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EMMETT DULANEY

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Emmett Dulaney

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About the Author

Emmett Dulaney (CompTIA Network+, Cloud+, Security+, A+, and others) has been the author of several books on certifications and operating systems over the past 25 years. He is a columnist for *Certification Magazine* and a professor at a small university in Indiana. He is currently the editor of a journal devoted to business education (and the business of education).

Dedication

For Harrison, Teresea, Wolfgang, and Elijah: never stop networking

—Emmett Dulaney

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Thanks are due to Eleanor (Ellie) Bru for working on this title once more and making it as strong as it can be. An enormous amount of credit for this book always goes to Chris Crayton, who goes above and beyond what is expected and without whom the resulting text would only be a shadow of what it is. It is an honor to work with him. Thanks continue to be due to Mike Harwood, who wrote the first few editions, and to the team of talented individuals at Pearson who work behind the scenes and make each title the best it can be.

About the Technical Reviewer

Chris Crayton, MCSE, CISSP, CASP+, PenTest+, Project+, CySA+, Cloud+, S+, N+, A+, ITF+ 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 served as technical editor and content contributor on numerous technical titles for several of the leading publishing companies. He has also been recognized with many professional and teaching awards, and has served as a state-level SkillsUSA final competition judge.

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Introduction

Welcome to *CompTIA Network+ N10-009 Exam Cram*. This book is designed to prepare you to take—and pass—the CompTIA Network+ exam. The Network+ exam has become the leading introductory-level network certification available today. It is recognized by both employers and industry giants as providing candidates with a solid foundation of networking concepts, terminology, and skills. The Network+ exam covers a broad range of networking concepts to prepare candidates for the technologies they are likely to work with in today's network environments.

About Network+ Exam Cram

Exam Crams are designed to give you the information you need to know to prepare for a certification exam. They cut through the extra information, focusing on the areas you need to get through the exam. With this in mind, the elements within the Exam Cram titles are aimed at providing the exam information you need in the most succinct and accessible manner.

In this light, this book is organized to closely follow the actual CompTIA objectives for exam N10-009. As such, it is easy to find the information required for each of the specified CompTIA Network+ objectives. The objective focus design used by this Exam Cram is an important feature because the information you need to know is easily identifiable and accessible. To see what we mean, compare the CompTIA objectives to the book's layout, and you can see that the facts are right where you would expect them to be.

Within the chapters, potential exam hotspots are clearly highlighted with Exam Alerts. They have been carefully placed to let you know that the surrounding discussion is an important area for the exam. To further help you prepare for the exam, a Cram Sheet is included that you can use in the final stages of test preparation. Be sure to pay close attention to the bulleted points on the Cram Sheet because they pinpoint the technologies and facts you probably will encounter on the test.

Finally, great effort has gone into the questions that appear throughout the chapter and the practice tests to ensure that they accurately represent the look and feel of the ones you will see on the real Network+ exam. Be sure, before taking the exam, that you are comfortable with both the format and content of the questions provided in this book.

About the Network+ Exam

The Network+ (N10-009 Edition) exam is the newest iteration of several versions of the exam. The new Network+ objectives are aimed toward those who have at least 9 to 12 months of experience in the IT networking field. While it is helpful if Network+ candidates have A+ certification (or its equivalent), it is not required, and this should not discourage those who do not.

You will have a maximum of 90 minutes to answer the 90 questions on the exam. The allotted time is quite generous, so when you finish, you probably will have time to double-check a few of the answers you were unsure of.

By the time the dust settles, you need a minimum score of 720 to pass the Network+ exam. This is on a scale of 100 to 900. For more information on the specifics of the Network+ exam, refer to CompTIA's main website at http://certification.comptia.org/.

CompTIA Network+ Exam Topics

Table I-1 lists general exam topics (that is, objectives) and specific topics under each general topic (that is, subobjectives) for the CompTIA Network+ N10-009 exam. This table also lists the chapter in which each exam topic is covered.

TABLE I-1 **CompTIA Network+ Exam Topics**

Chapter	N10-009 Exam Objective	N10-009 Exam Subobjective
1 (Networking Models, Ports, Protocols, and Services)	1.0 Networking Concepts	1.1 Explain concepts related to the Open Systems Interconnection (OSI) reference model. 1.4. Explain common networking ports, protocols, services, and traffic types.
2 (Network Topologies, Architectures, and Types)	1.0 Networking Concepts	1.6 Compare and contrast network topologies, architectures, and types.
3 (Network Addressing, Routing, and Switching)	1.0 Networking Concepts 2.0 Network Implementation 3.0 Network Operations	1.7 Given a scenario, use appropriate IPv4 network addressing. 2.1 Explain characteristics of routing technologies. 2.2 Given a scenario, configure switching technologies and features. 3.4 Given a scenario, implement IPv4 and IPv6 network services.

Chapter	N10-009 Exam Objective	N10-009 Exam Subobjective
4 (Network Implementations)	1.0 Networking Concepts	1.2 Compare and contrast networking appliances, applications, and functions. 1.8 Summarize evolving use cases for modern network environments.
5 (Cabling Solutions and Issues)	1.0 Networking Concepts 5.0 Network Troubleshooting	1.5 Compare and contrast transmission media and transceivers. 5.2 Given a scenario, troubleshoot common cabling and physical interface issues.
6 (Wireless Solutions)	2.0 Network Implementation	2.3 Given a scenario, select and configure wireless devices and technologies.
7 (Cloud Computing Concepts and Options)	1.0 Networking Concepts	1.3 Summarize cloud concepts and connectivity options.
8 (Network Operations)	2.0 Network Implementation 3.0 Network Operations	2.4 Explain important factors of physical installations. 3.1 Explain the purpose of organizational processes and procedures. 3.2 Given a scenario, use network monitoring technologies. 3.3 Explain disaster recovery (DR) concepts. 3.5 Compare and contrast network access and management methods.
9 (Network Security)	4.0 Network Security	4.1 Explain the importance of basic network security concepts. 4.2 Summarize various types of attacks and their impact to the network. 4.3 Given a scenario, apply network security features, defense techniques, and solutions.
10 (Network Troubleshooting)	5.0 Network Troubleshooting	5.1 Explain the troubleshooting methodology. 5.3 Given a scenario, troubleshoot common issues with network services. 5.4 Given a scenario, troubleshoot common performance issues. 5.5 Given a scenario, use the appropriate tool or protocol to solve networking issues.

Booking and Taking the Network+ Certification Exam

Unfortunately, testing is not free. You're charged for each test you take, whether you pass or fail. In the United States and Canada, tests are administered by Pearson VUE testing services. To access the VUE contact information and book an exam, refer to the website at http://www.pearsonvue.com or call 1-877-551-7587. When booking an exam, you need to provide the following information:

- Your name as you would like it to appear on your certificate.
- Your Social Security or Social Insurance number.
- Contact phone numbers (to be called in case of a problem).
- Mailing address, which identifies the address to which you want your certificate mailed.
- Exam number and title.
- Email address for contact purposes. This often is the fastest and most effective means to contact you. Test vendors require it for registration.
- Credit card information so that you can pay online. You can redeem vouchers by calling the respective testing center.

What to Expect from the Exam

If you haven't taken a certification test, the process can be a little unnerving. Even if you've taken numerous tests, it is not much better. Mastering the inner mental game often can be as much of a battle as knowing the material. Knowing what to expect before heading in can make the process a little more comfortable.

Certification tests are administered on a computer system at a VUE authorized testing center. The format of the exams is straightforward: each question has several possible answers to choose from. The questions in this book provide a good example of the types of questions you can expect on the exam. If you are comfortable with them, the test should hold few surprises. Many of the questions vary in length. Some of them are longer scenario questions, whereas others are short and to the point. Carefully read the questions; the longer questions often have a key point that will lead you to the correct answer.

Most of the questions on the Network+ exam require you to choose a single correct answer, but a few require multiple answers. When there are multiple

correct answers, a message at the bottom of the screen prompts you to "Choose all that apply." Be sure to read these messages.

A Few Exam-Day Details

It is recommended that you arrive at the examination room at least 15 minutes early, although a few minutes earlier certainly would not hurt. This will give you time to prepare and will give the test administrator time to answer any questions you might have before the test begins. Many people suggest that you review the most critical information about the test you're taking just before the test. (Exam Cram books provide a reference—the Cram Sheet, located inside the front of this book—that lists the essential information from the book in distilled form.) Arriving a few minutes early will give you some time to compose yourself and mentally review this critical information.

You will be asked to provide two forms of ID, one of which must be a photo ID. Both of the identifications you choose should have a signature. You also might need to sign in when you arrive and sign out when you leave.

Be warned: The rules are clear about what you can and cannot take into the examination room. Books, laptops, note sheets, and so on are not allowed in the examination room. The test administrator will hold these items, to be returned after you complete the exam. You might receive either a wipe board or a pen and a single piece of paper for making notes during the exam. The test administrator will ensure that no paper is removed from the examination room.

After the Test

Whether you want it or not, as soon as you finish your test, your score displays on the computer screen. In addition to the results appearing on the computer screen, a hard copy of the report prints for you. Like the onscreen report, the hard copy displays the results of your exam and provides a summary of how you did on each section and on each technology. If you were unsuccessful, this summary can help you determine the areas you need to brush up on.

Last-Minute Exam Tips

Studying for a certification exam is no different than studying for any other exam, but a few hints and tips can give you the edge on exam day:

- **Read all the material:** CompTIA has been known to include material not expressly specified in the objectives. This book has included additional

information not reflected in the objectives to give you the best possible preparation for the examination.

- **Watch for the Exam Tips and Notes:** The Network+ objectives include a wide range of technologies. ExamAlerts, Tips, and Notes found throughout each chapter are designed to pull out exam-related hotspots. These can be your best friends when preparing for the exam.
- **Use the questions to assess your knowledge:** Don't just read the chapter content; use the exam questions to find out what you know and what you don't. If you struggle, study some more, review, and then assess your knowledge again.
- **Review the exam objectives:** Develop your own questions and examples for each topic listed. If you can develop and answer several questions for each topic, you should not find it difficult to pass the exam.

Good luck!

Companion Website

Register this book to get access to the Pearson Test Prep practice test software and other study materials plus additional bonus content. Check this site regularly for new and updated postings written by the author that provide further insight into the more troublesome topics on the exams. Be sure to check the box that you would like to hear from us to receive updates and exclusive discounts on future editions of this product or related products.

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2. Enter the ISBN: 9780135340837.
3. Answer the challenge question as proof of purchase.
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Please note that many of our companion content files can be very large, especially image and video files.

If you are unable to locate the files for this title by following these steps, please visit www.pearsonITcertification.com/contact and select the Site Problems/ Comments option. Our customer service representatives will assist you.

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 accessing the registration code that comes with the book. You can access the code in these ways:

- You can get your access code by registering the print ISBN 9780135340837 on https://www.pearsonitcertification.com/register. Make sure to use the print book ISBN, regardless of whether you purchased an eBook or the print book. After 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.
- 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 https://www.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 on the first page of the book.

Step 2. Click the Practice Exams button.

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

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

Customizing Your Exams

After 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 because 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 will not provide the detailed score reports that the other two modes will, so it should not be used 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 the chapters, or you can narrow your selection to 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, first deselect all the chapters; then select only those on which you want 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. The two exams printed in the book are available to you as well as two additional exams of unique questions. You can have the test engine serve up exams from all four banks or just from one individual bank by selecting the desired banks in the exam bank area.

You can make several other customizations to your exam from the exam settings screen, such as the time of the exam, the number of questions, whether to randomize questions and answers, whether to show the number of correct answers for multiple answer questions, or 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, it will check to see if there are any updates to your exam data and automatically download any changes that were made since the last time you used the software. This requires that you are connected to the Internet at the time you launch 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, select the **Tools** tab and then click the **Update Products** button. Again, this is an issue only with the desktop Windows application.

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

Assessing Exam Readiness

Exam candidates never really know whether they are adequately prepared for the exam until they have completed about 30 percent of the questions. At that point, if you are not prepared, it is too late. The best way to determine your readiness is to work through the CramSaver quizzes at the beginning of each chapter and review the exam objectives and ExamAlerts presented in each chapter. It is best to work your way through the entire book unless you can complete each subject without having to do any research or look up any answers.

Figure Credits

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Chapter 10, Cram Quiz under “Troubleshooting Common Networking Issues,” screenshot of Internet Protocol Vertion 4 (TCP/IPv4) Properties: Microsoft Corporation

CHAPTER 2

Network Topologies, Architectures, and Types

This chapter covers the following official Network+ objective:

- 1.6 Compare and contrast network topologies, architectures, and types.

For more information on the official CompTIA Network+ exam topics, see the "About the Network+ Exam" section in the Introduction.

A variety of physical and logical network layouts are in use today. As a network administrator, you might find yourself working on these different network layouts or topologies. Therefore, you must understand how they are designed to function.

This chapter reviews general network considerations, such as the various topologies used on today's networks, *local-area networks* (LANs), and *wide-area networks* (WANs).

Network Topologies

▶ **1.6 Compare and contrast network topologies, architectures, and types.**

CramSaver

If you can correctly answer these questions before going through this section, save time by skimming the ExamAlerts in this section and then completing the Cram Quiz at the end of the section.

1. Which topology is commonly known as a hub and spoke model?
2. With which topology does every node have a direct connection to every other node?
3. True or false: Traffic flows entering and leaving a datacenter are known as East-West traffic.
4. True or false: In the three-tier hierarchical model, the access/edge layer ensures data is delivered to edge/end devices.

Answers

1. The star topology is commonly known as a hub and spoke model as it utilizes a centralized switch, or hub, and devices extend from it.
2. With a mesh topology, every node has a direct connection to every other node.
3. False. Traffic flows entering and leaving a datacenter are known as North-South traffic. East-West traffic refers to network traffic that flows within a datacenter between servers.
4. True. In the three-tier hierarchical model, the access/edge layer is the place where switches connect to and ensure data is delivered to edge/end devices.

A *topology* refers to a network's physical and logical layout. A network's *physical topology* refers to the actual layout of the computer cables and other network devices. A network's *logical topology* refers to the way in which the network appears to the devices that use it. Network topology diagrams are used to identify network components and how they are physically or logically connected.

Several topologies are in use on networks today. Some of the more common topologies are the star/hub and spoke, mesh, and hybrid models. The following sections provide an overview of each as well as look at some older topologies you may encounter.

Star/Hub and Spoke

In the *star topology*, all computers and other network devices connect to a central device called a *hub* or *switch* and, for that reason, it is also called a *hub and spoke network*. Each connected device requires a single cable to be connected to the hub or switch, creating a point-to-point connection between the device and the hub or switch.

Using a separate cable to connect to the hub or switch allows the network to be expanded without disruption. A break in any single cable does not cause the entire network to fail. Figure 2.1 shows a star/hub and spoke topology.

ExamAlert

Among the network topologies discussed in this chapter, the star topology is the easiest to expand in terms of the number of devices connected to the network.

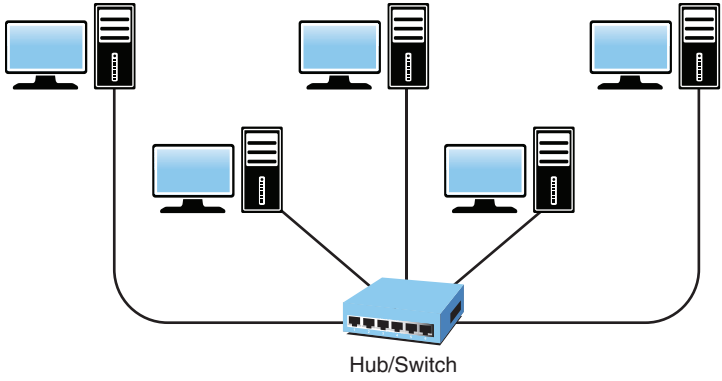

FIGURE 2.1 **Star/Hub and Spoke Topology**

The star/hub and spoke topology is the most widely implemented network design in use today, but it is not without shortcomings. Because all devices connect to a centralized hub or switch, this creates a single point of failure for the network. If the hub or switch fails, any device connected to it cannot access the network. Because of the number of cables required and the need for network devices, the cost of a star/hub and spoke network is often higher than other topologies. Table 2.1 summarizes the advantages and disadvantages of the star/hub and spoke topology.

TABLE 2.1 **Advantages and Disadvantages of the Star/Hub and Spoke Topology**

Advantages	Disadvantages
Star/hub and spoke networks are easily expanded without disruption to the network.	This topology requires more cable than most of the other topologies.
Cable failure affects only a single user.	A central connecting device allows for a single point of failure.
It is easy to troubleshoot and implement.	It requires additional networking equipment to create the network layout.

Mesh Topology

When it comes to the *mesh topology*, it is helpful to differentiate between a wired and wireless implementation, so we focus on the former here and the latter in Chapter 6, "Wireless Solutions." Mesh incorporates a unique network design in which each computer on the network connects to every other, creating a point-to-point connection between every device on the network. Since this is often done physically, the term *wired mesh* or *wired mesh topology* is sometimes used. The purpose of the mesh design is to provide a high level of *redundancy*. If one network cable fails, the data always has an alternative path to get to its destination; each node can act as a relay.

The wiring for a mesh network can be complicated, as illustrated by Figure 2.2. Furthermore, the cabling costs associated with the mesh topology can be high, and troubleshooting a failed cable can be tricky. As a result, the mesh topology is not the first choice for many wired networks but is more popular with servers/routers.

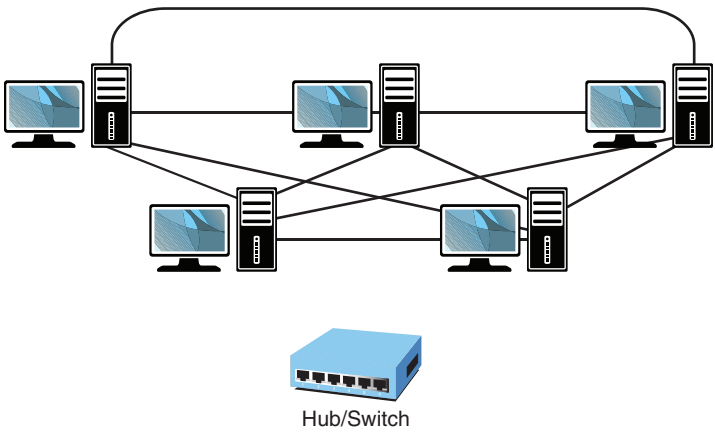

FIGURE 2.2 **Mesh Topology**

Table 2.2 summarizes the advantages and disadvantages of the mesh topology.

ExamAlert

Because of the redundant connections, the mesh topology offers better fault tolerance than other topologies.

Note

Fault tolerance is a process or capability of a network or system to continue working after there is a problem. It refers to a network or system's ability to continue operating after a malfunction or failure.

TABLE 2.2 **Advantages and Disadvantages of the Mesh Topology**

Advantages	Disadvantages
Mesh provides redundant paths between LAN topologies.	It requires more cable than the other topologies.
The network can be expanded without disruption to current users.	The implementation is complicated.

Hybrid Topology

A variation on a true mesh topology is the *hybrid* or *hybrid mesh*. It creates a redundant point-to-point network connection between only specific network devices (such as the servers). The hybrid mesh is most often seen in WAN implementations but can be used in any network.

Another way of describing the degree of mesh implementation is by labeling it as either *partial* or *full*. If it is a true mesh network with connections between each device, it can be labeled full mesh, and if it is less than that—a hybrid of any sort—it is called a *partial mesh network*.

Many of the topologies found in large networking environments are a hybrid of physical topologies. An example of a hybrid topology is the star/hub and spoke bus—a combination of the star/hub and spoke topology and the bus topology (explored further later in this chapter). Figure 2.3 shows how this might look in a network implementation.

ExamAlert

Another meaning: The term *hybrid topology* also can refer to the combination of wireless and wired networks. For the Network+ exam, however, the term *hybrid* most likely refers to the combination of physical networks.

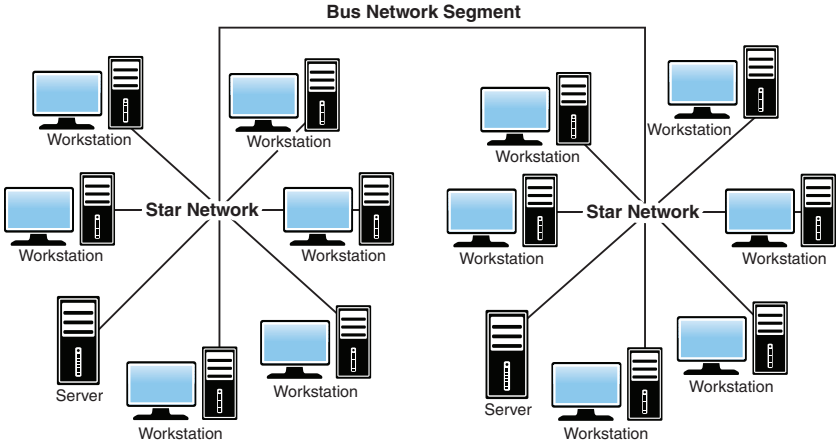

FIGURE 2.3 **A Star/Hub and Spoke Bus Topology**

Point to Point

A *point to point* (often written with hyphens: *point-to-point*) networking topology is a network configuration where two devices or nodes are directly connected to each other. In this topology, there is a dedicated communication link between the two endpoints, and data flows directly between them without the involvement of any intermediary devices. While the distinction can be nitpicky, mesh and star/hub and spoke networks are used to connect multiple devices to a network, while point-to-point topology is used to connect two devices.

It might not be the ideal choice for larger, more complex networks. In such cases, more scalable and flexible topologies like star/hub and spoke or mesh networks are typically preferred, since they can accommodate multiple devices and provide greater redundancy and fault tolerance.

> **Note**
>
> More information on point to point, as it relates to wireless networking, is provided in Chapter 6.

Spine and Leaf

Tiered models of computer network architecture are a way of organizing and structuring a network infrastructure into distinct layers (or *tiers*), each with specific functions and responsibilities. These models help simplify network design, management, and scalability.

A two-tier model that Cisco promotes for switches is the *spine and leaf* model. In this model, the spine is the *backbone* of the network, just as it would be in a skeleton and is responsible for interconnecting all the leaf switches in a full-mesh topology. Thanks to the mesh, every leaf is connected to every spine, and the path is randomly chosen so that the traffic load is evenly distributed among the top-tier switches. If one of the switches at the top tier were to fail, there would only be a slight degradation in performance throughout the datacenter.

Because of the design of this model, no matter which leaf switch is connected to a server, the traffic always has to cross the same number of devices to get to another server. This keeps latency at a steady level.

Note

Latency is the typical amount of time that it takes for packets of data to travel from one computer or system to the next. The higher the latency, the worse the experience when it comes to real-time video conferencing, webinars, gaming, and so on.

When *top-of-rack (ToR) switching* is incorporated into the network architecture, switches located within the same rack are connected to an in-rack network switch, which is connected to aggregation switches (usually via fiber cabling). The big advantage of this setup is that the switches within each rack can be connected with cheaper copper cabling and the cables to each rack are all that need to be fiber.

ExamAlert

Remember that in a spine and leaf model, the spine is the backbone of the network and is responsible for interconnecting all the leaf switches in a full-mesh topology. Know, as well, that all data flows require the same number of hops, they incorporate a full-mesh switching topology, and they use software-defined networking (SDN) to direct traffic, rather than blocking ports using the Spanning Tree Protocol (STP).

Three-Tier Hierarchical Model

Just as the spine and leaf is a two-tiered model, it is possible to improve system performance, as well as to improve security, by implementing an *n*-tiered model (wherein the *n*- can be one of several different numbers).

If we were looking at a database, for example, with a one-tier model, or single-tier environment, the database and the application exist on a single system. This is common on desktop systems running a standalone database. Early UNIX

implementations also worked in this manner; each user would sign on to a terminal and run a dedicated application that accessed the data. With two-tier architecture, the client workstation or system runs an application that communicates with the database that is running on a different server. This common implementation works well for many applications. With *three-tiered architecture*, otherwise known as a three-tier hierarchical model, security is enhanced. In this model, the end user is effectively isolated from the database by the introduction of a middle-tier server. This server accepts requests from clients, evaluates them, and then sends them on to the database server for processing. The database server sends the data back to the middle-tier server, which then sends the data to the client system. Becoming common in business today, this approach adds both capability and complexity.

While the examples are of database tiering, this same approach can be taken with devices such as routers, switches, and other servers. In a three-tiered model of routing and switching, the three tiers would be the core, the distribution/aggregation layer, and the access/edge. We walk through each of the layers present in this scenario.

Core Layer

The *core* layer is the backbone: the place where switching and routing meet (switching ends, routing begins). It provides high-speed, highly redundant forwarding services to move packets between distribution layer devices in different regions of the network. The core switches and routers would be the most powerful in the enterprise (in terms of their raw forwarding power) and would be used to manage the highest-speed connections (such as 100 Gigabit Ethernet). Core switches also incorporate internal firewall capability as part of their features, helping with segmentation and control of traffic moving from one part of the network to another.

Distribution/Aggregation Layer

The *distribution layer*, or *aggregation layer* (sometimes called the workgroup layer), is the layer in which management takes place. This is the place where Quality of Service (QoS) policies are managed, filtering is done, and routing takes place. Distribution layer devices can be used to manage individual branch-office WAN connections, and this is considered to be smart (usually offering a larger feature set than switches used at the access/edge layer). Lower latency and larger MAC address table sizes are important features for switches used at this level because they aggregate traffic from thousands of users rather than hundreds (as access/edge switches do).

Access/Edge Layer

Switches that allow end users and servers to connect to the enterprise are called access switches or edge switches, and the layer where they operate in the three-tiered model is known as the *access layer*, or *edge layer*. Devices at this layer may or may not provide Layer 3 switching services; the traditional focus is on minimizing the cost of each provisioned Ethernet port (known as "cost-per-port") and providing high port density. Because the focus is on connecting client nodes, such as workstations to the network, this is sometimes called the desktop layer.

> **Note**
>
> As was discussed in Chapter 1, "Networking Models, Ports, Protocols, and Services," a switch can work at either Layer 2 (the data link layer) or Layer 3 (the network layer) of the OSI model. When it filters traffic based on the MAC address, it is called a Layer 2 switch, since MAC addresses exist at Layer 2 of the OSI model (if it operated only with IP traffic, it would be a Layer 3 switch).

Table 2.3 highlights each of the layers of the three-tier hierarchical model.

TABLE 2.3 **Three-tier Hierarchical Model Layers**

Layer	Core	Distribution	Access
Description	Backbone of the network, provides high-speed connectivity between distribution layers and serves as a transit for all traffic	Aggregates traffic from access layer devices and distributes it to the appropriate destinations, provides policy enforcement and access control	Interfaces directly with end devices such as computers, printers, and IP phones, provides connectivity to the network
Function	Provides high-speed, low-latency forwarding of packets between distribution layer devices	Aggregates and filters traffic, enforces security policies, implements VLANs, routing protocols, and Quality of Service (QoS)	Delivers network services to end devices, such as Ethernet ports, wireless access points, and VLANs
Scale	Typically has the highest capacity and fastest speeds, often utilizes high-performance networking equipment	Capacity and performance requirements are moderate, often use Layer 3 switches and routers for routing and filtering	Usually consists of a large number of ports to accommodate end devices, employs switches with basic Layer 2 functionality

Layer	Core	Distribution	Access
Redundancy	Redundancy and high availability are critical, often implemented using redundant links and protocols like Virtual Router Redundancy Protocol (VRRP)	Redundancy is important but may not be as critical as in the core, often utilizes redundant uplinks and EtherChannel bundles	Redundancy is essential to ensure connectivity for end devices, typically implemented using redundant switches and network paths
Traffic flow	Handles transit traffic between distribution layer devices, typically high-speed and low-latency	Aggregates and filters traffic from access layer devices before forwarding it to the core or other distribution layer devices	Facilitates traffic between end devices and the rest of the network, including user data, management traffic, and control messages
Examples	High-speed routers, switches with large forwarding tables, MPLS networks	Layer 3 switches, VLANs, Quality of Service (QoS) policies, access control lists (ACLs)	Ethernet switches, wireless access points, Power over Ethernet (PoE) switches

ExamAlert

Remember: The core layer is the backbone of the network (where the fastest routers and switches operate to manage separate networks), whereas the distribution/aggregation layer (between the access/edge and core layers) is the "boundary" layer where ACLs and Layer 3 switches operate to properly manage data between VLANs and subnetworks. The access/edge layer is the place where switches connect to and ensure data is delivered to edge/end devices, such as computers and servers.

Collapsed Core

With a *collapsed core* architecture, the three-tier model becomes a two-tier model as the core and distribution layers are combined. While a three-tier model is necessary for complex installations that require access by multiple sites, devices, and users, the collapsed core approach is commonly used in datacenters and enterprise networks.

By collapsing the core and distribution layers into a single layer, the streamlined design provides both advantages and trade-offs. Advantages include simplicity, cost savings (via a reduced number of network devices and switches), efficient communication (with fewer layers, there are fewer network hops between devices), and scalability (it can scale relatively well for medium-sized networks and datacenters with a moderate number of devices). Disadvantages include limited redundancy (a failure at the collapsed core layer could

potentially impact the entire network), scalability constraints (it is not ideal for extremely large networks or datacenters with high traffic demands), and potential bottlenecks (there is a risk of network congestion if not properly designed and managed).

Traffic Flows

Traffic flows within a datacenter typically occur within the framework of one of two models: East-West or North-South. The names may not be the most intuitive, but the East-West traffic model means that data is flowing among devices within a specific datacenter, whereas North-South means that data is flowing into the datacenter (from a system physically outside the datacenter) or out of it (to a system physically outside the datacenter).

The naming convention comes from the way diagrams are drawn: data staying within the datacenter is traditionally drawn on the same horizontal line (East-to-West), while data leaving or entering is typically drawn on a vertical line (North-to-South). With the increase in virtualization being implemented at so many levels, the East-West traffic has increased in recent years. Table 2.4 summarizes the traffic flow possibilities.

> **Note**
>
> Network Functions Virtualization (NFV) is a network architecture concept that uses the proven technologies of IT virtualization. It delivers the network services needed to support an infrastructure independent from hardware by decoupling network functions from proprietary hardware appliances. This is covered in more detail in Chapter 7, "Cloud Computing Concepts and Options."

TABLE 2.4 **Traffic Flow Options**

Traffic Flow	Description	Characteristics	Examples
North-South	Refers to the traffic flow between a client and external resources	Typically involves communication between internal users or devices and external networks or services	Internet browsing, accessing cloud services
East-West	Relates to the traffic flow between internal resources within a network	Occurs within the boundaries of a datacenter or local network, involving communication between servers, virtual machines, or applications	Inter-server communication, database queries

ExamAlert

East-West traffic is a concept referring to network traffic flow within a datacenter between servers. North-South refers to data transfers between the datacenter and outside the network.

Older Topologies: Bus and Ring

There are two topologies that have been removed from this iteration of the CompTIA Network+ exam objectives that you will very likely encounter in the workplace: bus and ring. For that reason, it is highly suggested that you be aware of them, and coverage of them is included at the end of this chapter rather than in with the exam fodder.

A *bus topology* uses a trunk or backbone to connect all the computers on the network, as shown in Figure 2.4. Systems connect to this backbone using *T connectors* or taps (known as a vampire tap, if you must pierce the wire). To avoid signal reflection, a physical bus topology requires that each end of the physical bus be terminated, with one end also being grounded. Note that a hub or switch is not needed in this installation, and loose or missing terminators from a bus network disrupt data transmissions.

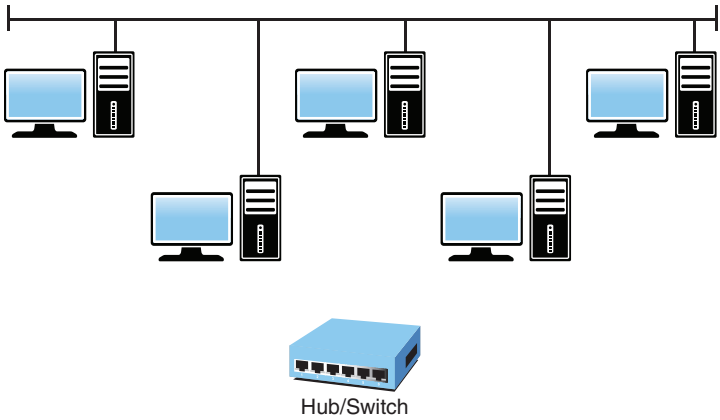

FIGURE 2.4 **Physical Bus Topology**

Table 2.5 summarizes the advantages and disadvantages of the bus topology.

TABLE 2.5 **Advantages and Disadvantages of the Bus Topology**

Advantages	Disadvantages
Compared to other topologies, a bus is cheap and easy to implement.	Network disruption might occur when computers are added or removed.
A bus requires less cable than other topologies.	Because all systems on the network connect to a single backbone, a break in the cable prevents all systems from accessing the network.
A bus does not use any specialized network equipment.	It is difficult to troubleshoot.

The *ring topology* is a logical ring, meaning that the data travels in a circular fashion from one computer to another on the network. It is not a physical ring topology. Figure 2.5 shows the logical layout of a ring topology. Note that a hub or switch is not needed in this installation either.

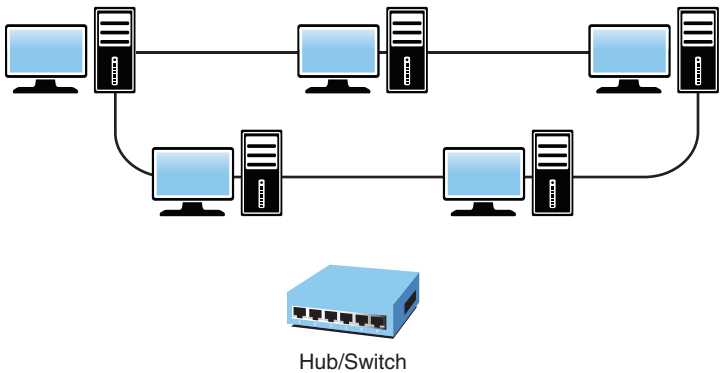

FIGURE 2.5 **Logical Design of a Ring Topology**

In a true ring topology, if a single computer or section of cable fails, the signal is interrupted. The entire network becomes inaccessible. Network disruption can also occur when computers are added to or removed from the network, making it an impractical network design in environments where the network changes often.

Ring networks can be set up in a fault-tolerant design, meaning that they have primary and secondary rings. If one ring fails, data can use the second ring to reach its destination. Naturally, the addition of the second ring adds to the cost of the network as well as the complexity. Table 2.6 summarizes the advantages and disadvantages of the ring topology.

TABLE 2.6 **Advantages and Disadvantages of the Ring Topology**

Advantages	Disadvantages
Cable faults are easily located, making troubleshooting easier.	Expansion to the network can cause network disruption.
Ring networks are moderately easy to install.	A single break in the cable can disrupt the entire network.

Cram Quiz

1. You have been asked to install a network that will give the network users the greatest amount of fault tolerance. Which of the following network topologies would you choose?
   - ❍ **A.** Star/hub and spoke
   - ❍ **B.** Ring
   - ❍ **C.** Mesh
   - ❍ **D.** Bus

2. Which of the following topologies allows for network expansion with the least amount of disruption for the current network users?
   - ❍ **A.** Bus
   - ❍ **B.** Ring
   - ❍ **C.** LAN
   - ❍ **D.** Star/hub and spoke

3. Which network topology offers the greatest level of redundancy but has the highest implementation cost?
   - ❍ **A.** Wireless mesh
   - ❍ **B.** Wired mesh
   - ❍ **C.** Hybrid star
   - ❍ **D.** Bus network

4. What traffic pattern refers to data that travels outside the datacenter or enterprise?
   - ❍ **A.** East-to-West
   - ❍ **B.** North-to-South
   - ❍ **C.** On-premises
   - ❍ **D.** West-to-South

5. What layer in three-tier hierarchical model network architecture is considered the backbone of a network?
   - ❍ **A.** Core layer
   - ❍ **B.** Distribution/aggregation layer
   - ❍ **C.** Access/edge layer
   - ❍ **D.** Application layer

6. Which topology utilizes a dedicated connection between two endpoints?
   - ❍ **A.** Mesh
   - ❍ **B.** Spine and leaf
   - ❍ **C.** Point to point
   - ❍ **D.** Star

7. Which topology is commonly used in datacenter environments for high scalability and flexibility?
   - ❍ **A.** Ad hoc
   - ❍ **B.** Hybrid
   - ❍ **C.** Star
   - ❍ **D.** Spine and leaf

8. This network architecture includes simplicity, cost savings (via a reduced number of network devices and switches), efficient communication (with fewer layers, there are fewer network hops between devices), and scalability (it can scale relatively well for medium-sized networks and datacenters with a moderate number of devices). Which network architecture is being described?
   - ❍ **A.** Collapsed core
   - ❍ **B.** NFV
   - ❍ **C.** ToR switching
   - ❍ **D.** Four-tier hierarchical model

9. Which layer in the three-tier hierarchical model network architecture facilitates traffic between end devices and the rest of the network?
   - ❍ **A.** Core layer
   - ❍ **B.** Distribution layer
   - ❍ **C.** Point-to-point layer
   - ❍ **D.** Access layer

Cram Quiz Answers

1. **C.** A mesh network uses a point-to-point connection to every device on the network. This creates multiple points for the data to be transmitted around the network and therefore creates a high degree of redundancy. The star/hub and spoke, ring, and bus topologies do not offer the greatest amount of fault tolerance.
2. **D.** On a star/hub and spoke network, each network device uses a separate cable to make a point-to-point connection to a centralized device, such as a hub or a switch. With such a configuration, a new device can be added to the network by attaching the new device to the hub or switch with its own cable. This process does not disrupt the users who are currently on the network. Answers A and B are incorrect because the addition of new network devices on a ring or bus network can cause a disruption in the network and cause network services to be unavailable during the installation of a new device.
3. **B.** The wired mesh topology requires each computer on the network to be individually connected to every other device. This configuration provides maximum reliability and redundancy for the network. However, it is very costly to implement because of the multiple wiring requirements.
4. **B.** North-South refers to data transfers between the datacenter and outside of the network. East-West traffic is a concept referring to network traffic flow within a datacenter between servers. On-premises can be thought of as the old, traditional approach: the data and the servers are kept in-house. Although West-to-South is a direction, it is not a valid specified data path.
5. **A.** The core layer is the backbone of the network where the fastest routers and switches operate to manage separate networks. The distribution/aggregation layer is between the access/edge and core layers. This is the "boundary" layer where ACLs and Layer 3 switches operate. The access/edge layer is the place where switches connect to and ensure data is delivered to edge/end devices. The application layer is the seventh and top layer of the OSI reference model.
6. **C.** Point-to-point topology involves a direct link between two devices, providing a dedicated connection for communication. It's commonly used in WAN connections, such as leased lines or serial connections.
7. **D.** Spine and leaf topology is prevalent in datacenters due to its scalability and high-performance characteristics. It consists of spine switches interconnected with leaf switches, offering multiple paths and high bandwidth for data traffic.
8. **A.** With a collapsed core architecture, the three-tier model becomes a two-tier model as the core and distribution layers are combined. By collapsing the core and distribution layers into a single layer, the streamlined design provides both advantages and trade-offs. Advantages include simplicity, cost savings (via a reduced number of network devices and switches), efficient communication (with fewer layers, there are fewer network hops between devices), and scalability (it can scale relatively well for medium-sized networks and datacenters with a moderate number of devices). Network Functions Virtualization (NFV) is a technology that allows for the virtualization of a replica of a network's physical topology and the way it behaves without changing the logical topology and the way that devices are managed. NFV allows for the virtualization of network functions such

as routers, firewalls, and switches, resulting in increased flexibility and scalability. When top-of-rack (ToR) switching is incorporated into the network architecture, switches located within the same rack are connected to an in-rack network switch, which is connected to aggregation switches (usually via fiber cabling). There is no such thing as the four-tier hierarchical model.

9. **D.** The access layer in three-tier hierarchical model network architecture facilitates traffic between end devices and the rest of the network, including user data, management traffic, and control messages. The core layer is the backbone of the network, provides high-speed connectivity between distribution layers, and serves as a transit for all traffic. The distribution layer aggregates and filters traffic; enforces security policies; and implements VLANs, routing protocols, and Quality of Service (QoS). Point to point is not a layer in the three-tier hierarchical model. It is a network configuration where two devices or nodes are directly connected to each other. In this topology, there is a dedicated communication link between the two endpoints, and data flows directly between them without the involvement of any intermediary devices.

What's Next?

The TCP/IP suite is the most widely implemented protocol on networks today. As such, it is an important topic on the Network+ exam. Chapter 3, "Network Addressing, Routing, and Switching," starts by discussing one of the more complex facets of TCP/IP: IP addresses.

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