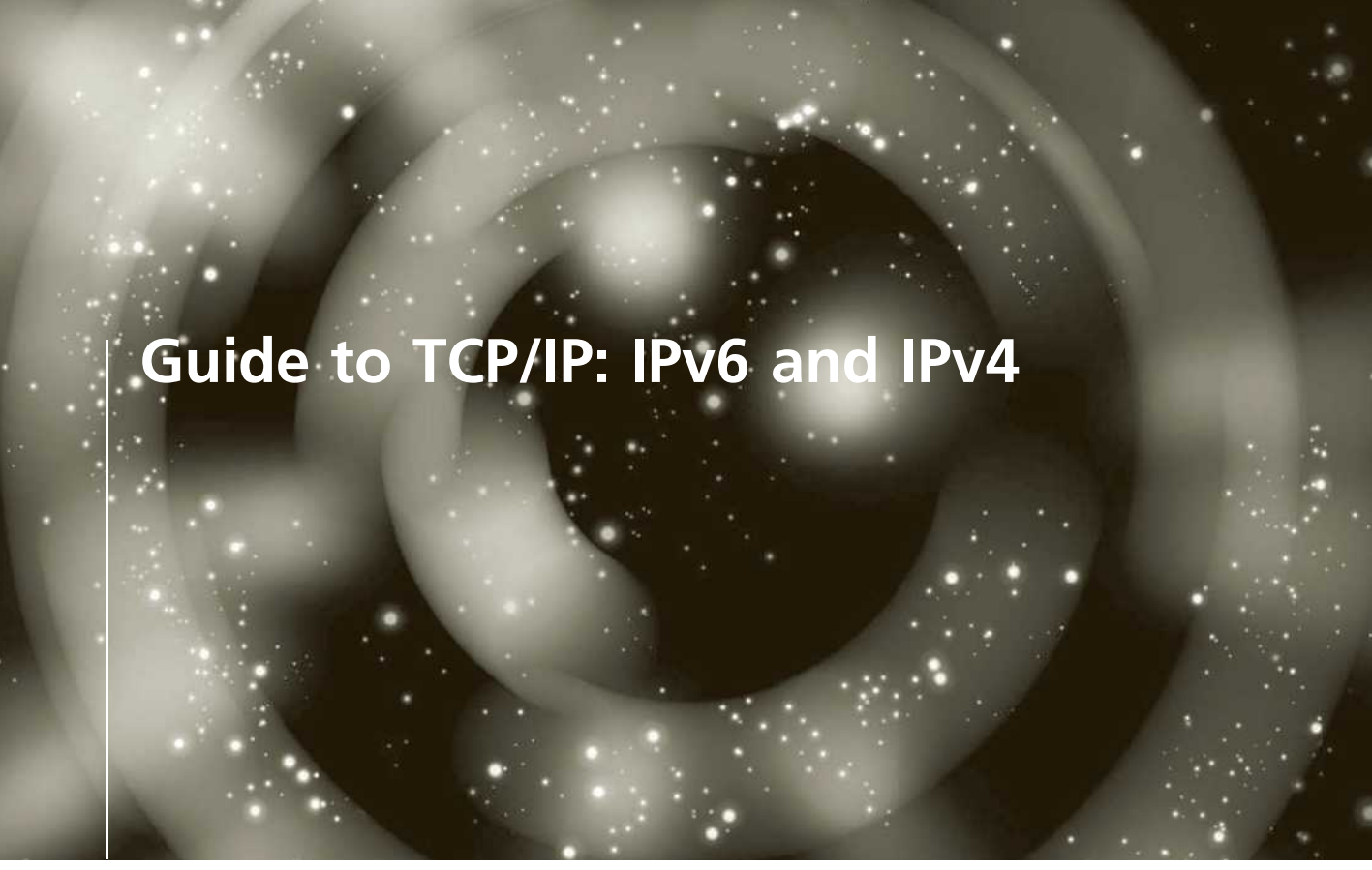
NETWORKING

Guide to TCP/IP

IPv6 and IPv4

Fifth Edition

James Pyles
Jeffrey L. Carrell
Ed Tittel



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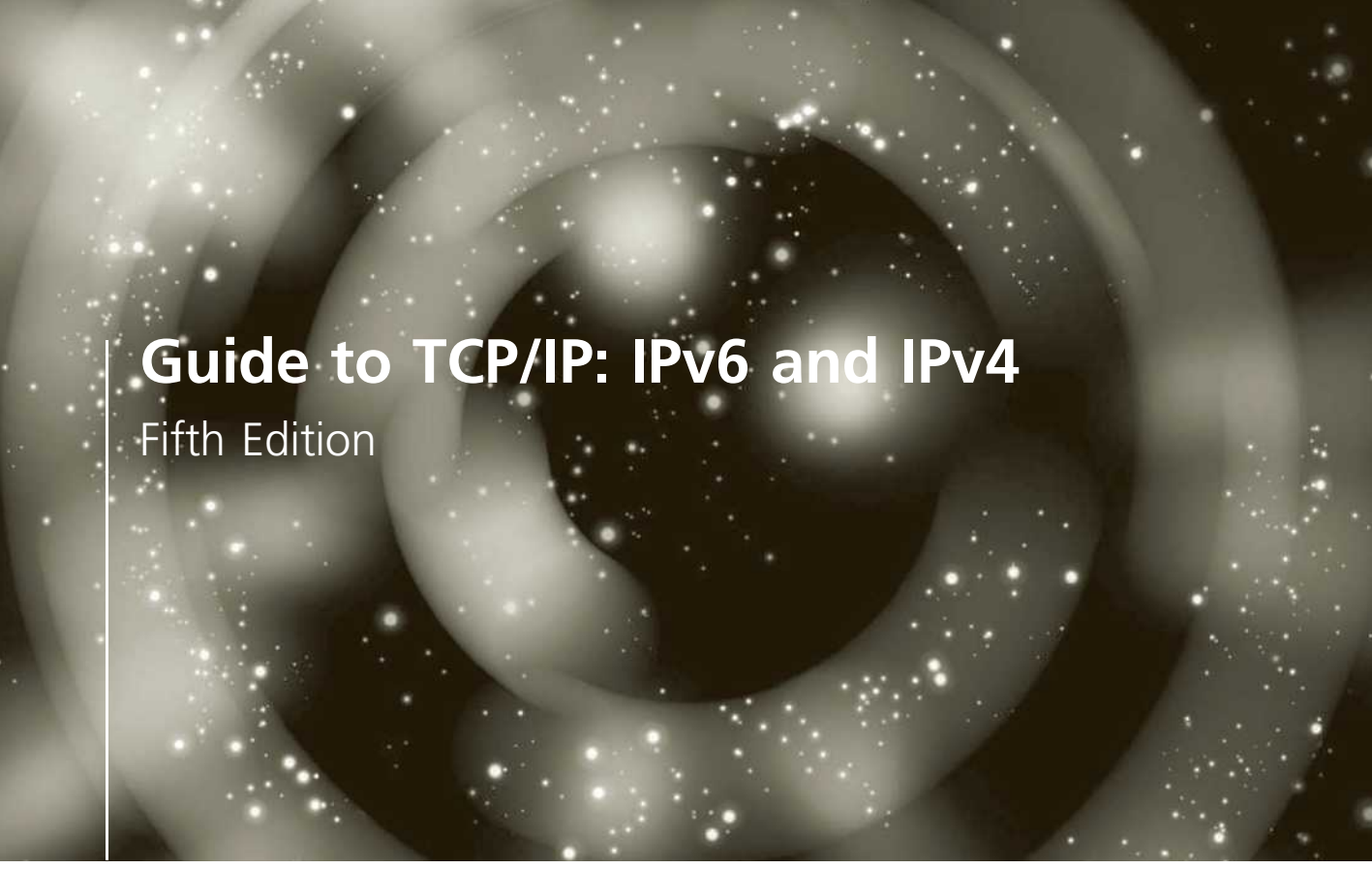

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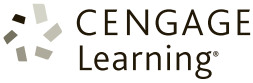

Guide to TCP/IP: IPv6 and IPv4, Fifth Edition

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Brief Contents

Table of Contents

CHAPTER 10

Preface

Welcome to *Guide to TCP/IP: IPv6 and IPv4, Fifth Edition*! TCP/IP stands for Transmission Control Protocol/Internet Protocol and defines the broad family of protocols and services that make the Internet able to function as we know it today. In covering TCP/IP, this book offers you real-world examples, interactive examples, and many Hands-On Projects that reinforce key concepts and teach the use of important monitoring and management tools. This book also includes voluminous protocol traces, or decodes, that will help you understand what TCP/IP looks like, and how it behaves, on your networks.

This book offers in-depth coverage of all the salient models, protocols, services, and standards that govern TCP/IP and that guide its behavior on modern networks. Throughout the book, we provide pointed questions to reinforce the concepts introduced in each chapter and to help prepare you to interact with TCP/IP in its native habitat—that is, on the vast majority of networks in use in the world today. In addition to the review questions, we provide detailed Hands-On Projects that provide you with firsthand experience in installing, configuring, using, and managing TCP/IP on a working network. Finally, to put a real-world slant on the concepts introduced in each chapter, we also include Case Projects that pose problems and require creative solutions that should prepare you for the kinds of situations and needs you'll face on a real, live network.

Intended Audience

This book is intended to serve the needs of individuals and information systems professionals who are interested in learning more about working with and on TCP/IP-based networks. These materials

have been specifically designed to prepare individuals to take an active role in administering a network infrastructure that uses TCP/IP, either as its only protocol suite or in concert with other protocol suites. Those students who work their way through this entire book should be well equipped to recognize, analyze, and troubleshoot a broad range of TCP/IP-related networking problems or phenomena.

Chapter Summaries

Chapter 1, "Introducing TCP/IP," begins with a brief look at TCP/IP and then covers the structure and origins of the standards documents known as Requests for Comments (RFCs), which describe and govern TCP/IP protocols, services, and practices. From there, it explores the Open Systems Interconnection (OSI) reference model for networking, as standardized by the International Organization for Standardization (ISO), and compares and contrasts this standard model to the TCP/IP networking model, around which TCP/IP is built. The chapter then provides an overview of TCP/IP protocols, services, sockets, and ports, and it concludes with an overview of protocol analysis. Wireshark is a type of protocol analyzer that captures, unpacks, and displays the contents of traffic on a network, including TCP/IP; it plays a significant role throughout the remainder of this book.

Chapter 2, "IP Addressing and Related Topics," covers the intricacies involved in managing unique IP addresses for both 32-bit IPv4 addresses and 128-bit IPv6 addresses. Beginning with the anatomy of a numeric IPv4 address, the chapter explores IPv4 address classes, special cases such as broadcast and multicast addresses, and subnets and supernets, and reviews the reasons for classless IPv4 addressing, public versus private IPv4 addresses, and IPv4 addressing schemes. The rest of the chapter repeats this coverage for IPv6, including a review of address formats and notation, address layouts and types, and address allocations. You'll also find addressing schemes and subnetting considerations covered, along with some discussion about how to manage the transition from IPv4 to IPv6 addresses.

Chapter 3, "Basic IP Packet Structures: Headers and Payloads," covers the key components of any IP packet (both for IPv4 and IPv6): the header that describes the packet for routing, forwarding, and filtering, and the payload that contains the data that the packet is meant to convey. IPv4 and IPv6 headers are laid out and dissected in detail, including IPv6 extension headers, and the use of transport and packet handling controls are described and explored. The chapter concludes with a comparison of header structures in IPv4 versus IPv6, with a rationale to explain redesign and changes involved.

Chapter 4, "Data Link and Network Layer Protocols in TCP/IP," explores and explains the TCP/IP protocols that operate at the Data Link and Network layers in the OSI reference model. In that context, it discusses data link protocols in general, examines IP frame types, and talks about hardware addresses in the IP environment and the various protocols—particularly ARP and RARP, for IPv4, and the Neighbor Discovery Protocol, or NDP, for IPv6—that support their use. The chapter also covers TCP/IP's most important protocol at the Network layer, the Internet Protocol (IP), along with routing protocols, mechanisms, and characteristics for IPv4 and IPv6, including RIPv1 and v2, OSPF, EIGRP, and BGP, with considerations for both IPv4 and IPv6 protocols and behaviors.

Chapter 5, "Internet Control Message Protocol," covers a key Network layer protocol for TCP/IP whose job is to ferry status and error messages about IP traffic back to its senders and to other "interested devices," such as routers or switches. Starting with a review of ICMPv4 and

ICMPv6 structures and functions, this chapter examines ICMP message types and codes, security issues, and concludes with a thorough review of testing and troubleshooting sequences for ICMP and decoding ICMP packets.

Chapter 6, "Neighbor Discovery in IPv6," digs into NDP to explain how neighbor discovery works on IPv6 networks. Topics covered include comparing NDP to related IPv4 protocols, various NDP message formats and options, and the overall neighbor discovery process on IPv6 networks.

Chapter 7, "IP Address Autoconfiguration," describes various autoaddressing schemes and mechanisms used on IPv4 and IPv6 networks, including the Dynamic Host Configuration Protocol, or DHCP, as well as autoconfiguration mechanisms used for IPv4 (APIPA and DHCP) and IPv6 (host/interface address determination, stateless and stateful address autoconfiguration, and DHCPv6).

Chapter 8, "Name Resolution on IP Networks," deals with key services used to resolve symbolic, human-readable network names and addresses into machine-intelligible network addresses. Topics covered include name resolution fundamentals and various network name resolution protocols. IPv4 and IPv6 name resolution via the Domain Name Service, or DNS, is described in detail, as is name resolution support for Microsoft Windows operating systems, including issues related to setup, configuration, troubleshooting, and relevant utilities.

Chapter 9, "TCP/IP Transport Layer Protocols," covers two key protocols that operate at the Transport layer of the OSI reference model: the heavy-duty, robust, reliable Transmission Control Protocol (TCP) and the lighter-weight but faster User Datagram Protocol (UDP). TCP is examined in great detail, with particular attention on its packet structures and functions (including IPv6 extension headers for TCP), whereas UDP gets the brief coverage it deserves. The chapter concludes with a discussion of common and appropriate uses for these two protocols.

Chapter 10, "Transitioning from IPv4 to IPv6: Interoperation," deals with issues and techniques that apply when IPv4 and IPv6 must coexist on the same networks, as will surely be the case for many networks for the foreseeable future. It explains the means whereby IPv4 and IPv6 can interact, explains hybrid IPv4/IPv6 networks and node types, and explores transition addresses and switchover mechanisms to make the change from IPv4 to IPv6 as straightforward as possible. Tunneling mechanisms and protocols, including ISATAP, 6to4, and Teredo, are described in detail.

Chapter 11, "Deploying IPv6," jumps into an area of great interest to Internet professionals—namely, what's involved in understanding, planning, deploying, and using IPv6 on modern TCP/IP networks. Topics covered include evaluating potential software and hardware changes, addressing schemes and autoaddressing, migration techniques, and priority schemes for various classes or types of network services.

Chapter 12, "Securing TCP/IP Environments," covers general network security basics, with a particular emphasis on IP security topics. It also addresses key topics that include perimeter security, infrastructure security, and host device security.

The book also includes **Appendix A,** which explains the required software and trace files available on the book's online resources Web site.

Online Content

The book's companion Web site at *www.cengagebrain.com* includes the following, plus much more:

- A list of the important RFCs mentioned throughout the text and the available IPv6-specific RFCs

RFCs are a dynamic collection of documents, so anything collected in static form represents a snapshot of what was current at the time the snapshot was taken. Always consult online RFCs for information about the most current documents and standards.

- A reference to TCP/IP-related command-line utilities for Windows desktop and Windows Server
- A list of the Windows desktop and Windows Server Registry settings found in numerous tables in this book

New to This Edition

- Content refreshed throughout for Windows 10, Windows Server 2012, and Wireshark v2.0.0
- Technical examples added that use Mac OS X and Ubuntu Linux
- Improved analysis problems, study/review questions, and updated labs to help students retain what they're learning better than ever before
- Bonus content available on MindTap or via special online access:
  - Hands-On Project assessment questions and answers for every chapter
  - Two new chapters on troubleshooting and the practical application of real-world technologies
  - Capstone labs

Features

To ensure a successful learning experience, this book includes the following pedagogical features:

- **Chapter Objectives:** Each chapter in this book begins with a detailed list of the concepts to be mastered within that chapter. This list provides you with a quick reference to the contents of that chapter as well as a useful study aid.
- **Illustrations and Tables:** Numerous illustrations of server screens and components aid you in the visualization of common setup steps, theories, and concepts. In addition, many tables provide details and comparisons of both practical and theoretical information and can be used for a quick review of topics. This book also includes a great number of protocol traces from both IPv4 and IPv6 protocols. Because of formatting differences between the two protocol families, these traces differ slightly, but they present more or less the same information, subject only to minor differences.
- **End-of-Chapter Material:** The end of each chapter includes the following features to reinforce the material covered in the chapter:
  - **Summary:** A bulleted list providing a brief but complete summary of the chapter
  - **Key Terms List:** A list of all new terms (the definitions are located in the Glossary at the back of this book)
  - **Review Questions:** A list of review questions that test your knowledge of the most important concepts covered in the chapter
  - **Hands-On Projects:** Projects that help you apply the knowledge gained in the chapter
  - **Case Study Projects:** Projects that take you through real-world scenarios

MindTap

MindTap for Guide to TCP/IP: IPv6 and IPv4 is an online learning solution designed to help students master the skills they need in today's workforce. Research shows that employers need critical thinkers, troubleshooters, and creative problem-solvers to stay relevant in our fast-paced, technology-driven world. MindTap helps users achieve this with assignments and activities that provide hands-on practice, real-life relevance, and mastery of difficult concepts. Students are guided through assignments that progress from basic knowledge and understanding to more challenging problems.

All MindTap activities and assignments are tied to learning objectives. The hands-on exercises provide real-life application and practice. Readings and "Whiteboard Shorts" support the lecture, while "In the News" assignments encourage students to stay current. Pre- and postcourse assessments allow instructors to measure how much students have learned using analytics and reporting that makes it easy to see where the class stands in terms of progress, engagement, and completion rates. Use the content and learning path as-is, or pick and choose how the material will wrap around your own. You control what the students see and when they see it. Learn more at *www.cengage.com/mindtap/*.

Instructor Resources

Free to all instructors who adopt *Guide to TCP/IP: IPv6 and IPv4* for their courses is a complete package of instructor resources. These resources are available from the Cengage Learning Web site, *www.cengagebrain.com*, by going to the product page for this book in the online catalog and choosing "Instructor Downloads."

Resources include:

Instructor's Manual: This manual includes course objectives and additional information to help your instruction.

Cengage Learning Testing Powered by Cognero: A flexible, online system that allows you to import, edit, and manipulate content from the text's test bank or elsewhere, including your own favorite test questions; create multiple test versions in an instant; and deliver tests from your LMS, your classroom, or wherever you want.

PowerPoint Presentations: A set of Microsoft PowerPoint slides is included for each chapter. These slides are meant to be used as a teaching aid for classroom presentations, to be made available to students for chapter review, or to be printed for classroom distribution. Instructors are also at liberty to add their own slides.

Figure Files: Figure files allow instructors to create their own presentations using figures taken from the text.

Text and Graphic Conventions

Wherever appropriate, additional information and exercises have been added to this book to help you better understand what is being discussed in the chapter. Icons throughout the text alert you to additional materials. The icons used in this textbook are as follows:

The Caution icon warns you about potential mistakes or problems and explains how to avoid them.

The Note icon is used to present additional helpful material related to the subject being described.

Tips based on the authors' experience provide extra information about how to attack a problem or what to do in real-world situations.

Each Hands-On Project in this book is preceded by the Hands-On icon and a description of the exercise that follows.

Case Project icons mark the case projects. These are more involved, scenario-based assignments. In this extensive case example, you are asked to implement independently what you have learned.

Author Team

James Pyles is a consultant, author, editor, and technical writer. He has worked as a technical writer for EmergeCore Networks, Aquent Studios, and iAnywhere/Sybase and has served as Developmental Editor for Global Support Content Operations at Hewlett-Packard. He is currently the technical writer and marketing contributor for Kount, a fraud and risk solutions company, in Boise Idaho.

Jeff Carrell is a network consultant, frequent industry speaker, freelance writer, network systems and security instructor, and course developer, all with a focus on IPv6 systems interoperability. Since building his first Novell LAN in 1986, Jeff has enjoyed successful career advancements with several network manufacturers, such as Novell, Foundry Networks, and HP Networking, as a presales consulting engineer and technical instructor. In an end-user position, he has designed mission-critical, high-availability networks.

Ed Tittel was on the adjunct faculty at Austin Community College from 1997 through 2003 and taught at Interop from 1996 to 2004. He is a Network Certified Professional and works as a full-time freelance writer and consultant in Round Rock, Texas. He has contributed to over 100 books on computing across a broad range of subjects and is the author of numerous Course Technology titles. He also writes and blogs for TechTarget.com, Tom's IT Pro, and other Web sites.

Acknowledgments

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The authors would also like to thank Kim Lindros, the behind-the-scenes author team manager who helped bring this book to fruition on behalf of the authors.

James Pyles: I appreciate the opportunity to serve as lead author updating this fine book for its fifth edition. I especially want to thank Ed Tittel and Kim Lindros for inviting me along for the ride. I also am extremely grateful to Jeff Carrell, at whose feet I would gladly sit at any time in order to learn the arcane mysteries of IPv6. No acknowledgment would be complete without my recognition of my lovely wife Lin and the invaluable support she has provided me in all of my endeavors. Given the rapidly evolving nature of the Internet as we proceed into the twenty-first century, I can't help but think of my grandchildren, who will inherit the future from us. May we leave them and their generation a worthy legacy.

Jeff Carrell: With God's help, all things are possible. Thank you to my wife and best friend Cynthia for all your love, encouragement, and patience; I am truly blessed to have you in my life. Thank you to my friends and colleagues who provided input and encouragement along the way. Thanks to Ed Tittel for the opportunity, inspiration, and mentoring. The project was huge, exciting, and awesome to be a part of. Thanks to Kim Lindros, who not only kept us moving but made sure we stayed on task. I could not imagine working on this project without you. Finally, thanks to James Pyles, who provided technical leadership, updates, and new content.

Ed Tittel: My profound thanks to Jim Pyles for taking over as lead author and architect for the fifth edition of this book and to Jeff Carrell for addressing technical considerations throughout the writing phase and for providing new content and exercises. Also, thanks again to Kim Lindros for making this book a viable proposition. Finally, thank you to my lovely wife Dina and son Gregory, who have brought me much joy and happiness. All that I do, I do for you two.

Readers are encouraged to e-mail comments, questions, and suggestions regarding *Guide to TCP/IP: IPv6 and IPv4, Fifth Edition* and the accompanying student and instructor resources Web site to *tcpip5e@guidetotcpip.com*.

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