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CCNAv7:
Intoduction to Network (ITN)

Companion Guide

Networking Academy
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Introduction to Networks Companion Guide (CCNAv7)

Cisco Networking Academy

Cisco Press

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Published by:
Cisco Press

ScoutAutomatedPrintCode

Library of Congress Control Number: 2020935402

ISBN-13: 978-0-13-663366-2
ISBN-10: 0-13-663366-8

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Contents at a Glance

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Contents

Command Syntax Conventions

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

- **Boldface** indicates commands and keywords that are entered literally as shown. In actual configuration examples and output (not general command syntax), boldface indicates commands that are manually input by the user (such as a **show** command).
- *Italic* indicates arguments for which you supply actual values.
- Vertical bars (|) separate alternative, mutually exclusive elements.
- Square brackets ([ ]) indicate an optional element.
- Braces ({ }) indicate a required choice.
- Braces within brackets ([{ }]) indicate a required choice within an optional element.

Introduction

Introduction to Networks Companion Guide (CCNAv7) is the official supplemental textbook for the Cisco Network Academy CCNA Introduction to Networks Version 7 course. Cisco Networking Academy is a comprehensive program that delivers information technology skills to students around the world. The curriculum emphasizes real-world practical application and provides opportunities to gain the skills and hands-on experience needed to design, install, operate, and maintain networks in small business, medium-sized business as well as enterprise and service provider environments.

This book provides a ready reference that explains the same networking concepts, technologies, protocols, and devices as the online curriculum. This book emphasizes key topics, terms, and activities and provides some alternative explanations and examples to supplement the course. You can use the online curriculum as directed by your instructor and then use this *Companion Guide*'s study tools to help solidify your understanding of all the topics.

Who Should Read This Book

The book, like the course it accompanies, is designed as an introduction to data network technology for those pursuing careers as network professionals as well as those who need an introduction to network technology for professional growth. Topics are presented concisely, starting with the most fundamental concepts and progressing to a comprehensive understanding of network communication. The content of this text provides the foundation for additional Cisco Networking Academy courses and preparation for the CCNA certification.

Book Features

The educational features of this book focus on supporting topic coverage, readability, and practice of the course material to facilitate your full understanding of the course material.

Topic Coverage

The following list gives you a thorough overview of the features provided in each chapter so that you can make constructive use of your study time:

- **Objectives:** Listed at the beginning of each chapter, the objectives reference the core concepts covered in the chapter. The objectives match the objectives stated in the corresponding chapters of the online curriculum; however, the question format in the *Companion Guide* encourages you to think about finding the answers as you read the chapter.

- **Notes:** These are short sidebars that point out interesting facts, timesaving methods, and important safety issues.
- **Summary:** At the end of each chapter is a summary of the chapter's key concepts. It provides a synopsis of the chapter and serves as a study aid.
- **Practice:** At the end of chapter is a full list of all the labs, class activities, and Packet Tracer activities to refer to at study time.

Readability

The following features are provided to help you understand networking vocabulary:

- **Key terms:** Each chapter begins with a list of key terms, along with a page-number reference to find the term used inside the chapter. The terms are listed in the order in which they are explained in the chapter. This handy reference allows you to find a term, flip to the page where the term appears, and see the term used in context. The Key Terms Glossary defines all the key terms.
- **Key Terms Glossary:** This book contains an all-new Key Terms Glossary that defines more than 1000 terms.

Practice

Practice makes perfect. This *Companion Guide* offers you ample opportunities to put what you learn into practice. You will find the following features valuable and effective in reinforcing the instruction that you receive:

- **Check Your Understanding questions and answer key:** Review questions are presented at the end of each chapter as a self-assessment tool. These questions match the style of questions in the online course. Appendix A, "Answers to 'Check Your Understanding' Questions," provides an answer key to all the questions and includes an explanation of each answer.

Interactive Graphic

- **Labs and activities:** Throughout each chapter, you are directed back to the online course to take advantage of the activities provided to reinforce concepts. In addition, at the end of each chapter is a "Practice" section that lists all the labs and activities to provide practice with the topics introduced in this chapter.

Video

- **Page references to online course:** After most headings is a number in parentheses—for example, (1.1.2). This number refers to the page number in the online course so that you can easily jump to that spot online to view a video, practice an activity, perform a lab, or review a topic.

About Packet Tracer Software and Activities

Packet Tracer Activity

Interspersed throughout the chapters, you'll find a few Cisco Packet Tracer activities. Packet Tracer allows you to create networks, visualize how packets flow in a network, and use basic testing tools to determine whether a network would work. When you see this icon, you can use Packet Tracer with the listed file to perform a task suggested in this book. The activity files are available in the online course. Packet Tracer software is available only through the Cisco Networking Academy website. Ask your instructor for access to Packet Tracer.

How This Book Is Organized

This book corresponds closely to the Cisco Networking Academy CCNA IT Essential v7 course and is divided into 17 chapters, one appendix, and a glossary of key terms:

- **Chapter 1, "Networking Today":** This chapter introduces the concept of a network and provides an overview of the different types of networks encountered. It examines how networks impact the way we work, learn, and play. This chapter also examines recent trends in networks, such as video, cloud computing, and BYOD and how to help ensure robust, reliable, secure networks to support these trends.
- **Chapter 2, "Basic Switch and End Device Configuration":** This chapter introduces the operating system used with most Cisco devices: Cisco IOS. The basic purpose and functions of IOS are described, as are methods to access IOS. The chapter also describes how to maneuver through the IOS command-line interface as well as basic IOS device configuration.
- **Chapter 3, "Protocols and Models":** This chapter examines the importance of rules or protocols for network communication. It explores the OSI reference model and the TCP/IP communication suite and examines how these models provide the necessary protocols to allow communication to occur on a modern converged network.
- **Chapter 4, "Physical Layer":** This chapter introduces the lowest layer of the OSI model: the physical layer. This chapter explains the transmission of bits over the physical medium.
- **Chapter 5, "Number Systems":** This chapter explains how to convert between decimal, binary, and hexadecimal number systems. Understanding these number systems is essential to understanding IPv4, IPv6, and Ethernet MAC addressing.

- **Chapter 6, "Data Link Layer":** This chapter discusses how the data link layer prepares network layer packets for transmission, controls access to the physical media, and transports data across various media. This chapter includes a description of the encapsulation protocols and processes that occur as data travels across the LAN and the WAN.
- **Chapter 7, "Ethernet Switching":** This chapter examines the functionality of the Ethernet LAN protocols. It explores how Ethernet functions, including how devices use Ethernet MAC addresses to communicate in a multiaccess network. The chapter discusses how Ethernet switches build MAC address tables and forward Ethernet frames.
- **Chapter 8, "Network Layer":** This chapter introduces the function of the network layer—routing—and the basic device that performs this function—the router. It presents important routing concepts related to addressing, path determination, and data packets for both IPv4 and IPv6. The chapter also introduces how routers perform packet forwarding, static and dynamic routing, and the IP routing table.
- **Chapter 9, "Address Resolution":** This chapter discusses how host computers and other end devices determine the Ethernet MAC address for a known IPv4 or IPv6 address. This chapter examines the ARP protocol for IPv4 address resolution and the Neighbor Discovery Protocol for IPv6.
- **Chapter 10, "Basic Router Configuration":** This chapter explains how to configure a Cisco router, including IPv4 and IPv6 addressing on an interface.
- **Chapter 11, "IPv4 Addressing":** This chapter focuses on IPv4 network addressing, including the types of addresses and address assignment. It describes how to use subnet masks to determine the number of subnetworks and hosts in a network. It examines how to improve network performance by optimally dividing the IPv4 address space based on network requirements. It explores the calculation of valid host addresses and the determination of both subnet and broadcast addresses.
- **Chapter 12, "IPv6 Addressing":** This chapter focuses on IPv6 network addressing, including IPv6 address representation, types of addresses, and the structure of different types of IPv6 address. The chapter introduces the different methods that an end device can receive an IPv6 address automatically.
- **Chapter 13, "ICMP":** This chapter introduces Internet Control Message Protocol (ICMP) tools, such as **ping** and **trace**.

- **Chapter 14, "Transport Layer":** This chapter introduces Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) and examines how each of these protocols transports information across the network. It explores how TCP uses segmentation, the three-way handshake, and expectational acknowledg ments to ensure reliable delivery of data. It also examines the best-effort delivery mechanism provided by UDP and describes when its use would be preferred over the use of TCP.
- **Chapter 15, "Application Layer":** This chapter introduces some protocols of the TCP/IP application layer, which also relates to the top three layers of the OSI model. The chapter focuses on the role of the application layer and how the applications, services, and protocols in the application layer make robust communication across data networks possible. This will be demonstrated by examining some key protocols and services, including HTTP, HTTPS, DNS, DHCP, SMTP/POP, and FTP.
- **Chapter 16, "Network Security Fundamentals":** This chapter introduces network security threats and vulnerabilities. Various network attacks and mitigation techniques are discussed, along with how to secure network devices.
- **Chapter 17, "Build a Small Network":** This chapter reexamines the various components in a small network and describes how they work together to allow network growth. It examines network configuration and troubleshooting issues, along with different troubleshooting methodologies.
- **Appendix A, "Answers to 'Check Your Understanding' Questions":** This appendix lists the answers to the "Check Your Understanding" review questions that are included at the end of each chapter.
- **Key Terms Glossary:** The Key Terms Glossary provides definitions for all the key terms identified in each chapter.

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CHAPTER 1

Networking Today

Objectives

Upon completion of this chapter, you will be able to answer the following questions:

- How do networks affect our daily lives?
- How are host and network devices used?
- What are network representations, and how are they used in network topologies?
- What are the characteristics of common types of networks?
- How do LANs and WANs interconnect to the internet?
- What are the four basic requirements of a reliable network?
- How do trends such as BYOD, online collaboration, video, and cloud computing change the way we interact?
- What are some basic security threats and solutions for all networks?
- What employment opportunities are available in the networking field?

Key Terms

This chapter uses the following key terms. You can find the definitions in the glossary at the end of the book.

server page 4

client page 4

end device page 6

intermediary device page 6

topology page 10

small office and home office (SOHO) networks page 12

local-area networks (LANs) page 13

wide-area networks (WANs) page 13

internet page 15

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internet service provider (ISP) page 17

digital subscriber line (DSL) page 18

cellular connection page 18

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dialup telephone connection page 19

converged data network page 21

fault-tolerant network page 24

scalable network page 24

quality of service (QoS) page 25

Introduction (1.0)

Congratulations! This chapter starts you on your path to a successful career in information technology by giving you a foundational understanding of the creation, operation, and maintenance of networks. As a bonus, you get to dive into networking simulations using Packet Tracer. We promise you will really enjoy it!

Networks Affect Our Lives (1.1)

Networks are all around us. They provide us with a way to communicate and share information and resources with individuals in the same location or around the world. Networks require an extensive array of technologies and procedures that can readily adapt to varying conditions and requirements.

Networks Connect Us (1.1.1)

Among all of the essentials for human existence, the need to interact with others ranks just below our need to sustain life. Communication is almost as important to us as our reliance on air, water, food, and shelter.

In today's world, through the use of networks, we are connected as never before. People with ideas can communicate instantly with others to make those ideas reality. News events and discoveries are known worldwide in seconds. Individuals can even connect and play games with friends physically separated by oceans and continents.

Video

Video—The Cisco Networking Academy Learning Experience (1.1.2)

World changers aren't born. They are made. Since 1997 Cisco Networking Academy has been working toward a single goal: educating and building the skills of the next generation of talent required for the digital economy. Refer to the online course to view this video.

No Boundaries (1.1.3)

Advancements in networking technologies are perhaps the most significant changes in the world today. They are helping to create a world in which national borders, geographic distances, and physical limitations become less relevant and present ever-diminishing obstacles.

The internet has changed the manner in which our social, commercial, political, and personal interactions occur. The immediate nature of communications over the internet encourages the creation of global communities. Global communities allow for social interaction that is independent of location or time zone.

The creation of online communities for the exchange of ideas and information has the potential to increase productivity opportunities around the globe.

The cloud lets us store documents and pictures and access them anywhere, anytime. So whether we are on a train, in a park, or standing on top of a mountain, we can seamlessly access our cloud-stored data and applications on any device.

Network Components (1.2)

Many different components are required to enable a network to provide services and resources. These various components work together to ensure that resources are delivered in an efficient manner to those requiring the services.

Host Roles (1.2.1)

If you want to be part of a global online community, your computer, tablet, or smartphone must first be connected to a network. That network must be connected to the internet. This section discusses the parts of a network. See if you recognize these components in your own home or school network!

Any computer that is connected to a network and that participates directly in network communication is classified as a host. Hosts can be called end devices. Some hosts are also called clients. However, the term *host* specifically refers to a device on a network that is assigned a number for communication purposes. This number, which identifies the host within the particular network, is called the Internet Protocol (IP) address. An IP address identifies the host and the network to which the host is attached.

Servers are computers with software that allows them to provide information, such as email or web pages, to other end devices on the network. Each service requires separate server software. For example, a server requires web server software in order to provide web services to the network. A computer with server software can simultaneously provide services to many different clients.

As mentioned earlier, a client is a type of host. *Clients* have software for requesting and displaying the information obtained from the server, as shown in Figure 1-1.

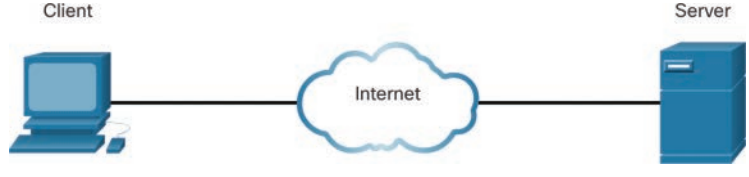

Figure 1-1 A Client and a Server

An example of client software is a web browser, such as Chrome or Firefox. A single computer can also run multiple types of client software. For example, a user can

check email and view a web page while instant messaging and listening to an audio stream. Table 1-1 lists three common types of server software.

Table 1-1 Common Server Software

Software Type	Description
Email	An email server runs email server software. Clients use mail client software, such as Microsoft Outlook, to access email on the server.
Web	A web server runs web server software. Clients use browser software, such as Windows Internet Explorer, to access web pages on the server.
File	A file server stores corporate and user files in a central location. The client devices access these files with client software such as Windows File Explorer.

Peer-to-Peer (1.2.2)

Client and server software usually run on separate computers, but it is also possible for one computer to be used for both roles at the same time. In small businesses and homes, many computers function as both servers and clients on the network. This type of network, called a peer-to-peer network, is shown in Figure 1-2.

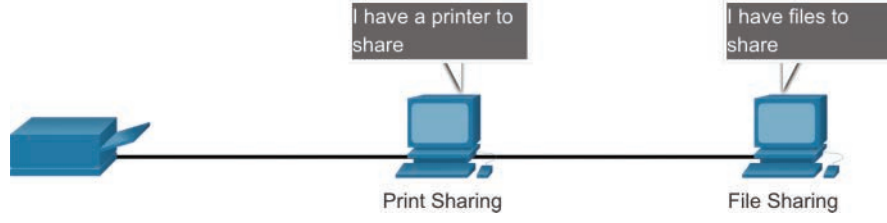

Figure 1-2 Peer-to-Peer Network

Table 1-2 outlines the advantages and disadvantages of peer-to-peer networking.

Table 1-2 Peer-to-Peer Networking Advantages and Disadvantages

Advantages	Disadvantages
Easy to set up	No centralized administration
Less complex	Not as secure
Lower cost because network devices and dedicated servers may not be required	Not scalable
Can be used for simple tasks such as transferring files and sharing printers	All devices may act as both clients and servers, which can slow their performance

End Devices (1.2.3)

The network devices that people are most familiar with are end devices. To distinguish one end device from another, each end device on a network has an address. When an *end device* initiates communication, it uses the address of the destination end device to specify where to deliver the message.

An end device is either the source or destination of a message transmitted over the network, as shown in Figure 1-3.

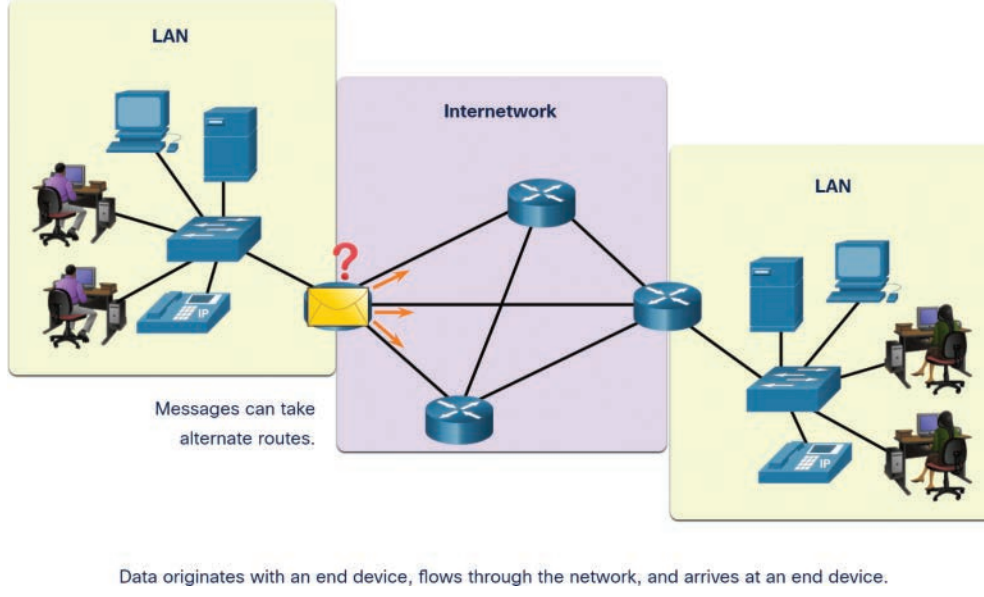

Figure 1-3 Data Flow Through a Network

Intermediary Devices (1.2.4)

Intermediary devices connect individual end devices to a network. They can connect multiple individual networks to form an internetwork. These intermediary devices provide connectivity and ensure that data flows across the network.

Intermediary devices use the destination end device address, in conjunction with information about the network interconnections, to determine the path that messages should take through the network. Figure 1-4 shows examples of the most common intermediary devices.

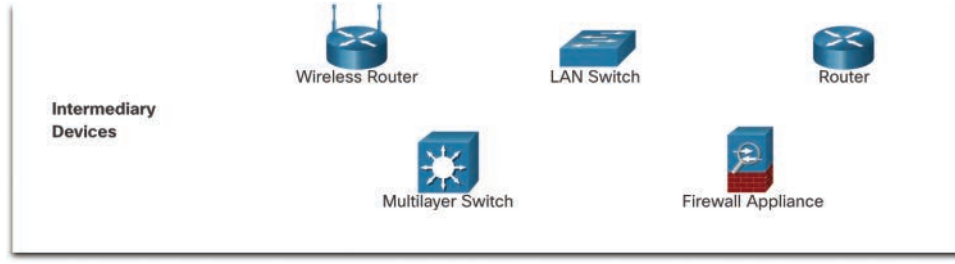

Figure 1-4 Intermediary Devices

Intermediary network devices perform some or all of these functions:

- Regenerate and retransmit communication signals
- Maintain information about what pathways exist through the network and internetwork
- Notify other devices about errors and communication failures
- Direct data along alternate pathways when there is a link failure
- Classify and direct messages according to priorities
- Permit or deny the flow of data, based on security settings

Note

Figure 1-4 does not show any legacy Ethernet hubs. An Ethernet hub is also known as a multiport repeater. Repeaters regenerate and retransmit communication signals. Notice that every intermediary device performs the function of a repeater.

Network Media (1.2.5)

Communication transmits across a network on media. The media provide the channel over which a message travels from source to destination.

Modern networks primarily use three types of media to interconnect devices, as shown in Figure 1-5:

- **Metal wires within cables:** Data is encoded into electrical impulses.
- **Glass or plastic fibers within cables (fiber-optic cable):** Data is encoded into pulses of light.
- **Wireless transmission:** Data is encoded via modulation of specific frequencies of electromagnetic waves.

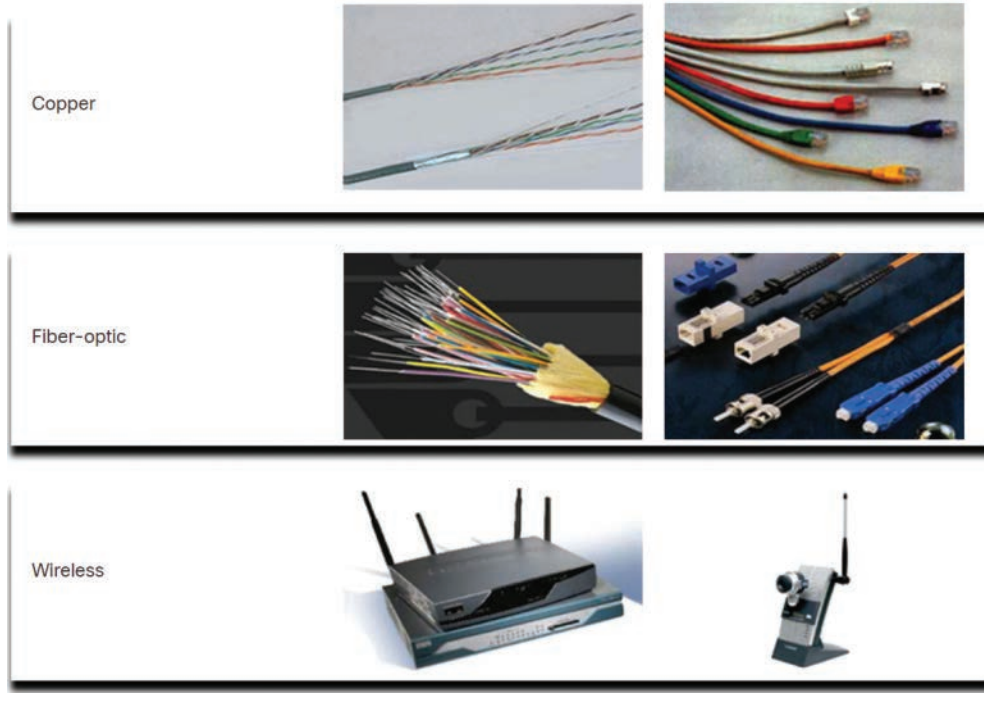

Figure 1-5 Network Media

Different types of network media have different features and benefits. Not all network media have the same characteristics, and they are not all appropriate for the same purpose.

Interactive Graphic

Check Your Understanding—Network Components (1.2.6)

Refer to the online course to complete this activity.

Network Representations and Topologies (1.3)

A network's infrastructure is documented using commonly used symbols to represent devices and different types of diagrams to represent the interconnection of these devices in the network. Understanding these symbols and diagrams is an important aspect of understanding network communications.

Network Representations (1.3.1)

Network architects and administrators must be able to show what their networks look like. They need to be able to easily see which components connect to other components, where they are located, and how they are connected. Diagrams of networks

often use symbols, like those shown in Figure 1-6, to represent the different devices and connections in a network.

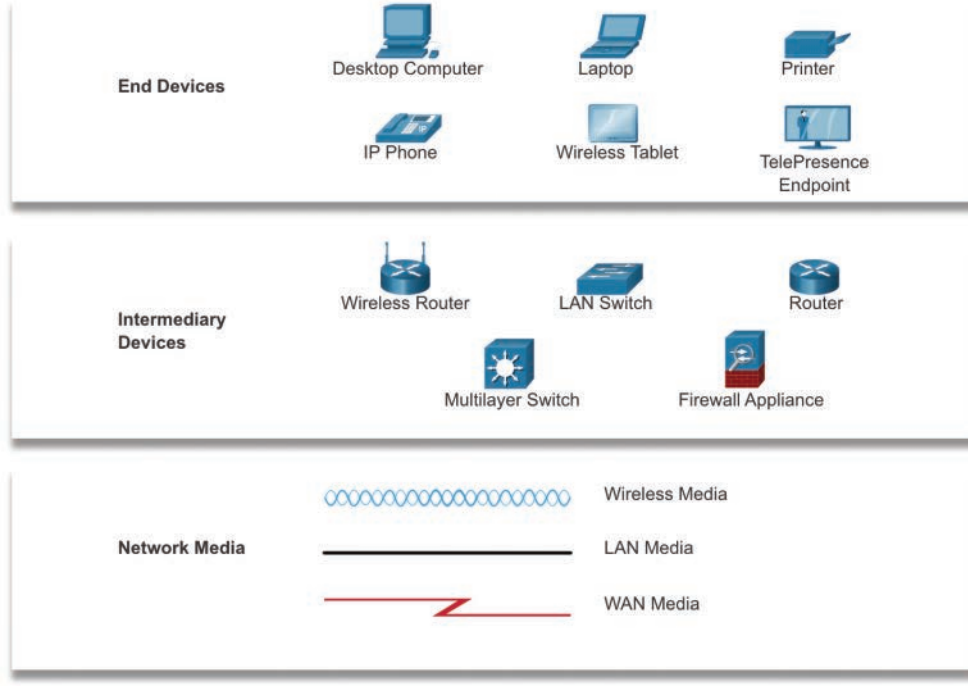

Figure 1-6 Network Symbols for Topology Diagrams

A diagram provides an easy way to understand how devices connect in a network. This type of "picture" of a network is known as a *topology diagram*. The ability to recognize the logical representations of the physical networking components is critical to being able to visualize the organization and operation of a network.

In addition to these representations, specialized terminology is used to describe how each of these devices and media connect to each other:

- **Network interface card (NIC):** A NIC physically connects an end device to a network.
- **Physical port:** A port is a connector or an outlet on a networking device where a medium connects to an end device or another networking device.
- **Interface:** An interface is a specialized port on a networking device that connects to a network. Because routers connect networks, the ports on a router are referred to as *network interfaces*.