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31 Days Before Your CCENT Exam

Second Edition

Allan Johnson

A Day-By-Day Review Guide for the ICND1/CCENT (100-101) Certification Exam

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About the Author

Allan Johnson entered the academic world in 1999 after ten years as a business owner/operator to dedicate his efforts to his passion for teaching. He holds both an MBA and an M.Ed. in occupational training and development. He taught CCNA courses at the high school level for seven years and has taught both CCNA and CCNP courses at Del Mar College in Corpus Christi, Texas. In 2003, Allan began to commit much of his time and energy to the CCNA Instructional Support Team, providing services to Networking Academy instructors worldwide and creating training materials. He now works full time for Cisco Networking Academy as a learning systems developer.

About the Technical Reviewer

Steve Stiles is a Cisco Networking Academy Instructor for Rhodes State College and a Cisco Certified Instructor Trainer, having earned CCNA Security and CCNP level certifications. He was the recipient of the 2012 Outstanding Teacher of the Year award by the Ohio Association of Two Year Colleges and co-recipient of the Outstanding Faculty of the Year award at Rhodes State College.

Dedication

For my wife, Becky. Without the sacrifices you made during the project, this work would not have come to fruition. Thank you for providing me the comfort and resting place only you can give.

Acknowledgments

When I began to think of whom I would like to have as a technical editor for this work, Steve Stiles immediately came to mind. With his instructor and industry background, as well as his excellent work building activities for the new Cisco Networking Academy curriculum, he was an obvious choice. Thankfully, when Mary Beth Ray contacted him, he was willing and able to do the arduous review work necessary to make sure that you get a book that is both technically accurate and unambiguous.

This book is a concise summary of the work of Cisco Press CCNA authors. Wendell Odom's *Cisco CCENT/CCNA ICND1 100-101 Official Cert Guide* and Anthony Sequeira's *Interconnecting Cisco Network Devices, Part 1 (ICND1) Foundation Learning Guide* were two of my main sources. The different approaches that these two authors—both CCIEs—take toward the CCNA material gives the reader the breadth and the depth needed to master the CCNA exam topics.

The Cisco Networking Academy authors for the online curriculum and series of Companion Guides take the reader deeper, past the CCNA exam topics, with the ultimate goal of not only preparing the student for CCNA certification, but also for more advanced college-level technology courses and degrees. Thank you especially to Amy Gerrie and her team of authors—Rick Graziani, Wayne Lewis, and Bob Vachon—for their excellent treatment of the material; it is reflected throughout this book.

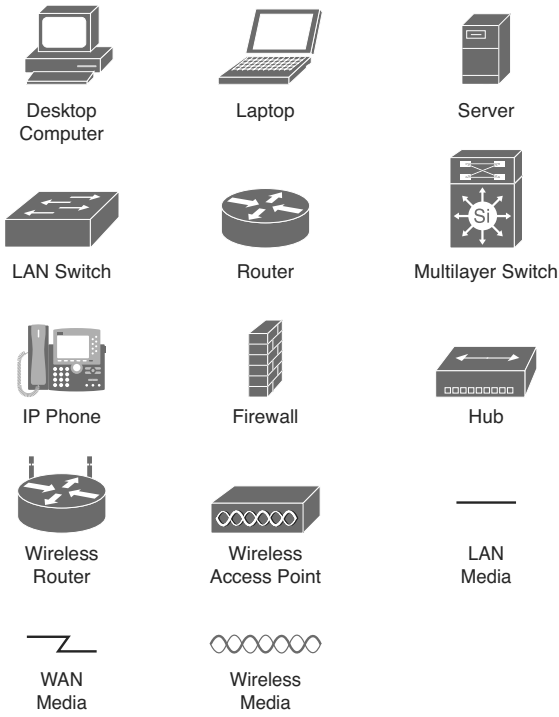
Mary Beth Ray, executive editor, amazes me with her ability to juggle multiple projects at once, steering each from beginning to end. I can always count on her to make the tough decisions. Thank you, Mary Beth, for bringing this project to me.

This is my fifth project with Christopher Cleveland as development editor. His dedication to perfection pays dividends in countless, unseen ways. Thank you again, Chris, for providing me with much needed guidance and support. This book could not be a reality without your persistence.

Contents at a Glance

Contents

Icons Used in This Book



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

You are almost there! If you're reading this Introduction, you've probably already spent a considerable amount of time and energy pursuing your CCENT certification. Regardless of how you got to this point in your travels through your CCENT studies, *31 Days Before Your CCENT Certification Exam* most likely represents the last leg of your journey on your way to the destination: to become a Cisco Certified Entry Networking Technician. However, if you are like I am, you might be reading this book at the beginning of your studies. If such is the case, this book provides you with an excellent overview of the material that you must now spend a great deal of time studying and practicing. However, I must warn you: Unless you are extremely well-versed in networking technologies and have considerable experience configuring and troubleshooting Cisco routers and switches, this book will not serve you well as the sole resource for CCENT exam preparation. Therefore, let me spend some time discussing my recommendations for study resources.

Study Resources

Cisco Press offers an abundance of CCNA-related books to serve as your primary source for learning how to install, configure, operate, and troubleshoot small- to medium-size routed and switched networks.

Primary Resources

First on the list must be Wendell Odom's *Cisco CCENT/CCNA ICND1 100-101 Official Cert Guide* (ISBN: 9781587143854). If you do not buy any other books, buy this one. Wendell's method of teaching, combined with his technical expertise and down-to-earth style, is unsurpassed in our industry. As you read through his books, you sense that he is sitting right there next to you walking you through the material. The practice exams and study materials on the DVD in the back of the book are worth the price of the book. There is no better resource on the market for a CCNA candidate.

Next on the list must be Anthony Sequeira's *Interconnecting Cisco Network Devices, Part 1 (ICND1) Foundation Learning Guide* (ISBN: 9781587143762). This book is indispensable to those students who take the first of two Cisco-recommended training class for CCNA preparation: Interconnecting Cisco Network Devices 1 (ICND1). These courses, available through Cisco Training Partners in a variety of formats, are usually of a very short duration (one to six weeks) and are geared toward the industry professional already working in the field of networking. Anthony's book serves the reader well as a concise, but thorough, treatment of the CCENT exam topics. His method and approach often differ and complement Wendell's approach. I recommend that you also refer to this book.

If you are a Cisco Networking Academy student, you are blessed with access to the online version of the CCNA Routing and Switching curriculum and the wildly popular Packet Tracer network simulator. Although there are currently two paths for the CCNA curriculum, I used the Introduction to Networking (ITN) and Routing and Switching Essential (RSE) courses in my daily review of the exam topics. ITN introduces basic concepts of computer networks, including deep dives into the seven layers of the OSI model, IP addressing, and the fundamentals of Ethernet. Successfully completing the course means that you should be able to build small LANs and implement basic addressing and configurations on routers

and switches. RSE expands on ITN, taking the student further into basic router and switch configuration. Successfully completing the course means that you should be able to configure and troubleshoot routers and switches using a variety of technologies including RIPv2, single-area OSPF, VLANs, and inter-VLAN routing for both IPv4 and IPv6 networks. To learn more about CCNA Routing and Switching courses and to find an Academy near you, visit www.netacad.com.

However, if you are not an Academy student but would like to benefit from the extensive authoring done for these courses, you can buy any or all the CCNA Routing and Switching Companion Guides (CG) and Lab Manuals (LM) of the Academy's popular online curriculum. Although you will not have access to the Packet Tracer network simulator software, you will have access to the tireless work of an outstanding team of Cisco Academy Instructors dedicated to providing students with comprehensive and engaging CCNA preparation course material. The titles and ISBNs for the CCNA Routing and Switching CGs and LMs are as follows:

- Introduction to Networks Companion Guide (ISBN: 9781587133169)
- Introduction to Networks Lab Manual (ISBN: 9781587133121)
- Routing and Switching Essentials Companion Guide (ISBN: 9781587133183)
- Routing and Switching Essentials Lab Manual (ISBN: 9781587133206)

You can find these books at www.ciscopress.com by clicking the **Cisco Networking Academy** link.

Supplemental Resources

In addition to the book you hold in your hands, there are four more supplemental resources I recommend to augment your final 31 days of review and preparation.

First, a plug for my own book, the *CCENT Practice and Study Guide, Exercises, Activities and Scenarios to Prepare for the ICND1/CCENT (100-101) Certification Exam* (ISBN: 9781587133459). The subtitle is a concise summary of what you will get. Although an appropriate resource for anyone, this book is specifically geared toward the Cisco Networking Academy instructors and students who want a resource to supplement the online curriculum. Mirroring the chapter layout of the first two online courses, the CCENT PSG offers exercises that help you learn the concepts and configurations that are crucial to your success as a CCENT candidate.

Second, Wendell Odom and Sean Wilkins have created over 250 structured labs that are available in the Cisco CCENT ICND1 100-101 Network Simulator (ISBN: 9780789750433). These simulations map precisely to chapters in his book, but are also a great practice resource for anyone. The four types of labs in this product present you with progressively more difficult real-world challenges. Skill builder labs help you practice short, focused configuration tasks. Subnetting exercises help you improve the speed and accuracy of your subnetting calculations. Complex Configuration Scenario labs present realistic multilayered, multitechnology configuration tasks. Finally, challenging Troubleshooting Scenario labs provide you with an opportunity to test your problem identification and resolution skills. If you need that extra edge or are struggling with a particular configuration or troubleshooting concept, you'll find these simulations very helpful.

Third, Eric Rivard is the author of *Cisco CCENT ICND1 100-101 Flash Cards and Exam Practice Pack* (ISBN: 9781587203992). The text portion of the book includes over 450 flash cards that quickly review exam topics in bite-sized pieces. Also included is over 100 pages in the Quick Reference Guide, which is designed for late-stage exam preparation. And on the included CD, you will find a test engine with over 150 CCENT practice exam questions.

NOTE: If you are certain that you will be also pursuing your CCNA certification, the more economical purchase might be to buy the *Cisco CCNA Routing and Switching 200-120 Flash Cards and Exam Practice Pack* (ISBN: 9781587204005). The first half of this book is a repeat of the CCENT version.

Fourth, there is Scott Empson's very popular *CCNA Routing and Switching Portable Command Guide, Third Edition* (ISBN: 9781587204302). This guide is way more than just a listing of commands and what they do. Yes, it summarizes all the CCNA certification-level IOS commands, keywords, command arguments, and associated prompts. But it also provides you with tips and examples of how to apply the commands to real-world scenarios. Configuration examples throughout the book provide you with a better understanding of how these commands are used in simple network designs.

The Cisco Learning Network

Finally, if you have not done so already, you should now register with The Cisco Learning Network at https://learningnetwork.cisco.com. Sponsored by Cisco, The Cisco Learning Network is a free social learning network where IT professionals can engage in the common pursuit of enhancing and advancing their IT careers. Here you will find many resources to help you prepare for your CCNA exam as well as a community of like-minded people ready to answer your questions, help you with your struggles, and share in your triumphs.

So which resources should you buy? That question is largely up to how deep your pockets are or how much you like books. If you're like I am, you must have it all! I admit it. My bookcase is a testament to my Cisco "geekness." But if you are on a budget, choose one of the primary study resources and one of the supplemental resources, such as Wendell Odom's certification book and my practice study guide. Whatever you choose, you will be in good hands. Any or all of these authors will serve you well.

Goals and Methods

The main goal of this book is to provide you with a clear and succinct review of the CCENT objectives. Each day's exam topics are grouped into a common conceptual framework and use the following format:

- A title for the day that concisely states the overall topic
- A list of one or more CCENT 100-101 ICND1 Exam Topics to be reviewed
- A Key Topics section to introduce the review material and quickly orient you to the day's focus
- An extensive review section consisting of short paragraphs, lists, tables, examples, and graphics

- A Study Resources section to provide you with a quick reference for locating more in-depth treatment of the day's topics

The book counts down starting with Day 31 and continues through exam day to provide post-test information. You will also find a calendar and checklist that you can tear out and use during your exam preparation inside the book.

Use the calendar to enter each actual date beside the countdown day and the exact day, time, and location of your CCENT exam. The calendar provides a visual for the time that you can dedicate to each CCENT exam topic.

The checklist highlights important tasks and deadlines leading up to your exam. Use it to help you map out your studies.

Who Should Read This Book

The audience for this book is anyone finishing his or her preparation for taking the CCENT 100-101 ICND1 exam. A secondary audience is anyone needing a refresher review of CCENT exam topics—possibly before attempting to recertify or sit for another certification to which the CCNA is a prerequisite.

Getting to Know the CCENT 100-101 ICND1 Exam

For the current certifications, announced in spring 2013, Cisco created the ICND1 (100-101) and ICND2 (200-101) exams, along with the CCNA (200-120) exam. To become CCENT certified, you only need to pass the ICND1 exam. To become CCNA Routing and Switching certified, you must pass both the ICND1 and ICND2 exams, or just the CCNA exam. The CCNA exam simply covers all the topics of the ICND1 and ICND2 exams, giving you two options for gaining your CCNA Routing and Switching certification. The two-exam path gives people with less experience a chance to study for a smaller set of topics at one time. The one-exam option provides a more cost-effective certification path for those who want to prepare for all the topics at once. This book focuses exclusively on the CCENT path, using the entire list of topics published for the CCENT 100-101 ICND1 exam.

Currently for the CCENT exam, you are allowed 90 minutes to answer 50–60 questions. Use the following steps to access a tutorial at home that demonstrates the exam environment before you go to take the exam:

Step 1. Visit www.vue.com/cisco.

Step 2. Look for a link to the certification tutorial. Currently, it can be found on the right side of the web page under the heading "Related Links."

Step 3. Click the certification tutorial link.

When you get to the testing center and check in, the proctor verifies your identity, gives you some general instructions and then takes you into a quiet room containing a PC. When you're at the PC, you have a few things to do before the timer starts on your exam. For instance, you can take the tutorial to get accustomed to the PC and the testing engine. Every time I sit for an exam, I go through the tutorial even though I know how the test

engine works. It helps me settle my nerves and get focused. Anyone who has user-level skills in getting around a PC should have no problems with the testing environment.

When you start the exam, you are asked a series of questions. Each question is presented one at a time and must be answered before moving on to the next question. The exam engine does not let you go back and change your answer. The exam questions can be in one of the following formats:

- Multiple choice
- Fill-in-the-blank
- Drag-and-drop
- Testlet
- Simlet
- Simulation

The multiple-choice format simply requires that you point and click a circle or check box next to the correct answer or answers. Cisco traditionally tells you how many answers you need to choose, and the testing software prevents you from choosing too many or too few.

Fill-in-the-blank questions typically only require you to type numbers. However, if words are requested, the case does not matter unless the answer is a command that is case sensitive (such as passwords and device names when configuring authentication).

Drag-and-drop questions require you to click and hold, move a button or icon to another area, and release the mouse button to place the object somewhere else—typically in a list. For some questions, to get the question correct, you might need to put a list of five things in the proper order.

Testlets contain one general scenario and several multiple-choice questions about the scenario. These are ideal if you are confident in your knowledge of the scenario's content because you can leverage your strength over multiple questions.

A simlet is similar to a testlet in that you are given a scenario with several multiple-choice questions. However, a simlet uses a network simulator to allow you access to a simulation of the command line of Cisco IOS Software. You can then use **show** commands to examine a network's current behavior and answer the question.

A simulation also uses a network simulator, but you are given a task to accomplish such as implementing a network solution or troubleshooting an existing network implementation. You do this by configuring one or more routers and switches. The exam then grades the question based on the configuration you changed or added. A newer form of the simulation question is the GUI-based simulation, where a graphical interface like that found on a Linksys router or the Cisco Security Device Manager are simulated.

What Topics Are Covered on the CCENT Exam?

The topics of the CCENT 100-101 ICND1 exam focus on the following seven key categories:

- Operation of IP Data Networks
- LAN Switching Technologies
- IP Addressing for IPv4 and IPv6
- IP Routing Technologies
- IP Services
- Network Device Security
- Troubleshooting

Although Cisco outlines general exam topics, it is possible that not all topics will appear on the CCENT exam and that topics that are not specifically listed might appear on the exam. The exam topics provided by Cisco and included in this book are a general framework for exam preparation. Be sure to check the Cisco website for the latest exam topics.

Registering for the CCENT 100-101 Exam

If you are starting your *31 Days to Your CCENT Certification Exam* today, register for the exam right now. In my testing experience, there is no better motivator than a scheduled test date staring me in the face. I'm willing to bet that it's the same for you. Don't worry about unforeseen circumstances. You can cancel your exam registration for a full refund up to 24 hours before taking the exam. So if you're ready, you should gather the following information in Table I-1 and register right now!

Table I-1 Personal Information for CCENT 100-101 ICND1 Exam Registration

Item	Notes
Legal Name	
Social Security or Passport Number	
Cisco Certification ID or Test ID[1]	
Cisco Academy Username[2]	
Cisco Academy ID Number[2]	
Company Name	
Valid Email Address	
Voucher Number[2]	
Method of Payment	

[1]Applies to exam candidates who have previously taken a Cisco certification exam

[2]Applies to Cisco Networking Academy students only

To register for an exam, visit Pearson VUE online at www.vue.com/cisco. The process and available test times will vary based on the local testing center you choose.

Remember, there is no better motivation for study than an actual test date. *Sign up today.*

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Ethernet and Media Access Control

CCENT 100-101 ICND1 Exam Topics

- Determine the technology and media access control method for Ethernet networks.

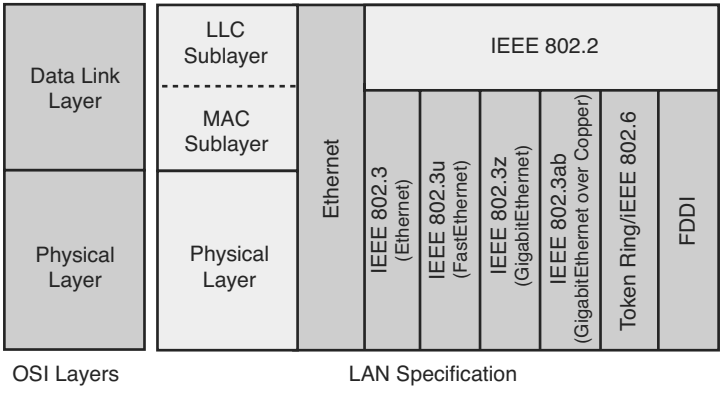
Key Topics

Ethernet has continued to evolve from the 10BASE2 flavor, capable of speeds up to 10Mbps, to the newest 10GigE (10 Gigabit Ethernet), capable of speeds up to 10Gbps. Since 1985, the IEEE has continued to upgrade the 802.3 standards to provide faster speeds without changing the underlying frame structure. This feature, among others, has made Ethernet the choice for LAN implementations worldwide. Today we review Ethernet technologies and operation at both the data link and physical layers.

Ethernet Overview

802.3 is the IEEE standard for Ethernet, and both terms are commonly used interchangeably. The terms *Ethernet* and *802.3* both refer to a family of standards that together define the physical and data link layers of the definitive LAN technology. Figure 29-1 shows a comparison of Ethernet standards to the OSI model.

Figure 29-1 Ethernet Standards and the OSI Model



Ethernet separates the functions of the data link layer into two distinct sublayers:

- **Logical Link Control (LLC) sublayer:** Defined in the 802.2 standard
- **Media Access Control (MAC) sublayer:** Defined in the 802.3 standard

The LLC sublayer handles communication between the network layer and the MAC sublayer. In general, LLC provides a way to identify the protocol that is passed from the data link layer to the network layer. In this way, the fields of the MAC sublayer are not populated with protocol type information, as was the case in earlier Ethernet implementations.

The MAC sublayer has two primary responsibilities:

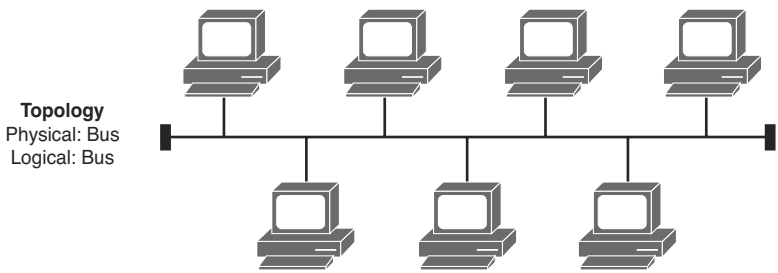
- **Data encapsulation:** Includes frame assembly before transmission, frame parsing upon reception of a frame, data link layer MAC addressing, and error detection.
- **Media Access Control:** Because Ethernet is a shared media and all devices can transmit at any time, media access is controlled by a method called Carrier Sense Multiple Access with Collision Detection (CSMA/CD) when operating in half-duplex mode.

At the physical layer, Ethernet specifies and implements encoding and decoding schemes that enable frame bits to be carried as signals across both unshielded twisted-pair (UTP) copper cables and optical fiber cables. In early implementations, Ethernet used coaxial cabling.

Legacy Ethernet Technologies

Ethernet is best understood by first considering the two early Ethernet specifications—10BASE5 and 10BASE2. With these two specifications, the network engineer installs a series of coaxial cables connecting each device on the Ethernet network, as shown in Figure 29-2.

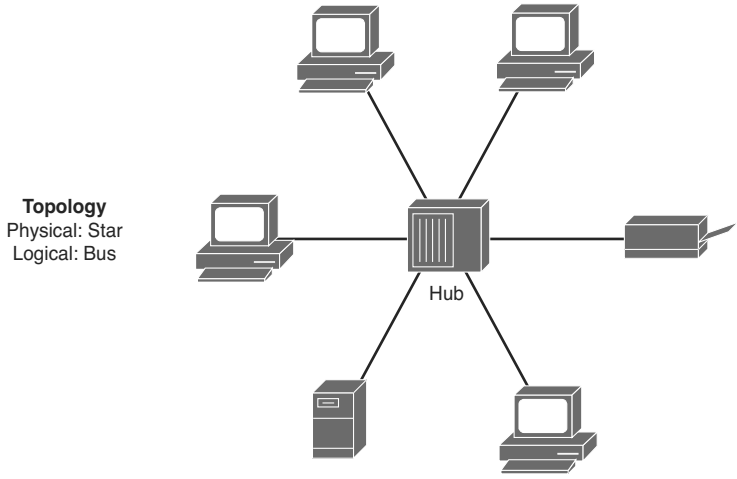
Figure 29-2 Ethernet Physical and Logical Bus Topology



The series of cables creates an electrical circuit, called a *bus*, which is shared among all devices on the Ethernet. When a computer wants to send some bits to another computer on the bus, it sends an electrical signal and the electricity propagates to all devices on the Ethernet.

With the change of media to UTP and the introduction of the first hubs, Ethernet physical topologies migrated to a star, as shown in Figure 29-3.

Figure 29-3 Ethernet Physical Star and Logical Bus Topology



Regardless of the change in the physical topology from a bus to a star, hubs logically operate similarly to a traditional bus topology and require the use of CSMA/CD.

CSMA/CD

Because Ethernet is a shared media where every device has the right to send at any time, it also defines a specification for how to ensure that only one device sends traffic at a time. The CSMA/CD algorithm defines how the Ethernet logical bus is accessed.

CSMA/CD logic helps prevent collisions and also defines how to act when a collision does occur. The CSMA/CD algorithm works like this:

1. A device with a frame to send listens until the Ethernet is not busy.
2. When the Ethernet is not busy, the sender(s) begin(s) sending the frame.
3. The sender(s) listen(s) to make sure that no collision occurred.
4. If a collision occurs, the devices that had been sending a frame each send a jamming signal to ensure that all stations recognize the collision.
5. After the jamming is complete, each sender randomizes a timer and waits that long before trying to resend the collided frame.
6. When each random timer expires, the process starts again from the beginning.

When CSMA/CD is in effect, it also means that a device's network interface card (NIC) is operating in half-duplex mode—either sending or receiving frames. CSMA/CD is disabled when a NIC autodetects that it can operate in—or is manually configured to operate in—full-duplex mode. In full-duplex mode, a NIC can send and receive simultaneously.

Legacy Ethernet Summary

Today, you might occasionally use LAN hubs, but you will more likely use switches instead of hubs. However, keep in mind the following key points about the history of Ethernet:

- The original Ethernet LANs created an electrical bus to which all devices connected.
- 10BASE2 and 10BASE5 repeaters extended the length of LANs by cleaning up the electrical signal and repeating it—a Layer 1 function—but without interpreting the meaning of the electrical signal.
- Hubs are repeaters that provide a centralized connection point for UTP cabling—but they still create a single electrical bus, shared by the various devices, just like 10BASE5 and 10BASE2.
- Because collisions could occur in any of these cases, Ethernet defines the CSMA/CD algorithm, which tells devices how to both avoid collisions and take action when collisions do occur.

Current Ethernet Technologies

Refer to Figure 29-1 and notice the different 802.3 standards. Each new physical layer standard from the IEEE requires many differences at the physical layer. However, each of these physical layer standards uses the same 802.3 header, and each uses the upper LLC sublayer as well. Table 29-1 lists today's most commonly used IEEE Ethernet physical layer standards.

Table 29-1 Today's Most Common Types of Ethernet

Common Name	Speed	Alternative Name	Name of IEEE Standard	Cable Type, Maximum Length
Ethernet	10Mbps	10BASE-T	802.3	Copper, 100 m
Fast Ethernet	100Mbps	100BASE-TX	802.3u	Copper, 100 m
Gigabit Ethernet	1000Mbps	1000BASE-LX	802.3z	Fiber, 550 m
Gigabit Ethernet	1000Mbps	1000BASE-T	802.3ab	Copper, 100 m
10GigE (Gigabit Ethernet)	10Gbps	10GBASE-T	802.3an	Copper, 100 m

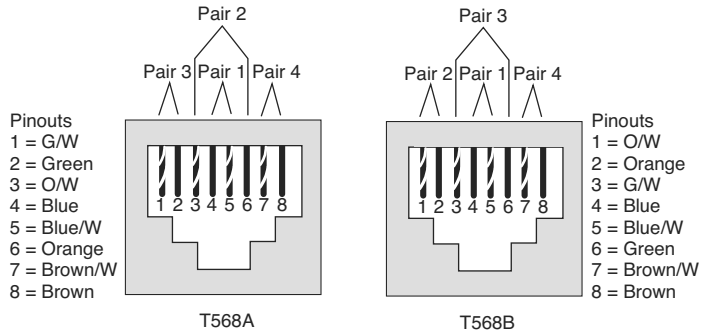
UTP Cabling

The three most common Ethernet standards used today—10BASE-T (Ethernet), 100BASE-TX (Fast Ethernet, or FE), and 1000BASE-T (Gigabit Ethernet, or GE)—use UTP cabling. Some key differences exist, particularly with the number of wire pairs needed in each case and in the type (category) of cabling.

The UTP cabling used by popular Ethernet standards includes either two or four pairs of wires. The cable ends typically use an RJ-45 connector. The RJ-45 connector has eight specific physical locations into which the eight wires in the cable can be inserted, called pin positions or, simply, pins.

The Telecommunications Industry Association (TIA) and the Electronics Industry Alliance (EIA) define standards for UTP cabling, color-coding for wires, and standard pinouts on the cables. Figure 29-4 shows two TIA/EIA pinout standards, with the color-coding and pair numbers listed.

Figure 29-4 TIA/EIA Standard Ethernet Cabling Pinouts



For the exam, you should be well prepared to choose which type of cable (straight-through or crossover) is needed in each part of the network. In short, devices on opposite ends of a cable that use the same pair of pins to transmit need a crossover cable. Devices that use an opposite pair of pins to transmit need a straight-through cable. Table 29-2 lists typical devices and the pin pairs they use, assuming that they use 10BASE-T and 100BASE-TX.

Table 29-2 10BASE-T and 100BASE-TX Pin Pairs Used

Devices That Transmit on 1,2 and Receive on 3,6	Devices That Transmit on 3,6 and Receive on 1,2
PC NICs	Hubs
Routers	Switches
Wireless access points (Ethernet interfaces)	—
Networked printers (printers that connect directly to the LAN)	—

1000BASE-T requires four wire pairs because Gigabit Ethernet transmits and receives on each of the four wire pairs simultaneously.

However, Gigabit Ethernet does have a concept of straight-through and crossover cables, with a minor difference in the crossover cables. The pinouts for a straight-through cable are the same—pin 1 to pin 1, pin 2 to pin 2, and so on. The crossover cable crosses the same two-wire pair as the crossover cable for the other types of Ethernet—the pair at pins 1,2 and 3,6—as well as crossing the two other pairs (the pair at pins 4,5 with the pair at pins 7,8).

Benefits of Using Switches

A collision domain is a set of devices whose frames could collide. All devices on a 10BASE2, 10BASE5, or any network using a hub risk collisions between the frames that they send, so all devices on one of these types of Ethernet networks are in the same collision domain and use CSMA/CD to detect and resolve collisions.

LAN switches significantly reduce, or even eliminate, the number of collisions on a LAN. Unlike hubs, switches do not create a single shared bus. Instead, switches do the following:

- They interpret the bits in the received frame so that they can typically send the frame out the one required port, rather than all other ports.
- If a switch needs to forward multiple frames out the same port, the switch buffers the frames in memory, sending one at a time, thereby avoiding collisions.

In addition, switches with only one device cabled to each port of the switch allow the use of full-duplex operation. Full-duplex means that the NIC can send and receive concurrently, effectively doubling the bandwidth of a 100Mbps link to 200Mbps—100Mbps for sending and 100Mbps for receiving.

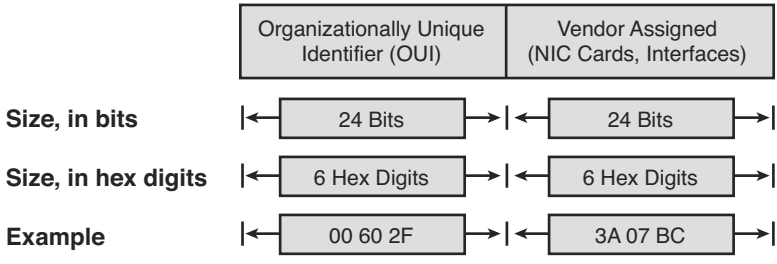
These seemingly simple switch features provide significant performance improvements as compared with using hubs. In particular:

- If only one device is cabled to each port of a switch, no collisions can occur.
- Devices connected to one switch port do not share their bandwidth with devices connected to another switch port. Each has its own separate bandwidth, meaning that a switch with 100Mbps ports has 100Mbps of bandwidth per port.

Ethernet Addressing

The IEEE defines the format and assignment of LAN addresses. To ensure a unique MAC address, the first half of the address identifies the manufacturer of the card. This code is called the organizationally unique identifier (OUI). Each manufacturer assigns a MAC address with its own OUI as the first half of the address. The second half of the address is assigned by the manufacturer and is never used on another card or network interface with the same OUI. Figure 29-5 shows the structure of a unicast Ethernet address.

Figure 29-5 Structure of a Unicast Ethernet Address



Ethernet also has group addresses, which identify more than one NIC or network interface. The IEEE defines two general categories of group addresses for Ethernet:

- **Broadcast addresses:** The broadcast address implies that all devices on the LAN should process the frame and has a value of FFFF.FFFF.FFFF.
- **Multicast addresses:** Multicast addresses are used to allow a subset of devices on a LAN to communicate. When IP multicasts over an Ethernet, the multicast MAC addresses used by IP follow this format: 0100.5exx.xxxx. The xx.xxxx portion is divided between IPv4 multicast (00:0000–7F.FFFF) and MPLS multicast (80:0000–8F:FFFF). Multiprotocol Label Switching (MPLS) is a CCNP topic.

Ethernet Framing

The physical layer helps you get a string of bits from one device to another. The framing of the bits allows the receiving device to interpret the bits. The term *framing* refers to the definition of the fields assumed to be in the data that is received. Framing defines the meaning of the bits transmitted and received over a network.

The framing used for Ethernet has changed a couple of times over the years. Each iteration of Ethernet is shown in Figure 29-6, with the current version shown at the bottom.

Figure 29-6 Ethernet Frame Formats

DIX

Preamble 8	Destination 6	Source 6	**Type** 2	Data and Pad 46 – 1500	FCS 4

IEEE 802.3 (Original)

Preamble 7	**SFD** 1	Destination 6	Source 6	**Length** 2	Data and Pad 46 – 1500	FCS 4

IEEE 802.3 (Revised 1997)

	Preamble 7	**SFD** 1	Destination 6	Source 6	**Length/ Type** 2	Data and Pad 46 – 1500	FCS 4
Bytes							

The fields in the last version shown in Figure 29-6 are explained further in Table 29-3.

Table 29-3 IEEE 802.3 Ethernet Field Descriptions

Field	Field Length in Bytes	Description
Preamble	7	Synchronization
Start Frame Delimiter (SFD)	1	Signifies that the next byte begins the Destination MAC field
Destination MAC Address	6	Identifies the intended recipient of this frame
Source MAC Address	6	Identifies the sender of this frame
Length	2	Defines the length of the data field of the frame (either length or type is present, but not both)
Type	2	Defines the type of protocol listed inside the frame (either length or type is present, but not both)
Data and Pad	46–1500	Holds data from a higher layer, typically a Layer 3 PDU (generic), and often an IP packet
Frame Check Sequence (FCS)	4	Provides a method for the receiving NIC to determine whether the frame experienced transmission errors

The Role of the Physical Layer

We have already discussed the most popular cabling used in LANs—UTP. But to fully understand the operation of the network, you should know some additional basic concepts of the physical layer.

The OSI physical layer accepts a complete frame from the data link layer and encodes it as a series of signals that are transmitted onto the local media.

The delivery of frames across the local media requires the following physical layer elements:

- The physical media and associated connectors
- A representation of bits on the media
- Encoding of data and control information
- Transmitter and receiver circuitry on the network devices

There are three basic forms of network media on which data is represented:

- Copper cable
- Fiber
- Wireless (IEEE 802.11)

Bits are represented on the medium by changing one or more of the following characteristics of a signal:

- Amplitude
- Frequency
- Phase

The nature of the actual signals representing the bits on the media will depend on the signaling method in use. Some methods might use one attribute of a signal to represent a single 0 and use another attribute of a signal to represent a single 1. The actual signaling method and its detailed operation are not important to your CCNA exam preparation.

Study Resources

For today's exam topics, refer to the following resources for more study.

Resource	Location	Topic
Primary Resources		
Network Basics	10	All
Introduction to Networks	5	All
ICND1 Official Cert Guide	2	Building Physical Ethernet Networks with UTP Sending Data in Ethernet Networks
ICND1 Foundation Learning Guide	3	All
Supplemental Resources		
CCENT Practice and Study Guide	5	All
Flash Cards	3	Relevant Questions
CCNA R&S Portable Command Guide	4	All

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Index

Symbols

A

B

C

D

E

F

G

H

I

J-K-L

M

N

O

P

Q

R

S

T

U

V

W-X-Y-Z