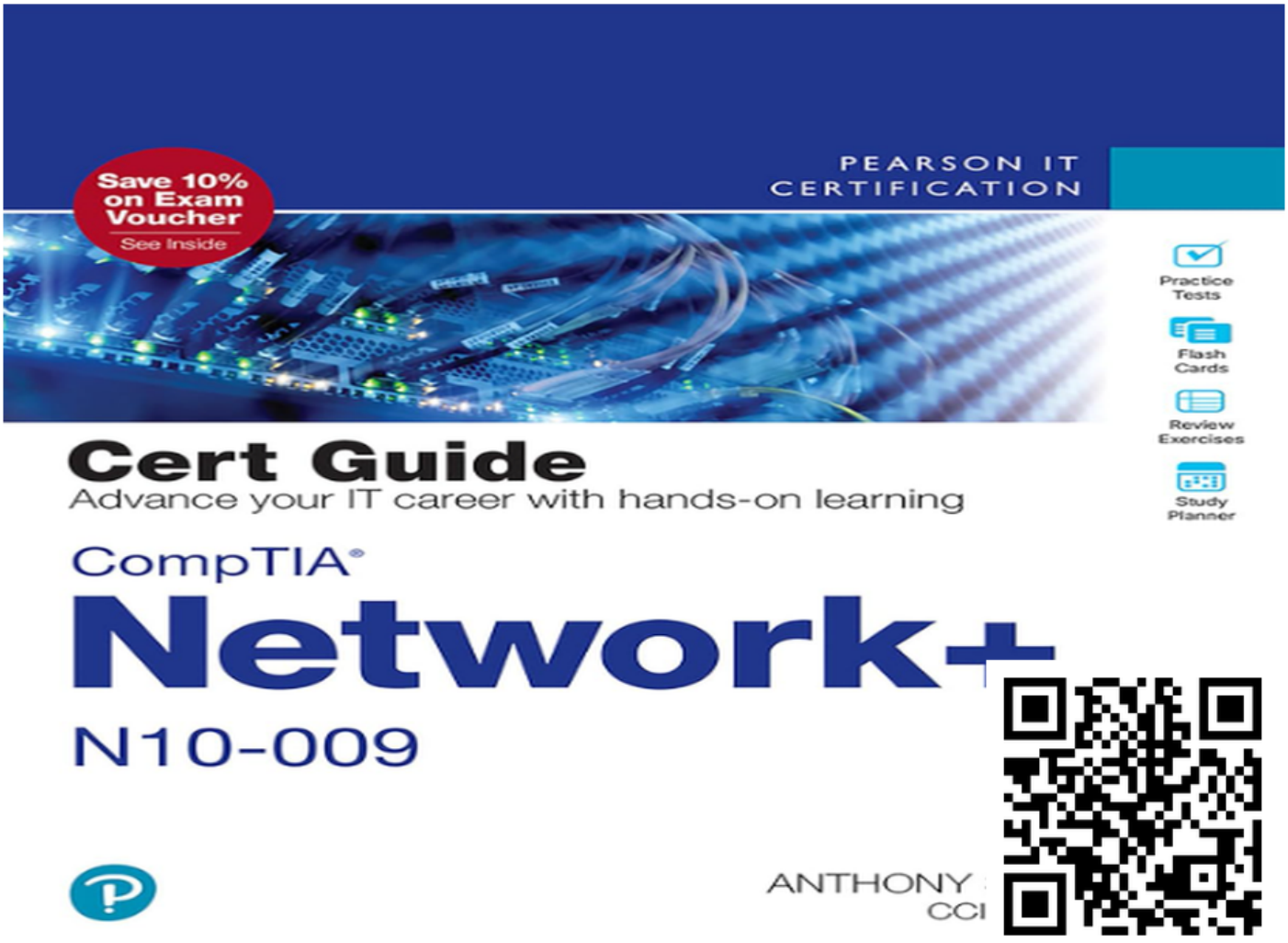

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CompTIA® Network+ N10-009 Cert Guide

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Pearson

CompTIA® Network+ N10-009 Cert Guide

Hoboken, New Jersey

ISBN-13: 978-0-13-536788-9

ISBN-10: 0-13-536788-3

Library of Congress Cataloging-in-Publication Data is on file.

$PrintCode

GM K12, Early Career and Professional Learning
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Contents at a Glance

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About the Author

Anthony Sequeira (CCIE No. 15626) began his IT career in 1994 with IBM in Tampa, Florida. He quickly formed his own computer consultancy, Computer Solutions, and then discovered his true passion: teaching and writing about networking technologies. Anthony lectured to massive audiences around the world while working for Mastering Computers. Anthony has never been happier in his career than he is now, as a senior technical instructor for ACI Learning. ACI is a leader in audit, cybersecurity, and IT pro training in self-paced and instructor-led formats.

Dedication

This book is dedicated to my daughter, Bella Sequeira, who inspires me to do great work every day.

Acknowledgments

I cannot thank Nancy Davis and Chris Cleveland enough for their patience as I created this latest edition of the text. Also, huge thanks to my editors, Chris Crayton and Bill McManus. Their work on this text improved it dramatically.

About the Technical Reviewer

Chris Crayton is a technical consultant, trainer, author, and industry-leading technical editor. He has worked as a computer technology and networking instructor, information security director, network administrator, network engineer, and PC specialist. Chris has authored several print and online books on PC repair, CompTIA A+, CompTIA Security+, and Microsoft Windows. He has also served as technical editor and content contributor on numerous technical titles for several of the leading publishing companies. He holds numerous industry certifications, has been recognized with many professional and teaching awards, and has served as a state-level SkillsUSA final competition judge. Chris tech edited and contributed to this book to make it better for students and those wishing to better their lives.

We Want to Hear from You!

As the reader of this book, *you* are our most important critic and commentator. We value your opinion and want to know what we're doing right, what we could do better, what areas you'd like to see us publish in, and any other words of wisdom you're willing to pass our way.

We welcome your comments. You can email or write to let us know what you did or didn't like about this book—as well as what we can do to make our books better.

Please note that we cannot help you with technical problems related to the topic of this book.

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Introduction

The CompTIA Network+ certification is a popular certification for those entering the computer networking field. Although many vendor-specific networking certifications are popular in the industry, the CompTIA Network+ certification is unique in that it is vendor neutral. It does not focus its content on the techniques and technologies of any one specific network vendor. The CompTIA Network+ certification often acts as a stepping-stone to more specialized and vendor-specific certifications, such as those offered by Cisco Systems.

On the CompTIA Network+ exam, the topics are mostly generic in that they can apply to networking equipment regardless of vendor. Although the CompTIA Network+ certification is vendor neutral, network software and systems are implemented by multiple independent vendors. Therefore, several of the exercises, examples, and simulations in this book include using particular vendors' configurations and technologies, such as Microsoft Windows operating systems or Cisco Systems routers and switches. More detailed training for a specific vendor's software and hardware can be found in books and training specific to that vendor.

Who Should Read This Book?

This book was written with two audiences in mind: those who want to learn all they can about networking technology and those who want to pass the CompTIA Network+ exam. I think that both groups are going to be very impressed with the breadth of technologies this book details. Although it would be impossible to cover every topic in networking today, this book manages to cover all the massive areas that make networking an exciting field that many people want to learn.

Readers will range from people who are attempting to attain a position in the IT field to people who want to keep their skills sharp or perhaps retain their job when facing a company policy that mandates they take the new exams. This book is also for those who want to acquire additional certifications beyond the Network+ certification (for example, the Cisco Certified Network Associate [CCNA] certification and beyond). The book is designed to enable an easy transition to future certification studies.

Resources

This book comes with a wealth of digital resources to help you review, practice, and assess your knowledge. The end of each chapter contains a review section that references several of these tools, and you should be sure to use them as you complete each chapter to help reinforce what you are learning. You can use them again after

you finish the book to help review and make sure you are fully prepared for the exam.

Here's a list of resources available on the companion website:

- Interactive glossary flash card application
- Interactive exam essentials appendix
- The Pearson Test Prep (PTP) practice test app
- Video training on key exam topics
- Memory table review exercises and answer keys
- A study planner tool
- Instructions to redeem your Network+ certification exam voucher, which provides a 10% discount on the exam

To access the companion website, follow these steps:

Step 1. Go to **https://www.pearsonITcertification.com/register** by December 31, 2027.

Step 2. Either log in to your account if you have an existing account already or create a new account.

Step 3. Enter the ISBN of this book (**9780135367889**) and click **Submit**.

Step 4. Answer the challenge questions to validate your purchase.

Step 5. In your account page, click the **Registered Products** tab and then click the **Access Bonus Content** link.

How to Access the Pearson Test Prep (PTP) App

You have two options for installing and using the Pearson Test Prep application: a web app and a desktop app. To use the Pearson Test Prep application, start by finding the registration code that comes with the book. You can find the code in these ways:

- You can get your access code by registering the print ISBN (9780135367889) on pearsonITcertification.com/register. Make sure to use the print book ISBN regardless of whether you purchased an eBook or the print book. Once you register the book, your access code will be populated on your account page under the Registered Products tab. Instructions for how to redeem the code are available on the book's companion website by clicking the Access Bonus Content link.

- Premium Edition: If you purchase the Premium Edition eBook and Practice Test directly from the Pearson IT Certification website, the code will be populated on your account page after purchase. Just log in at pearsonITcertification.com, click Account to see details of your account, and click the digital purchases tab.

NOTE After you register your book, your code can always be found in your account under the Registered Products tab.

Once you have the access code, to find instructions about both the PTP web app and the desktop app, follow these steps:

Step 1. Open this book's companion website as shown earlier on the first page of the book, under the "Companion Website and Pearson Test Prep Access Code" heading.

Step 2. Click the **Practice Exams** button.

Step 3. Follow the instructions listed there for both installing the desktop app and for using the web app.

Note that if you want to use the web app only at this point, just navigate to pearsontestprep.com, log in using the same credentials used to register your book or purchase the Premium Edition, and register this book's practice tests using the registration code you just found. The process should take only a couple of minutes.

Customizing Your Exams

Once you are in the exam settings screen, you can choose to take exams in one of three modes:

- **Study mode:** Enables you to fully customize your exams and review answers as you are taking the exam. This is typically the mode you would use first to assess your knowledge and identify information gaps.
- **Practice Exam mode:** Locks certain customization options, as it is presenting a realistic exam experience. Use this mode when you are preparing to test your exam readiness.
- **Flash Card mode:** Strips out the answers and presents you with only the question stem. This mode is great for late-stage preparation when you really want to challenge yourself to provide answers without the benefit of seeing

multiple-choice options. This mode does not provide the detailed score reports that the other two modes do, so you should not use it if you are trying to identify knowledge gaps.

In addition to these three modes, you will be able to select the source of your questions. You can choose to take exams that cover all of the chapters or you can narrow your selection to just a single chapter or the chapters that make up specific parts in the book. All chapters are selected by default. If you want to narrow your focus to individual chapters, simply deselect all the chapters and then select only those on which you wish to focus in the Objectives area.

You can also select the exam banks on which to focus. Each exam bank comes complete with a full exam of questions that cover topics in every chapter. You can have the test engine serve up exams from all test banks or just from one individual bank by selecting the desired banks in the exam bank area.

There are several other customizations you can make to your exam from the exam settings screen, such as the time of the exam, the number of questions served up, whether to randomize questions and answers, whether to show the number of correct answers for multiple-answer questions, and whether to serve up only specific types of questions. You can also create custom test banks by selecting only questions that you have marked or questions on which you have added notes.

Updating Your Exams

If you are using the online version of the Pearson Test Prep software, you should always have access to the latest version of the software as well as the exam data. If you are using the Windows desktop version, every time you launch the software while connected to the Internet, it checks if there are any updates to your exam data and automatically downloads any changes that were made since the last time you used the software.

Sometimes, due to many factors, the exam data may not fully download when you activate your exam. If you find that figures or exhibits are missing, you may need to manually update your exams. To update a particular exam you have already activated and downloaded, simply click the **Tools** tab and click the **Update Products** button. Again, this is only an issue with the desktop Windows application.

If you wish to check for updates to the Pearson Test Prep exam engine software, Windows desktop version, simply click the **Tools** tab and click the **Update Application** button. This ensures that you are running the latest version of the software engine.

Goals and Methods

The goal of this book is to assist you in learning and understanding the technologies covered in the Network+ N10-009 blueprint from CompTIA. This book also helps you prepare for the N10-009 version of the CompTIA Network+ exam.

To aid you in mastering and understanding the Network+ certification objectives, this book uses the following methods:

- **Opening topics list:** This list spells out the Network+ objectives and topics that are covered in the chapter.
- **Foundation topics:** At the heart of a chapter, the sections under "Foundation Topics" explain the topics from hands-on and theory-based standpoints. These sections include in-depth descriptions, tables, and figures that build your knowledge so that you can pass the N10-009 exam. Each chapter is broken into multiple sections.
- **Key topics:** The "Review All Key Topics" section indicates important figures, tables, and lists of information that you need to review for the exam. Key Topic icons are sprinkled throughout each chapter, and a table at the end of each chapter lists the important parts of the text called out by these icons.
- **Memory tables:** You can find memory tables and their answer key on the book's companion website in Appendixes B and C, respectively. Use them to help memorize important information.
- **Key terms:** Key terms without definitions are listed at the end of each chapter. Write down the definition of each term and check your work against the definitions in the Glossary. On the companion website, you will find a flash card application with all the glossary terms separated by chapter, and you can use it to study key terms as well.
- **Practice exams:** As previously described, this book comes complete with several full-length practice exams available to you in the Pearson Test Prep practice test software, which you can download and install from the companion website. The Pearson Test Prep software is also available to you online, at www.PearsonTestPrep.com. Follow the directions at the beginning of the book under "Companion Website and Pearson Test Prep Access Code." Be sure to run through the questions in exam bank 1 as you complete each chapter in study mode. When you have completed the book, take a full practice test using exam bank 2 questions in practice exam mode to test your exam readiness.

For current information about the CompTIA Network+ certification exam, visit https://www.comptia.org/certifications/network.

Strategies for Exam Preparation

This book comes with a study planner tool on the companion website. It is a spreadsheet that helps you keep track of the activities you need to perform in each chapter and helps you organize your exam preparation tasks. As you read the chapters in this book, jot down notes with key concepts or configurations in the study planner. Each chapter ends with a summary and series of exam preparation tasks to help you reinforce what you have learned. These tasks include review exercises such as reviewing key topics, completing memory tables, defining key terms, answering review questions, and performing exercises. Make sure you perform these tasks as you complete each chapter to improve your retention of the material and record your progress in the study planner.

The book concludes with Chapter 26, "Final Preparation," which offers you guidance on your final exam preparation and provides you with some helpful exam advice. Make sure you read over that chapter to help assess your exam readiness and identify areas where you need to focus your review.

Download the current exam objectives by submitting a form on the following web page: https://www.comptia.org/certifications/network.

Use the practice exams, which are included on this book's companion website. As you work through the practice exams, use the practice test software reporting features to note the areas where you lack confidence and then review the related concepts. After you review those areas, work through the practice exams a second time and rate your skills. Keep in mind that the more you work through the practice exams, the more familiar the questions become, and the less accurately the practice exams judge your skills.

After you work through the practice exams a second time and feel confident with your skills, schedule the real CompTIA Network+ exam (N10-009).

CompTIA Network+ Exam Topics

Table I-1 lists general exam topics (*objectives*) and specific topics under each general topic (*subobjectives*) for the CompTIA Network+ N10-009 exam. This table lists the primary chapter in which each exam topic is covered. Note that many objectives and subobjectives are interrelated and are addressed in multiple chapters in the book.

Table I-1 CompTIA Network+ Exam Topics

Chapter	N10-009 Exam Objective	N10-009 Exam Subobjective
Chapter 1: The OSI Model and Encapsulation	1.0 Networking Concepts	1.1 Explain concepts related to the Open Systems Interconnection (OSI) reference model.
Chapter 2: Networking Appliances, Applications, and Functions	1.0 Networking Concepts	1.2 Compare and contrast networking appliances, applications, and functions.
Chapter 3: Cloud Concepts	1.0 Networking Concepts	1.3 Summarize cloud concepts and connectivity options.
Chapter 4: Networking Ports, Protocols, Services, and Traffic Types	1.0 Networking Concepts	1.4 Explain common networking ports, protocols, services, and traffic types.
Chapter 5: Transmission Media and Transceivers	1.0 Networking Concepts	1.5 Compare and contrast transmission media and transceivers.
Chapter 6: Network Topologies, Architectures, and Types	1.0 Networking Concepts	1.6 Compare and contrast network topologies, architectures, and types.
Chapter 7: IPv4 Addressing	1.0 Networking Concepts	1.7 Given a scenario, use appropriate IPv4 network addressing.
Chapter 8: Evolving Use Cases	1.0 Networking Concepts	1.8 Summarize evolving use cases for modern network environments.
Chapter 9: Routing Technologies	2.0 Network Implementation	2.1 Explain characteristics of routing technologies.
Chapter 10: Ethernet Switching Technologies	2.0 Network Implementation	2.2 Given a scenario, configure switching technologies and features.
Chapter 11: Configure Wireless Devices and Technologies	2.0 Network Implementation	2.3 Given a scenario, select and configure wireless devices and technologies.
Chapter 12: Physical Installations	2.0 Network Implementation	2.4 Explain important factors of physical installations.
Chapter 13: Organizational Processes and Procedures	3.0 Network Operations	3.1 Explain the purpose of organizational processes and procedures.
Chapter 14: Network Monitoring	3.0 Network Operations	3.2 Given a scenario, use network monitoring technologies.
Chapter 15: Disaster Recovery	3.0 Network Operations	3.3 Explain disaster recovery (DR) concepts.

Chapter	N10-009 Exam Objective	N10-009 Exam Subobjective
Chapter 16: IPv4 and IPv6 Network Services	3.0 Network Operations	3.4 Given a scenario, implement IPv4 and IPv6 network services.
Chapter 17: Network Access and Management Methods	3.0 Network Operations	3.5 Compare and contrast network access and management methods.
Chapter 18: Network Security Concepts	4.0 Network Security	4.1 Explain the importance of basic network security concepts.
Chapter 19: Types of Network Attacks	4.0 Network Security	4.2 Summarize various types of attacks and their impact to the network.
Chapter 20: Network Security Features	4.0 Network Security	4.3 Given a scenario, apply network security features, defense techniques, and solutions.
Chapter 21: A Network Troubleshooting Methodology	5.0 Network Troubleshooting	5.1 Explain the troubleshooting methodology.
Chapter 22: Troubleshoot Common Cabling Problems	5.0 Network Troubleshooting	5.2 Given a scenario, troubleshoot common cabling and physical interface issues.
Chapter 23: Troubleshoot Common Issues with Network Services	5.0 Network Troubleshooting	5.3 Given a scenario, troubleshoot common issues with network services.
Chapter 24: Troubleshoot Common Performance Issues	5.0 Network Troubleshooting	5.4 Given a scenario, troubleshoot common performance issues.
Chapter 25: Network Troubleshooting Tools	5.0 Network Troubleshooting	5.5 Given a scenario, use the appropriate tool or protocol to solve networking issues.

How This Book Is Organized

Although this book could be read cover to cover, it is designed to be flexible and allow you to easily move between chapters and sections of chapters to cover just the material that you need more work with. However, if you do intend to read all the chapters, the order in the book is an excellent sequence to use:

- **Chapter 1: The OSI Model and Encapsulation**—This chapter details the OSI model and its seven layers. This chapter also presents the encapsulation and deencapsulation processes associated with this important model.
- **Chapter 2: Networking Appliances, Applications, and Functions**—This chapter presents commonly used physical and virtual appliances in use in

networks today. This chapter also covers commonly used applications and network functions.

- **Chapter 3: Cloud Concepts**—This chapter covers some of the most important cloud concepts used in modern networking. Just some of the topics covered include deployment models, service models, and cloud connectivity options.
- **Chapter 4: Networking Ports, Protocols, Services, and Traffic Types**—This chapter ensures you are familiar with some of the most popular ports, protocols, and services in use today. This chapter also covers the traffic types of unicast, multicast, anycast, and broadcast.
- **Chapter 5: Transmission Media and Transceivers**—This chapter is all about the wireless and wired connections we make in modern networks. This chapter also covers the transceivers and connector types we often see in our networks today.
- **Chapter 6: Network Topologies, Architectures, and Types**—This chapter covers common network topologies, including mesh, hybrid, hub and spoke, and more. This chapter also covers common traffic flow types found in today's networking environments.
- **Chapter 7: IPv4 Addressing**—This chapter is all about IPv4 addressing. This includes coverage of public versus private IP addressing, subnetting, and the IPv4 address classes.
- **Chapter 8: Evolving Use Cases**—This chapter is all about some of the more cutting-edge technologies appearing in our most modern of networks today. Just some of the technologies that are covered include software-defined networking, Virtual Extensible Local Area Network (VXLAN), and IPv6 addressing.
- **Chapter 9: Routing Technologies**—This chapter tackles technologies that are specific to routing in our networks. This includes such topics as static versus dynamic routing, route selection, address translation, and first hop redundancy protocols.
- **Chapter 10: Ethernet Switching Technologies**—This chapter describes technologies related to switching in today's networks. This includes such topics as VLANs, switch interface configurations, and Spanning Tree Protocol.
- **Chapter 11: Configure Wireless Devices and Technologies**—This chapter examines topics related to Wi-Fi in networks today. This includes topics such as frequency options, network types, encryption, and many more.

- **Chapter 12: Physical Installations**—This chapter examines several important factors you should consider when you are planning and operating physical installations for networking equipment. This chapter includes topics like power and environmental factors.
- **Chapter 13: Organizational Processes and Procedures**—This chapter focuses on the purpose of organizational processes and procedures. Topics like documentation, life-cycle management, change management, and configuration management are all covered.
- **Chapter 14: Network Monitoring**—This chapter presents many different options and methods when it comes to monitoring modern networks. Topics include SNMP, SIEMs, and many more.
- **Chapter 15: Disaster Recovery**—This chapter focuses on disaster recovery (DR) topics. This includes things like DR metrics, DR sites, and high-availability approaches.
- **Chapter 16: IPv4 and IPv6 Network Services**—This chapter presents many examples of popular IPv4 and IPv6 services found in networks today. Topics in this chapter include dynamic addressing options, name resolution services, and time protocols.
- **Chapter 17: Network Access and Management Methods**—This chapter presents various options available today for network access and network management. Topics include VPNs, connection methods, and specific technologies like jump boxes.
- **Chapter 18: Network Security Concepts**—This chapter is a big one. Why? It tackles the hugely important topic of basic network security concepts. Here you will learn about things like logical security, physical security, and common security terminology.
- **Chapter 19: Types of Network Attacks**—What are some of the most common network attacks in use today? This chapter addresses this question head on and covers such topics as DoS and DDoS attacks, social engineering attacks, and many, many more.
- **Chapter 20: Network Security Features**—This chapter covers network security features, defense techniques, and solutions. This includes a discussion of device hardening, network access controls, key management, security rules, and zones.
- **Chapter 21: A Network Troubleshooting Methodology**—This chapter provides guidance on a well-planned and effective troubleshooting methodology. This methodology begins with problem identification and ends with the documentation of findings.

- **Chapter 22: Troubleshoot Common Cabling Problems**—This chapter covers troubleshooting common cabling and physical interface issues. The chapter focuses on three main areas: cable issues, interface issues, and hardware issues.
- **Chapter 23: Troubleshoot Common Issues with Network Services**—This chapter focuses on troubleshooting common issues with network services. This includes the two main areas of switching- and routing-based services.
- **Chapter 24: Troubleshoot Common Performance Issues**—These days, a network that is performing poorly can be nearly as disruptive as a network that is not functioning at all. This chapter guides you through troubleshooting the most common of performance issues. Both wired and wireless networks are discussed.
- **Chapter 25: Network Troubleshooting Tools**—This chapter focuses on the use of network troubleshooting tools that can help you solve common issues. This includes the three main categories of tools: software tools, hardware tools, and basic networking device commands.

Figure Credits

This chapter covers the following topics related to Objective 1.1 (Explain concepts related to the Open Systems Interconnection [OSI] reference model) of the CompTIA Network+ N10-009 certification exam:

- OSI model
  - Layer 1—Physical
  - Layer 2—Data link
  - Layer 3—Network
  - Layer 4—Transport
  - Layer 5—Session
  - Layer 6—Presentation
  - Layer 7—Application

CHAPTER 1

The OSI Model and Encapsulation

Way back in 1977, the International Organization for Standardization (ISO) developed a subcommittee to focus on the interoperability of multivendor communications systems. This is fancy language for getting network "stuff" to communicate with other network "stuff," even if different companies made the network "stuff." What sprang from this subcommittee was the ***Open Systems Interconnection (OSI) reference model*** (also referred to as the *OSI model* or the *OSI stack*). Thanks to this model, you can talk about any networking technology and categorize that technology as residing at one or more of the seven layers of the model.

This chapter defines those seven layers and offers examples of what you might find at each layer. It also contrasts the OSI model with another model—the TCP/IP stack, also known as the Department of Defense (DoD) model—that focuses on Internet Protocol (IP) communications.

Foundation Topics

The Purpose of Reference Models

Throughout this book, various protocols and devices that play a role in your network (and your networking career) are introduced. To better understand how a technology fits in, it helps to have a common point of reference against which various technologies from different vendors can be compared. The OSI model provides us an ideal point of reference for our learning and discovery.

Understanding the OSI model is also very useful in troubleshooting networks. In fact, Chapter 21, "A Network Troubleshooting Methodology," provides some concrete methods for using the OSI model in conjunction with thorough network troubleshooting.

One of the most common ways of categorizing the function of a network technology is to say at what layer (or layers) of the OSI model that technology runs. Understanding how that technology performs a certain function at a certain layer of the OSI model helps you determine whether one device is going to be able to communicate with another device, which might or might not be using a similar technology, at that layer of the OSI reference model.

For example, when your end-user device connects to a web server on the Internet, your service provider assigns your device an IP address. Similarly, the web server to which you are communicating has an IP address. As described in this chapter, an IP address lives at Layer 3 (the network layer) of the OSI model. Because your device and the web server use a common protocol (that is, IP) at Layer 3, they are capable of communicating with one another.

Notice also in this example that you are interested in receiving the data from the web server, which will be web pages filled with text and graphics and maybe even videos. This is the information you are really after. You (typically) do not care about the IP addresses in use or any of the other information required by the network devices to make this transfer happen. In technical terms, you are interested in the *payload* of the packets sent from the web server. The ***payload*** provides a simple and generic method of describing the data itself, which is separate and distinct from any of the other information required for proper transmission.

Personally, I have been in the computer-networking industry since 1996, and I have had the OSI model explained in many classes I have attended and books I have read. From this, I have taken away a collection of metaphors to help describe the operation of the different layers of the OSI model. Some of the metaphors involve sending a letter from one location to another or placing a message in a series of

envelopes. These are often excellent metaphors for encapsulation and decapsulation (covered later in this chapter), but they do not work all that well for the OSI model in general. My favorite way to describe the OSI model is to simply think of it as being analogous to a bookcase, such as the one shown in Figure 1-1.

Figure 1-1 A Bookcase Is Analogous to the OSI Model

If you were to look at this or any other bookcase in my home office, you would see that I have organized diverse types of books on different shelves. One shelf holds my collection of technical books, another shelf holds the books I wrote for Pearson and other publishers, another shelf holds books regarding self-improvement and finance. I have grouped similar books together on each shelf, just as the OSI model groups similar protocols and functions together in a layer.

A common pitfall my readers meet when studying the OSI model is to try to neatly fit all the devices and protocols in their network into one of the OSI model's seven layers. However, not every technology fits perfectly into these layers. In fact, some networks might not have any technologies running at one or more of these layers. This reminds me of my favorite statement about the OSI model. It comes from Rich Seifert's book *The Switch Book*. In that book, Rich reminds us that the OSI model is a *reference* model, not a *reverence* model. That is, no cosmic law states that all technologies must cleanly plug into the model. So, as you discover the characteristics of