technologies, and standards. In addition, it discusses the function of a router in a WAN.
- **Chapter 2, “Introduction to Routers,”** describes how to start a router for the first time by using the correct commands and startup sequence to do an initial configuration of the router. This chapter also explains the startup sequence of a router and the setup dialog that the router uses to create an initial configuration file using current versions of Cisco IOS Software.
- **Chapter 3, “Configuring a Router,”** discusses the router modes and configuration methods for updating a router’s configuration file. It is important that a firm understand Cisco IOS Software and know the procedures for starting a router. In addition, this chapter describes the tasks necessary for password recovery.
- **Chapter 4, “Learning About Other Devices,”** covers how to implement, monitor, and maintain Cisco Discovery Protocol by using the correct router commands. In addition, this chapter explains the three most used commands.
- **Chapter 5, “Managing Cisco IOS Software,”** examines the stages of the router boot sequence. It also covers how to use a variety of Cisco IOS Software source options, execute commands to load Cisco IOS Software onto the router, maintain backup files, and upgrade Cisco IOS Software. In addition, this chapter discusses the functions of the configuration register and tells how to determine the version of the IOS file. Finally, this chapter describes how to use a TFTP server as a software source.
- **Chapter 6, “Routing and Routing Protocols,”** covers the router’s use and operations in performing the

key internetworking function of the Open System Interconnection (OSI) reference model's network layer, Layer 3. In addition, this chapter discusses the difference between routing and routed protocols and tells how routers track distance between locations. Finally, this chapter introduces distance vector, link-state, and hybrid routing approaches and details how each resolves common routing problems.

- **Chapter 7, “Distance Vector Routing Protocols,”** covers the initial configuration of the router to enable the Routing Information Protocol (RIP) and the Interior Gateway Routing Protocol (IGRP). In addition, this chapter describes how to monitor IP routing protocols.
- **Chapter 8, “TCP/IP Suite Error and Control Messages,”** covers ICMP, the ICMP message format, ICMP error message types, potential causes of specific ICMP error messages, a variety of ICMP control messages used in networks today, and the causes for ICMP control messages.
- **Chapter 9, “Basic Router Troubleshooting,”** provides an introduction to network testing. It emphasizes the necessity of using a structured approach to troubleshooting. Finally, this chapter describes the fundamentals of troubleshooting routers.
- **Chapter 10, “Intermediate TCP/IP,”** describes TCP/IP operation to ensure communication across any set of interconnected networks. In addition, this chapter covers the TCP/IP protocol stack components, such as protocols to support file transfer, e-mail, remote login, and other applications. This chapter also introduces reliable and unreliable transport layer protocols and details connectionless datagram (packet) delivery at the network layer. Finally, it explains how ARP and RARP work.
- **Chapter 11, “Access Control Lists (ACLs),”** includes tips, considerations, recommendations, and general guidelines on how to use ACLs, and includes the commands and configurations needed to create ACLs. Finally, this chapter provides examples of standard and extended ACLs and tells how to apply ACLs to router interfaces.

Appendixes

- **Appendix A, “Structured Cabling,”** includes coverage of structured cabling systems, standards, and codes. In addition, this appendix provides coverage of cabling safety, tools of the trade, installation process, finish phase, overview of the cabling business. This appendix also provides a cabling case study that covers how to apply all of the information in this chapter to a real-world scenario. This appendix provides some valuable information that you will need to know as a CCNA.
- **Appendix B, “Check Your Understanding Answer Key,”** provides the answers to the Check Your Understanding questions that you find at the end of each chapter.
- **Appendix C, “Glossary of Key Terms,”** provides a compiled list of all the key terms that appear throughout this book.

About the CD-ROM

A CD-ROM accompanies this book to further enhance your learning experience. The CD contains a test engine with CCNA practice exam questions, Interactive Media Activities, PhotoZooms of networking equipment and hardware, and instructional Videos and animations that highlight potentially difficult concepts. These materials support self-directed study by allowing you to engage in learning and skill building exercises outside of the classroom. The CD-ROM also contains Packet Tracer 3.1, a standalone, medium-fidelity simulation environment for students and instructors to design, configure, and troubleshoot CCNA-level networks.

Table of Contents

Part I CCNA 1	1	Network Topology	40
Chapter 1		Network Protocols	44
Introduction to Networking	2	Local-Area Networks (LANs)	44
Objectives	2	Wide-Area Networks (WANs)	45
Additional Topics of Interest	2	Metropolitan-Area Networks (MANs)	46
Connecting to the Internet	2	Storage-Area Networks (SANs)	47
Requirements for Internet Connection	3	Virtual Private Network (VPN)	48
PC Basics	3	Benefits of VPNs	48
Network Interface Card	6	Intranets and Extranets	49
NIC and Modem Installation	7	Bandwidth	49
Overview of High-Speed and Dialup		Importance of Bandwidth	50
Connectivity	8	Analogies	50
TCP/IP Description and Configuration	9	Measurement	51
Testing Connectivity with Ping	9	Limitations	52
Web Browser and Plug-Ins	10	Throughput	53
Troubleshooting Internet Connection		Data Transfer Calculation	54
Problems	11	Digital Versus Analog	54
Network Math	11	Networking Models	55
Binary Presentation of Data	11	Using Layers to Analyze Problems in a	
Bits and Bytes	12	Flow of Materials	55
Base 10 Number System	13	Using Layers to Describe Data	
Base 2 Number System	14	Communication	56
Converting Decimal Numbers to 8-Bit Binary		OSI Model	57
Numbers	15	OSI Layers	58
Converting 8-Bit Binary Numbers to Decimal		Peer-to-Peer Communications	59
Numbers	15	TCP/IP Model	60
Four-Octet Dotted-Decimal Representation of		Detailed Encapsulation Process	61
a 32-Bit Binary Number	18	Summary	63
Hexadecimal	18	Key Terms	64
Boolean or Binary Logic	20	Check Your Understanding	66
IP Addresses and Network Masks	21	Chapter 3	
Summary	22	Networking Media	69
Key Terms	22	Objectives	69
Check Your Understanding	25	Additional Topics of Interest	69
Chapter 2		Copper Media	69
Networking Fundamentals	27	Atoms and Electrons	70
Objectives	27	Voltage	72
Additional Topics of Interest	27	Resistance and Impedance	72
Networking Terminology	28	Current	73
Data Networks	28	Circuits	73
Network History	30	Cable Specifications	75
Networking Devices	31	Coaxial Cable	76
		STP Cable	79
		UTP Cable	79
		Optical Media	81
		The Electromagnetic Spectrum	82

Ray Model of Light	83	Summary	124
Reflection	84	Key Terms	124
Refraction	84	Check Your Understanding	126
Total Internal Reflection	85		
Multimode Fiber	88	Chapter 5	
Single-Mode Fiber	89	Cabling LANs and WANs	128
Other Optical Components	90	Objectives	128
Signals and Noise in Optical Fibers	92	Additional Topics of Interest	128
Installation, Care, and Testing of Optical Fiber	93	Cabling LANs	129
Wireless Media	99	LAN Physical Layer	129
Wireless LAN Organization and Standards	99	Ethernet in the Campus	130
Wireless Devices and Topologies	100	Ethernet Media and Connector Requirements	131
How Wireless LANs Communicate	101		
Authentication and Association	102	Connection Media	132
The Radiowave and Microwave Spectrums	103	UTP Implementation	133
Signals and Noise on a WLAN	104	Repeaters	135
Wireless Security	104	Hubs	136
Summary	105	Wireless	136
Key Terms	106	Bridges	137
Check Your Understanding	108	Switches	138
		Host Connectivity	139
Chapter 4		Peer-to-Peer	140
Cabling Testing	110	Client/Server	142
Objectives	110	Cabling WANs	143
Additional Topics of Interest	110	WAN Physical Layer	143
Frequency-Based Cable Testing	110	WAN Serial Connections	144
Waves	110	Routers and Serial Connections	145
Sine Waves and Square Waves	111	Routers and ISDN BRI Connections	147
Exponents and Logarithms	112	Routers and DSL Connections	148
Decibels	113	Routers and Cable Connections	149
Time and Frequency of Signals	113	Setting Up Console Connections	150
Analog and Digital Signals	114	Summary	151
Noise in Time and Frequency	114	Key Terms	151
Bandwidth	115	Check Your Understanding	152
Signals and Noise	116		
Signaling Over Copper and Fiber-Optic Cabling	116	Chapter 6	
Attenuation and Insertion Loss on Copper Media	118	Ethernet Fundamentals	154
Sources of Noise on Copper Media	118	Objectives	154
Types of Crosstalk	119	Additional Topics of Interest	154
Cable Testing Standards	120	Ethernet Fundamentals	154
Other Test Parameters	121	Introduction to Ethernet	155
Time-Based Parameters	122	IEEE Ethernet Naming Rules	156
Testing Optical Fiber	122	Ethernet and the OSI Model	157
A New Standard	123	Naming	158

Layer 2 Framing	159
Ethernet Frame Structure	161
Ethernet Frame Fields	162
Ethernet Operation	163
Media Access Control (MAC)	163
MAC Rules and Collision Detection/ Backoff	165
Ethernet Timing	167
Interframe Spacing and Backoff	169
Error Handling	170
Types of Collisions	171
Ethernet Errors	173
FCS and Beyond	174
Ethernet Autonegotiation	175
Link Establishment and Full and Half Duplex	177
Summary	178
Key Terms	178
Check Your Understanding	180

Chapter 7

Ethernet Technologies	182
Objectives	182
Additional Topics of Interest	182
10-Mbps and 100-Mbps Ethernet	182
10-Mbps Ethernet	183
10BASE5	185
10BASE2	187
10BASE-T	187
10BASE-T Wiring and Architecture	189
100-Mbps Ethernet	190
100BASE-TX	191
100BASE-FX	193
Fast Ethernet Architecture	194
Gigabit and 10-Gigabit Ethernet	196
1000-Mbps Ethernet	196
1000BASE-T	197
1000BASE-SX and LX	200
Gigabit Ethernet Architecture	201
10-Gigabit Ethernet	202
10-Gigabit Ethernet Architectures	204
Future of Ethernet	206
Summary	207
Key Terms	208
Check Your Understanding	209

Chapter 8

Ethernet Switching	210
Objectives	210
Ethernet Switching	211
Layer 2 Bridging	211
Layer 2 Switching	211
Switch Operation	213
Latency	214
Switch Modes	214
Spanning-Tree Protocol	215
Collision Domains and Broadcast Domains	217
Shared Media Environments	217
Collision Domains	218
Segmentation	220
Layer 2 Broadcasts	221
Broadcast Domains	223
Introduction to Data Flow	224
What Is a Network Segment?	225
Summary	225
Key Terms	226
Check Your Understanding	227

Chapter 9

TCP/IP Protocol Suite and IP Addressing	229
Objectives	229
Introduction to TCP/IP	229
History and Future of TCP/IP	230
Application Layer	230
Transport Layer	231
Internet Layer	232
Network Access Layer	233
The OSI Model and the TCP/IP Model	234
Internet Architecture	234
Internet Addresses	236
IP Addressing	236
Decimal and Binary Conversion	238
IPv4 Addressing	240
Class A, B, C, D, and E IP Addresses	241
Reserved IP Addresses	243
Public and Private IP Addresses	245
Introduction to Subnetting	246
IPv4 Versus IPv6	247
Obtaining an IP Address	249
Obtaining an Internet Address	249
Static Assignment of an IP Address	249
RARP IP Address Assignment	250

BOOTP IP Address Assignment	251	Introduction to the TCP/IP Transport Layer	293
DHCP IP Address Management	252	Flow Control	294
Problems in Address Resolution	253	Session Establishment, Maintenance, and Termination	295
Address Resolution Protocol	255	Three-Way Handshake	296
Summary	257	Windowing	297
Key Terms	258	Acknowledgment	298
Check Your Understanding	258	Transmission Control Protocol (TCP)	299
		User Datagram Protocol (UDP)	300
		TCP and UDP Port Numbers	300
Chapter 10		The Application Layer	302
Routing Fundamentals and Subnets	261	Introduction to the TCP/IP Application Layer	302
Objectives	261	DNS	304
Routed Protocol	261	FTP and TFTP	305
Routable and Routed Protocols	261	HTTP	306
IP as a Routed Protocol	263	SMTP	306
Packet Propagation and Switching Within a Router	264	SNMP	307
Connectionless and Connection-Oriented Delivery	265	Telnet	307
Anatomy of an IP Packet	266	Summary	308
IP Routing Protocols	267	Key Terms	308
Routing Overview	267	Check Your Understanding	309
Routing Versus Switching	268		
Routed Versus Routing	270	Part II CCNA 2	313
Path Determination	272		
Routing Tables	274	Chapter 1	
Routing Algorithms and Metrics	275	WANs and Routers	314
IGP and EGP	276	Objectives	314
Link-State and Distance Vector Routing Protocols	278	WANs	314
The Mechanics of Subnetting	280	Introduction to WANs	314
Classes of Network IP Addresses	280	Introduction to Routers in a WAN	319
Introduction to and Reasons for Subnetting	280	Router LANs and WANs	319
Establishing the Subnet Mask Address	281	Role of Routers in a WAN	329
Applying the Subnet Mask	283	Academy Approach to Hands-On Labs	329
Subnetting Class A and B Networks	285	Routers	330
Calculating the Resident Subnetwork Through ANDing	286	Router Internal Components	330
Summary	286	Router Physical Characteristics	334
Key Terms	289	Router External Connections	335
Check Your Understanding	291	Management Port Connections	335
		Console Port Connections	336
Chapter 11		Connecting Router LAN Interfaces	337
TCP/IP Transport and Application Layers	293	Connecting WAN Interfaces	338
Objectives	293	Summary	339
TCP/IP Transport Layer	293	Key Terms	340
		Check Your Understanding	340

Chapter 2

Introduction to Routers	343
Objectives	343
Operating Cisco IOS Software	343
The Purpose of Cisco IOS Software	343
Router User Interface	344
Router User Interface Modes	344
Cisco IOS Software Features	344
Operation of Cisco IOS Software	347
Starting a Router	348
Initial Startup of Cisco Routers	348
Router LED Indicators	352
The Initial Router Boot Up	352
Establish a Console Connection	355
Router Login	356
Keyboard Help In the Router CLI	357
Enhanced Editing Commands	360
Router Command History	361
Troubleshooting Command-Line Errors	362
The show version Command	362
Summary	363
Key Terms	363
Check Your Understanding	364

Chapter 3

Configuring a Router	366
Objectives	366
Configuring a Router	366
CLI Command Modes	366
Configuring a Router Name	372
Configuring Router Passwords	372
Examining the show Commands	373
Configuring a Serial Interface	375
Making Configuration Changes	376
Configuring an Ethernet Interface	377
Finishing the Configuration	377
Importance of Configuration Standards	377
Interface Descriptions	378
Configuring Interface Description	378
Login Banners	378
Configuring Message-of-the-Day (MOTD)	379
Host Name Resolution	379
Configuring Host Tables	380
Configuration Backup and Documentation	380
Backing Up Configuration Files	381

Summary	385
Key Terms	386
Check Your Understanding	386

Chapter 4

Learning About Other Devices	388
Objectives	388
Discovering and Connecting to Neighbors	388
Introduction to CDP	388
Information Obtained with CDP	389
Showing CDP Neighbors	389
Implementation, Monitoring, and Maintenance of CDP	391
Creating a Network Map of the Environment	392
Disabling CDP	392
Troubleshooting CDP	392
Getting Information About Remote Devices	393
Telnet	393
Establishing and Verifying a Telnet Connection	393
Disconnecting and Suspending Telnet Sessions	394
Advanced Telnet Operation	395
Alternative Connectivity Tests	395
Troubleshooting IP Addressing Issues	400
Summary	400
Key Terms	401
Check Your Understanding	401

Chapter 5

Managing Cisco IOS Software	403
Objectives	403
Router Boot Sequence and Verification	403
Stages of the Router Power-On Boot Sequence	403
How a Cisco Device Locates and Loads IOS	404
Using the boot system Command	405
Configuration Register	406
Troubleshooting IOS Boot Failure	407
Managing the Cisco File System	408
IOS File System Overview	408
IOS Naming Conventions	410