

## Introduction

The Cisco Certified Internetwork Expert (CCIE) certification may be the most challenging and prestigious of all networking certifications. It has received numerous awards and certainly has built a reputation as one of the most difficult certifications to earn in all of the technology world. Having a CCIE certification opens doors professionally typically results in higher pay and looks great on a resume.

Cisco currently offers several CCIE certifications. This book covers the version 3.0 exam blueprint topics of the written exam for the CCIE Routing and Switching certification. The following list details the currently available CCIE certifications at the time of this book's publication; check <http://www.cisco.com/go/ccie> for the latest information. The certifications are listed in the order in which they were made available to the public.

- CCIE Routing and Switching
- CCIE Security
- CCIE Service Provider
- CCIE Voice
- CCIE Storage Networking

Each of the CCIE certifications requires the candidate to pass both a written exam and a one-day, hands-on lab exam. The written exam is intended to test your knowledge of theory, protocols, and configuration concepts that follow good design practices. The lab exam proves that you can configure and troubleshoot actual gear.

## Why Should I Take the CCIE Routing and Switching Written Exam?

The first and most obvious reason to take the CCIE Routing and Switching written exam is that it is the first step toward obtaining the CCIE Routing and Switching certification. Also, you cannot schedule a CCIE lab exam until you pass the corresponding written exam. In short, if you want all the professional benefits of a CCIE Routing and Switching certification, you start by passing the written exam.

The benefits of getting a CCIE certification are varied, among which are the following:

- Better pay
- Career advancement opportunities
- Applies to certain minimum requirements for Cisco Silver and Gold Channel Partners, as well as those seeking Master Specialization, making you more valuable to Channel Partners

- Better movement through the problem-resolution process when calling the Cisco TAC
- Prestige
- Credibility for consultants and customer engineers, including the use of the Cisco CCIE logo

The other big reason to take the CCIE Routing and Switching written exam is that it recertifies an individual's associate-, professional-, and expert-level Cisco certifications. In other words, passing any CCIE written exam recertifies that person's CCNA, CCNP, CCIP, CCSP, CCDP, and so on. (Recertification requirements do change, so please verify the requirements at <http://www.cisco.com/go/certifications>.)

## CCIE Routing and Switching Written Exam 350-001

The CCIE Routing and Switching written exam, as of the time of publication, consists of a two-hour exam administered at a proctored exam facility affiliated with Pearson VUE (<http://www.vue.com/cisco>). The exam typically includes approximately 100 multiple-choice questions. No simulation questions are currently part of the written exam.

As with most exams, everyone wants to know what is on the exam. Cisco provides general guidance as to topics on the exam in the CCIE Routing and Switching written exam blueprint, the most recent copy of which can be accessed from <http://www.cisco.com/go/ccie>.

Cisco changes both the CCIE written and lab blueprints over time, but Cisco seldom, if ever, changes the exam numbers. (Cisco changes the exam numbers of the associate- and professional-level certifications when it makes major changes to what is covered on those exams.) Knowing that the content will change over time, this book includes Appendix C, "CCIE Routing and Switching Exam Updates: Version 1.0." This appendix will include coverage of any newly added topics to the CCIE Routing and Switching written exam. When Cisco changes the blueprint, the authors will add content to cover the new topics at <http://www.ciscopress.com/title/9781587201967> and make that content available to all readers who have bought the earlier edition of the book. For future printings, Cisco Press will put that new content into Appendix C.

The CCIE Routing and Switching written exam blueprint, as of the time of publication, is listed in Table I-1. Table I-1 also lists the chapter(s) that cover each topic.

**Table 8-1** *CCIE Routing and Switching Written Exam Blueprint*

Blueprint Topic	Chapter(s)
<b>I. General Networking Theory</b>	
A. General Routing Concepts	4, 6, 7, 10
1. Link State and Distance Vector Protocols	7
2. Split Horizon	7

**Table 8-1** *CCIE Routing and Switching Written Exam Blueprint (Continued)*

<b>Blueprint Topic</b>	<b>Chapter(s)</b>
3. Summarization	4, 10
4. Classful and a Classless Routing Protocol	6
5. Routing Decision Criteria	10
<b>B. Routing Information Base (RIB) and Routing Protocols Interaction</b>	10, 11
1. Administrative Distance	10
2. Routing Table	10
3. RIB and Forwarding Information Base Interaction	10, 11
<b>C. Redistribution</b>	10
1. Redistribution Between Routing	10
2. Troubleshooting Routing Loop	10
<b>II. Bridging and LAN Switching</b>	
<b>A. Spanning Tree Protocol (STP)</b>	1, 3, 18
1. 802.1d	3
2. 802.1w	3
3. 802.1s	3
4. Loopguard	3
5. Rootguard	3
6. Bridge Protocol Data Unit (BPDU) Guard	3
7. Storm Control	18
8. Rapid Spanning Tree Protocol (RSTP)	3
9. Unicast flooding	1
10. STP port roles, Failure propagation, and Loopguard Operation	3
<b>B. LAN Switching</b>	1, 2, 3
1. Trunks	2, 3
2. VLAN Trunking Protocol (VTP) Administrative Functions	2
<b>C. Ethernet</b>	1
1. Speed	1
2. Duplex	1
3. Ethernet	1

*continues*

**Table 8-1** CCIE Routing and Switching Written Exam Blueprint (Continued)

<b>Blueprint Topic</b>	<b>Chapter(s)</b>
4. Fast Ethernet	1
5. Gigabit Ethernet	1
<b>III. IP</b>	
A. Addressing	4, 5
1. Subnetting	4
2. Hot Standby Routing Protocol (HSRP)	5
3. Gateway Load Balancing Protocol (GLBP)	5
4. Virtual Router Redundancy Protocol (VRRP)	5
5. Network Address Translation (NAT)	4
B. Services	5
1. Network Time Protocol (NTP)	5
2. Dynamic Host Control Protocol (DHCP)	5
3. Web Cache Communication Protocol (WCCP)	5
C. Network Management	
1. Logging and Syslog	5
<b>IV. IP Routing</b>	
A. OSPF	9
1. Standard OSPF Area	9
2. Stub Area	9
3. Totally Stub Area	9
4. Not-So-Stubby-Area (NSSA)	9
5. Totally NSSA	9
6. Link State Advertisement (LSA) Types	9
7. Adjacency on a Point-to-Point and on a Multi-Access (Broadcast)	9
8. OSPF Graceful Restart	9
9. Troubleshooting Failing Adjacency Formation to Fail	9
10. Troubleshooting of External Route Installation in the RIB	9
B. BGP	11
1. Protocol on Which BGP Peers Communicate	11
2. Next Hop	11

**Table 8-1** *CCIE Routing and Switching Written Exam Blueprint (Continued)*

<b>Blueprint Topic</b>	<b>Chapter(s)</b>
3. Peering	11
4. Troubleshooting of BGP Route That Will Not Install in the Routing Table	11
<b>C. EIGRP</b>	8
1. Best Path	8
2. Loop Free Paths	8
3. EIGRP Operations When Alternate Loop Free Paths Are Available and When It Is Not Available	8
4. EIGRP Queries	8
5. Manual Summarization	8
6. Auto-Summarization	8
7. EIGRP Stubs	8
8. Troubleshooting of EIGRP Neighbor Adjacencies	8
<b>D. Policy Routing</b>	6, 12
1. Concept of policy routing	6, 12
<b>V. QoS</b>	
A. Modular QoS Command-Line (MQC) Applied To:	12, 13, 14
1. Network-Based Application Recognition (NBAR)	12
2. Class-Based Weighted Fair Queueing (CBWFQ) / Modified Deficit Round Robin (MDRR)	13, 14
3. Policing	14
4. Shaping	14
5. Marking	12, 14
6. Random Early Detection (RED)	13
<b>VI. WAN</b>	
A. Frame Relay	6, 15, 18
1. Local Management Interface (LMI)	6, 15
2. Traffic Shaping	15
3. Hub and Spoke routers	15
4. Dynamic Multipoint VPN (DMVPN)	18
5. DE	15

*continues*

**Table 8-1** *CCIE Routing and Switching Written Exam Blueprint (Continued)*

<b>Blueprint Topic</b>	<b>Chapter(s)</b>
<b>VII. IP Multicast</b>	
A. Internet Group Management Protocol (IGMP) v2	16, 17
B. Group Addresses	16, 17
C. Shared Trees	17
D. Source Trees	17
E. Protocol Independent Multicast (PIM) Mechanic	17
F. PIM Sparse Mode	17
G. Auto-RP	17
H. Anycast RP	17
<b>VIII. Security</b>	
A. Extended IP Access Lists	18
B. Unicast Reverse Path Forwarding (uRPF)	18
C. IP Source Guard	18
D. Context Based Access Control (CBAC)	18
<b>IX. MPLS (New)</b>	
A. Label Switching Router (LSR)	19
B. Label Switched Path (LSP)	19
C. Route Descriptor	19
D. Label Format	19
E. Label imposition/disposition	19
F. Label Distribution	19
<b>X. IPv6 (New)</b>	
A. IPv6 Addressing and Types	20
B. IPv6 Neighbor Discovery	20
C. Basic IPv6 functionality Protocols	20
D. IPv6 Multicast and Related Multicast Protocols	20
E. Tunneling Techniques	20
F. OSPFv3	20
G. EIGRPv6	20

The blueprint tells you what major topics to study and by implication, what not to study. However, the blueprint does not provide many details about the scope and depth covered for each topic. As you prepare for the written exam, it is a good idea to study more details than you think you need to pass the exam, because the lab exam is considerably more rigorous than the written exam.

Knowing what topics Cisco does not list in the blueprint is also useful, particularly topics that Cisco has removed from earlier blueprints. For example, in 2005, Cisco announced the removal of ISDN/DDR, IS-IS, ATM, and SONET from the written exam blueprint, but it added wireless. In 2007, Cisco announced a new CCIE Routing and Switching written blueprint, referenced as “version 3.0” (the older blueprints did not have a version). This version 3.0 blueprint also added and removed topics; for example, it removed wireless coverage, but added MPLS and expanded IPv6. Always check <http://www.cisco.com/go/ccie> for the latest information regarding any other new or deleted blueprint topics. For any major changes, the authors will post a new version of Appendix C, which will add coverage of the new topics. Go to <http://www.ciscopress.com/title/1587201968> for this book’s web page, and look for a new Appendix C if the blueprint changes.

## About the *CCIE Routing and Switching Official Exam Certification Guide, Third Edition*

This section provides a brief insight into the contents of the book, the major goals, and some of the book features that you will encounter when using this book.

### Book Organization

This book contains nine major parts, which correspond to, and are in the same order as, the last nine major headings in the 10-heading CCIE Routing and Switching written blueprint. The topics under the first heading of the blueprint, “General Networking Theory,” are covered in this book, but they are spread throughout the various parts of the book.

Each part of the book has one or more chapters. Some have a single chapter, such as Part VII, “Security.” However, Part III, “IP Routing,” has six chapters and a high page count.

Beyond the chapters in the nine major parts of the book, you will find several useful appendixes gathered in Part X. In particular, Appendix C, “CCIE Routing and Switching Exam Updates: Version 1.0,” as mentioned earlier, will be updated with subsequent versions online at <http://www.ciscopress.com/title/9781587201967> when appropriate to provide you with the most up-to-date material. Also included in Part X is a decimal to binary conversion chart for reference in Appendix B. There are also several useful appendixes that can only be accessed from the CD in the back of the book.

Following is a description of each part’s coverage:

- **Part I, “LAN Switching” (Chapters 1–3)**

This part focuses on LAN Layer 2 features, specifically Ethernet (Chapter 1), VLANs and trunking (Chapter 2), and Spanning Tree Protocol (Chapter 3).

- **Part II, “IP” (Chapters 4–5)**

This part is titled “IP” to match the blueprint, but it might be better titled “TCP/IP” because it covers details across the spectrum of the TCP/IP protocol stack. It includes IP addressing (Chapter 4) and IP services such as DHCP and ARP (Chapter 5).

- **Part III, “IP Routing” (Chapters 6–11)**

This part covers some of the more important topics on the exam and is easily the largest part of the book. It covers Layer 3 forwarding concepts (Chapter 6), followed by three routing protocol chapters, one each about RIP, EIGRP, and OSPF (Chapters 7 through 9, respectively). Following that, Chapter 10 covers route redistribution between IGP. At the end, Chapter 11 hits the details of BGP.



- **Part IV, “QoS” (Chapters 12–14)**

This part covers the more popular QoS tools, including some MQC-based tools, as well as several older tools, particularly FRTS. The chapters include coverage of classification and marking (Chapter 12), queuing and congestion avoidance (Chapter 13), plus shaping, policing, and link efficiency (Chapter 14).

- **Part V, “Wide-Area Networks” (Chapter 15)**

The WAN coverage has generally shrunk with the last several changes to the CCIE Routing and Switching written blueprints, so Frame Relay is all that remains in this section. However, the latest blueprint revision includes another WAN topic, MPLS, which is covered in Chapter 19. MPLS is covered in Part VIII of this book to keep the order of book parts in synch with the blueprint.

- **Part VI, “IP Multicast” (Chapters 16–17)**

This is one of the two parts of the book that cover topics that are mostly ignored for the CCNP exam. As a result, the text assumes that the reader has no knowledge of multicast before beginning this part. Chapter 16 covers multicast on LANs, including IGMP and how hosts join multicast groups. Chapter 17 covers multicast WAN topics.



- **Part VII, “Security” (Chapter 18)**

Given the CCIE tracks for both Security and Voice, Cisco has a small dilemma regarding whether to cover those topics on CCIE Routing and Switching, and if so, in how much detail. This part covers a variety of security topics appropriate for CCIE Routing and Switching, in a single chapter. This chapter focuses on switch and router security. (Note that Voice, whose protocols were formerly covered on CCIE Routing and Switching, is not covered in the current blueprint or in this book.)

- **Part VIII, “MPLS” (Chapter 19)**

As mentioned in the WAN section, MPLS is an addition to the latest blueprint and thus debuts with its own chapter. As with many larger topics in this book, the blueprint does not cover all parts of MPLS but rather focuses on enterprise-related topics such as core MPLS concepts and MPLS VPNs.

- **Part IX, “IP Version 6” (Chapter 20)**

IPv6 is comprehensively addressed in the version 3.0 exam blueprint, so we’ve added a fairly lengthy chapter to cover it.

- **Part X, “Appendixes”**

- **Appendix A, “Answers to the ‘Do I Know This Already?’ Quizzes”**

This appendix lists answers and explanations for the questions at the beginning of each chapter.

— **Appendix B, “Decimal to Binary Conversion Table”**

This appendix lists the decimal values 0 through 255, with their binary equivalents.

— **Appendix C, “CCIE Routing and Switching Exam Updates: Version 1.0”**

As of the first printing of the book, this appendix contains only a few words that reference the web page for this book at <http://www.ciscopress.com/title/9781587201967>. As the blueprint evolves over time, the authors will post new materials at the website. Any future printings of the book will include the latest newly added materials in printed form inside Appendix C.

**NOTE** Appendixes D through H are in printable, PDF format on the CD.

— **(CD-only) Appendix D, “IP Addressing Practice”**

This appendix lists several practice problems for IP subnetting and finding summary routes. The explanations to the answers use the shortcuts described in the book.

— **(CD-only) Appendix E, “Key Tables for CCIE Study”**

This appendix lists the most important tables from the core chapters of the book. The tables have much of the content removed so you can use them as an exercise. You can print the PDF and then fill in the table from memory, checking your answers against the completed tables in Appendix F.

— **(CD-only) Appendix F, “Solutions for Key Tables for CCIE Study”**

This appendix lists the completed tables from the Appendix E exercises so you can check your answers.

— **(CD-only) Appendix G, “IEEE 802.11 Fundamentals”**

Because wireless was removed from the version 3.0 blueprint, we’ve removed the two wireless chapters from the third edition of this book. However, there’s a chance that wireless will return to the CCIE Routing and Switching blueprint in the future, so we’re including those chapters as appendixes on the CD.

— **(CD-only) Appendix H, “Wireless LAN Solutions”**

Like Appendix G, Appendix H covers wireless materials that may be useful for future CCIE Routing and Switching study, if the blueprint is revised to once again include wireless coverage.

**NOTE** There is also a glossary near the end of the book. You can use it to look up key terms and to find the definitions for the exercise at the end of each chapter.

## Book Features

The core chapters of this book have several features that help you make the best use of your time:

- **“Do I Know This Already?” Quizzes**—Each chapter begins with a quiz that helps you to determine the amount of time you need to spend studying that chapter. If you score yourself strictly, and you miss only one question, then you may want to skip the core of the chapter and move on to the “Foundation Summary” section at the end of the chapter, which lets you review facts and spend time on other topics. If you miss more than one, you may want to spend some time reading the chapter or at least reading sections that cover topics about which you know you are weaker.
- **Foundation Topics**—These are the core sections of each chapter. They explain the protocols, concepts, and configuration for the topics in that chapter.
- **Foundation Summary**—The “Foundation Summary” section of this book departs from the typical features of the “Foundation Summary” section of other Cisco Press Exam Certification Guides. This section does not repeat any details from the “Foundation Topics” section; instead, it simply summarizes and lists facts related to the chapter but for which a longer or more detailed explanation is not warranted.
- **Key Topics**—Throughout the “Foundation Topics” section, a Key Topic icon has been placed beside the most important areas for review. After reading a chapter, when doing your final preparation for the exam, take the time to flip through the chapters, looking for the Key Topic icons, and review those paragraphs, tables, figures, and lists.
- **Fill in Key Tables from Memory**—The more important tables from the chapters have been copied to PDF files available on the CD as Appendix E. The tables have most of the information removed. After printing these mostly empty tables, you can use them to improve your memory of the facts in the table by trying to fill them out. This tool should be useful for memorizing key facts. CD-only Appendix F contains the completed tables so you can check your work.
- **CD-based practice exam**—The companion CD contains multiple-choice questions and a testing engine. The CD includes 300 questions unique to the CD. As part of your final preparation, you should practice with these questions to help you get used to the exam-taking process, as well as help refine and prove your knowledge of the exam topics.
- **Key Terms and Glossary**—The more important terms mentioned in each chapter are listed at the end of each chapter under the heading “Definitions.” The glossary, found at the end of the book, lists all the terms from the chapters. When studying each chapter, you should review the key terms, and for those terms about which you are unsure of the definition, you can review the short definitions from the glossary.
- **Further Reading**—Each chapter includes a suggested set of books and websites for additional study on the same topics covered in that chapter. Often, these references will be useful tools for preparation for the CCIE Routing and Switching lab exam.