



CCNP SWITCH Exam Preparation



CCNP SWITCH 642-813

Official Certification Guide

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CCNP SWITCH 642-813 Official Certification Guide

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Foreword

CCNP SWITCH 642-813 Official Certification Guide is an excellent self-study resource for the CCNP SWITCH exam. Passing this exam is a crucial step to attaining the valued CCNP Routing and Switching certification.

Gaining certification in Cisco technology is key to the continuing educational development of today's networking professional. Through certification programs, Cisco validates the skills and expertise required to effectively manage the modern enterprise network.

Cisco Press Certification Guides and preparation materials offer exceptional—and flexible—access to the knowledge and information required to stay current in your field of expertise or to gain new skills. Whether used as a supplement to more traditional training or as a primary source of learning, these materials offer users the information and knowledge validation required to gain new understanding and proficiencies.

Developed in conjunction with the Cisco certifications and training team, Cisco Press books are the only self-study books authorized by Cisco and offer students a series of exam practice tools and resource materials to help ensure that learners fully grasp the concepts and information presented.

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I hope that you find these materials to be an enriching and useful part of your exam preparation.

Erik Ullanderson
Manager, Global Certifications
Learning@Cisco
January 2010

Introduction: Overview of Certification and How to Succeed

Professional certifications have been an important part of the computing industry for many years and will continue to become more important. Many reasons exist for these certifications, but the most popularly cited reason is that of credibility. All other considerations held equal, the certified employee/consultant/job candidate is considered more valuable than one who is not.

Objectives and Methods

The most important and somewhat obvious objective of this book is to help you pass the Cisco CCNP SWITCH exam (Exam 642-813). In fact, if the primary objective of this book were different, the book's title would be misleading; however, the methods used in this book to help you pass the SWITCH exam are designed to also make you much more knowledgeable about how to do your job. Although this book and the accompanying CD have many exam preparation tasks and example test questions, the method in which they are used is not to simply make you memorize as many questions and answers as you possibly can.

The methodology of this book helps you discover the exam topics about which you need more review, fully understand and remember exam topic details, and prove to yourself that you have retained your knowledge of those topics. So this book helps you pass not by memorization, but by helping you truly learn and understand the topics. The SWITCH exam is just one of the foundation topics in the CCNP Routing and Switching certification, and the knowledge contained within is vitally important to consider yourself a truly skilled routing and switching engineer or specialist. This book would do you a disservice if it did not attempt to help you learn the material. To that end, the book can help you pass the SWITCH exam by using the following methods:

- Covering all the exam topics and helping you discover which exam topics you have not mastered
- Providing explanations and information to fill in your knowledge gaps
- Supplying exam preparation tasks and example networks with diagrams and sample configurations that all enhance your ability to recall and deduce the answers to test questions
- Providing practice exercises on the exam topics and the testing process through test questions on the CD

Who Should Read This Book?

This book is not designed to be a general networking topics book, although it can be used for that purpose. This book is intended to tremendously increase your chances of passing the Cisco SWITCH exam. Although other objectives can be achieved from using this book, the book is written with one goal in mind: to help you pass the exam.

The SWITCH exam is primarily based on the content of the Cisco SWITCH course. You should have either taken the course, read through the SWITCH coursebook or this book, or have a couple of years of LAN switching experience.

Cisco Certifications and Exams

Cisco offers four levels of routing and switching certification, each with an increasing level of proficiency: Entry, Associate, Professional, and Expert. These are commonly known by their acronyms CCENT (Cisco Certified Entry Networking Technician), CCNA (Cisco Certified Network Associate), CCNP (Cisco Certified Network Professional), and CCIE (Cisco Certified Internetworking Expert). There are others, too, but this book focuses on the certifications for enterprise networks.

For the CCNP Routing and Switching certification, you must pass exams on a series of CCNP topics, including the SWITCH, ROUTE, and TSHOOT exams. For most exams, Cisco does not publish the scores needed for passing. You need to take the exam to find that out for yourself.

To see the most current requirements for the CCNP Routing and Switching certification, go to Cisco.com and click Training and Events. There you can find out other exam details such as exam topics and how to register for an exam.

The strategy you use to prepare for the SWITCH exam might be slightly different from strategies used by other readers, mainly based on the skills, knowledge, and experience you already have obtained. For instance, if you have attended the SWITCH course, you might take a different approach than someone who learned switching through on-the-job training. Regardless of the strategy you use or the background you have, this book is designed to help you get to the point where you can pass the exam with the least amount of time required.

How This Book Is Organized

Although this book can be read cover to cover, it is designed to be flexible and allow you to easily move between chapters and sections of chapters to cover only the material that you need more work with. The chapters can be covered in any order, although some chapters are related and build upon each other. If you do intend to read them all, the order in the book is an excellent sequence to use.

Each core chapter covers a subset of the topics on the CCNP SWITCH exam. The chapters are organized into parts, covering the following topics:

Part I: New CCNP Exam Approaches

- **Chapter 1, “The Planning Tasks of the CCNP Exams”**—This chapter explains the roles of a networking professional in the context of the Cisco Lifecycle Model, where network tasks form a cycle over time. The CCNP SWITCH exam covers real-world or practical skills that are necessary as a network is designed, planned, implemented, verified, and tuned.

Part II: Building a Campus Network

- **Chapter 2, “Switch Operation”**—This chapter covers Layer 2 and multilayer switch operation, how various content-addressable memory (CAM) and ternary content-addressable memory (TCAM) tables are used to make switching decisions, and how to monitor these tables to aid in troubleshooting.
- **Chapter 3, “Switch Port Configuration”**—This chapter covers basic Ethernet concepts, how to use scalable Ethernet, how to connect switch and devices together, and how to verify switch port operation to aid in troubleshooting.
- **Chapter 4, “VLANs and Trunks”**—This chapter covers basic VLAN concepts, how to transport multiple VLANs over single links, how to configure VLAN trunks, and how to verify VLAN and trunk operation.
- **Chapter 5, “VLAN Trunking Protocol”**—This chapter covers VLAN management using VTP, VTP configuration, traffic management through VTP pruning, and how to verify VTP operation.
- **Chapter 6, “Aggregating Switch Links”**—This chapter covers switch port aggregation with EtherChannel, EtherChannel negotiation protocols, EtherChannel configuration, and how to verify EtherChannel operation.
- **Chapter 7, “Traditional Spanning Tree Protocol”**—This chapter covers IEEE 802.1D Spanning Tree Protocol (STP) and gives an overview of the other STP types that might be running on a switch.
- **Chapter 8, “Spanning-Tree Configuration”**—This chapter covers the STP root bridge, how to customize the STP topology, how to tune STP convergence, redundant link convergence, and how to verify STP operation.
- **Chapter 9, “Protecting the Spanning Tree Protocol Topology”**—This chapter covers protecting the STP topology using Root Guard, BPDU Guard, and Loop Guard, and also how to use BPDU filtering and how to verify that these STP protection mechanisms are functioning properly.
- **Chapter 10, “Advanced Spanning Tree Protocol”**—This chapter covers Rapid Spanning Tree Protocol (RSTP) for Rapid PVST+ and Multiple Spanning Tree (MST) Protocol.
- **Chapter 11, “Multilayer Switching”**—This chapter covers interVLAN routing, multilayer switching with Cisco Express Forwarding (CEF), and how to verify that multilayer switching is functioning properly.

Part III: Designing Campus Networks

- **Chapter 12, “Enterprise Campus Network Design”**—This chapter covers different campus network models, hierarchical network design, and how to design, size, and scale a campus network using a modular approach.
- **Chapter 13, “Layer 3 High Availability”**—This chapter covers providing redundant router or gateway addresses on Catalyst switches and verifying that redundancy is functioning properly.

Part IV: Campus Network Services

- **Chapter 14, “IP Telephony”**—This chapter covers how a Catalyst switch can provide power to operate a Cisco IP Phone, how voice traffic can be carried over the links between an IP Phone and a Catalyst switch, QoS for voice traffic, and how to verify that IP Telephony features are functioning properly.
- **Chapter 15, “Integrating Wireless LANs”**—This chapter covers different approaches to integrating autonomous and lightweight wireless access points into a switched campus network.

Part V: Securing Switched Networks

- **Chapter 16, “Securing Switch Access”**—This chapter covers switch authentication, authorization, and accounting (AAA); port security using MAC addresses; port-based security using IEEE 802.1x; DHCP snooping; and dynamic ARP inspection.
- **Chapter 17, “Securing with VLANs”**—This chapter covers how to control traffic within a VLAN using access lists, implementing private VLANs, and monitoring traffic on switch ports for security reasons.

Part VI: Final Exam Preparation

- **Chapter 18, “Final Preparation”**—This chapter explains how to use the practice exam CD to enhance your study, along with a basic study plan.

There is also an appendix that has answers to the “Do I Know This Already” quizzes and an appendix that tells you how to find any updates should there be changes to the exam.

Each chapter in the book uses several features to help you make the best use of your time in that chapter. The features are as follows:

- **Assessment**—Each chapter begins with a “Do I Know This Already?” quiz that helps you determine the amount of time you need to spend studying each topic of the chapter. If you intend to read the entire chapter, you can save the quiz for later use. Questions are all multiple choice, to give a quick assessment of your knowledge.
- **Foundation Topics**—This is the core section of each chapter that explains the protocols, concepts, and configuration for the topics in the chapter.
- **Exam Preparation Tasks**—At the end of each chapter, this section collects key topics, references to memory table exercises to be completed as memorization practice, key terms to define, and a command reference that summarizes relevant commands presented in the chapter.

Finally, there is a CD-based practice exam. The companion CD contains a practice CCNP SWITCH exam containing a bank of test questions to reinforce your understanding of the book's concepts. This is the best tool for helping you prepare for the actual test-taking process.

The CD also contains the Memory Table exercises and answer keys that come up at the end of each chapter.

How to Use This Book for Study

Retention and recall are the two features of human memory most closely related to performance on tests. This exam-preparation guide focuses on increasing both retention and recall of the topics on the exam. The other human characteristic involved in successfully passing the exam is intelligence; this book does not address that issue!

This book is designed with features to help you increase retention and recall. It does this in the following ways:

- By providing succinct and complete methods of helping you decide what you recall easily and what you do not recall at all.
- By giving references to the exact passages in the book that review those concepts you most need to recall, so you can quickly be reminded about a fact or concept. Repeating information that connects to another concept helps retention, and describing the same concept in several ways throughout a chapter increases the number of connectors to the same pieces of information.
- Finally, accompanying this book is a CD that has exam-like questions. These are useful for you to practice taking the exam and to get accustomed to the time restrictions imposed during the exam.

When taking the “Do I Know This Already?” assessment quizzes in each chapter, make sure that you treat yourself and your knowledge fairly. If you come across a question that makes you guess at an answer, mark it wrong immediately. This forces you to read through the part of the chapter that relates to that question and forces you to learn it more thoroughly.

If you find that you do well on the assessment quizzes, it still might be wise to quickly skim through each chapter to find sections or topics that do not readily come to mind. Look for the Key Topics icons. Sometimes even reading through the detailed table of contents will reveal topics that are unfamiliar or unclear. If that happens to you, mark those chapters or topics and spend time working through those parts of the book.



CCNP SWITCH Exam Topics

Carefully consider the exam topics Cisco has posted on its website as you study, particularly for clues to how deeply you should know each topic. Beyond that, you cannot go wrong by developing a broader knowledge of the subject matter. You can do that by reading and studying the topics presented in this book. Remember that it is in your best

interest to become proficient in each of the CCNP subjects. When it is time to use what you have learned, being well rounded counts more than being well tested.

Table I-1 shows the official exam topics for the SWITCH exam, as posted on Cisco.com. Note that Cisco has occasionally changed exam topics without changing the exam number, so do not be alarmed if small changes in the exam topics occur over time. When in doubt, go to Cisco.com and click Training and Events.

Table I-1—CCNP SWITCH Exam Topics

Exam Topic	Part of This Book Where Exam Topic Is Covered
<i>Implement VLAN-based solution, given a network design and a set of requirements</i>	
Determine network resources needed for implementing VLAN-based solution on a network.	Part II, “Building a Campus Network” Chapters 2–10
Create a VLAN-based implementation plan.	
Create a VLAN-based verification plan.	
Configure switch-to-switch connectivity for the VLAN-based solution.	
Configure loop prevention for the VLAN-based solution.	
Configure access ports for the VLAN-based solution.	
Verify the VLAN-based solution was implemented properly using show and debug commands.	
Document results of VLAN implementation and verification	
<i>Implement a security extension of a Layer 2 solution, given a network design and a set of requirements</i>	
Determine network resources needed for implementing a security solution.	Part V, “Securing Switched Networks” Chapters 16–17
Create a implementation plan for the security solution.	
Create a verification plan for the security solution.	
Configure port security features.	
Configure general switch security features.	
Configure private VLANs.	
Configure VACL and PACL.	
Verify the security solution was implemented properly using show and debug commands.	
Document results of security implementation and verification.	

Table I-1—CCNP SWITCH Exam Topics

Exam Topic	Part of This Book Where Exam Topic Is Covered
<i>Implement switch-based Layer 3 services, given a network design and a set of requirements</i>	
Determine network resources needed for implementing a switch-based Layer 3 solution.	Part II, “Building a Campus Network”
Create an implementation plan for the switch-based Layer 3 solution.	Chapter 11
Create a verification plan for the switch-based Layer 3 solution.	
Configure routing interfaces.	
Configure Layer 3 security.	
Verify the switch-based Layer 3 solution was implemented properly using show and debug commands.	
Document results of switch-based Layer 3 implementation and verification.	
<i>Prepare infrastructure to support advanced services</i>	
Implement a wireless extension of a Layer 2 solution.	Part IV, “Campus Network Services”
Implement a VoIP support solution.	Chapters 14–15
Implement video support solution.	
<i>Implement high availability, given a network design and a set of requirements</i>	
Determine network resources needed for implementing high availability on a network.	Part III, “Designing Campus Networks”
Create a high availability implementation plan.	Chapters 12–13
Create a high availability verification plan.	
Implement first-hop redundancy protocols.	
Implement switch supervisor redundancy.	
Verify high-availability solution was implemented properly using show and debug commands.	
Document results of high-availability implementation and verification.	

For More Information

If you have any comments about the book, you can submit those via the [Ciscopress.com](http://www.ciscopress.com) website. Just go to the website, select Contact Us, and type in your message. Cisco might make changes that affect the CCNP Routing and Switching certification from time to time. You should always check [Cisco.com](http://www.cisco.com) for the latest details. Also, you can look to <http://www.ciscopress.com/title/1587202433>, where we publish any information pertinent to how you might use this book differently in light of future changes from Cisco. For example, if Cisco decides to remove a major topic from the exam, it might post that on its website; Cisco Press will make an effort to list that information as well via an online updates appendix.



This chapter covers the following topics that you need to master for the CCNP SWITCH exam:

Protecting Against Unexpected BPDUs—This section covers the Root Guard and BPDU Guard features, which protect against unexpected root candidates and unexpected BPDUs, respectively.

Protecting Against Sudden Loss of BPDUs—This section discusses the Loop Guard and UDLD features, which detect and protect against the loss of root bridge BPDUs and conditions causing unidirectional links, respectively.

Using BPDU Filtering to Disable STP on a Port—This section explains how to filter BPDUs on a switch port to prevent the port from participating in STP altogether. Bridging loops are neither detected nor prevented.

Troubleshooting STP Protection—This section summarizes the commands that diagnose or verify actions to protect the topology.

Protecting the Spanning Tree Protocol Topology

Achieving and maintaining a loop-free Spanning Tree Protocol (STP) topology revolves around the simple process of sending and receiving bridge protocol data units (BPDU). Under normal conditions, with all switches playing fairly and according to the rules, a loop-free topology is determined dynamically.

This chapter discusses two basic conditions that can occur to disrupt the loop-free topology (even while STP is running):

On a port that has not been receiving BPDUs, BPDUs are not expected. When BPDUs suddenly appear for some reason, the STP topology can reconverge to give unexpected results.

On a port that normally receives BPDUs, BPDUs always are expected. When BPDUs suddenly disappear for some reason, a switch can make incorrect assumptions about the topology and unintentionally create loops.

“Do I Know This Already?” Quiz

The “Do I Know This Already?” quiz allows you to assess whether you should read this entire chapter thoroughly or jump to the “Exam Preparation Tasks” section. If you are in doubt based on your answers to these questions or your own assessment of your knowledge of the topics, read the entire chapter. Table 9-1 outlines the major headings in this chapter and the “Do I Know This Already?” quiz questions that go with them. You can find the answers in Appendix A, “Answers to the ‘Do I Know This Already?’ Quizzes.”

Table 9-1 “Do I Know This Already?” Foundation Topics Section-to-Question Mapping

Foundation Topics Section	Questions Covered in This Section
Protecting Against Unexpected BPDUs	1–5
Protecting Against Sudden Loss of BPDUs	6–11
Using BPDU Filtering to Disable STP on a Port	12
Troubleshooting STP Protection	13

1. Why is it important to protect the placement of the root bridge?
 - a. To keep two root bridges from becoming active
 - b. To keep the STP topology stable

- c. So all hosts have the correct gateway
 - d. So the root bridge can have complete knowledge of the STP topology
- 2. Which of the following features protects a switch port from accepting superior BPDUs?
 - a. STP Loop Guard
 - b. STP BPDU Guard
 - c. STP Root Guard
 - d. UDLD
- 3. Which of the following commands can you use to enable STP Root Guard on a switch port?
 - a. `spanning-tree root guard`
 - b. `spanning-tree root-guard`
 - c. `spanning-tree guard root`
 - d. `spanning-tree rootguard enable`
- 4. Where should the STP Root Guard feature be enabled on a switch?
 - a. All ports
 - b. Only ports where the root bridge should never appear
 - c. Only ports where the root bridge should be located
 - d. Only ports with PortFast enabled
- 5. Which of the following features protects a switch port from accepting BPDUs when PortFast is enabled?
 - a. STP Loop Guard
 - b. STP BPDU Guard
 - c. STP Root Guard
 - d. UDLD
- 6. To maintain a loop-free STP topology, which one of the following should a switch up-link be protected against?
 - a. A sudden loss of BPDUs
 - b. Too many BPDUs
 - c. The wrong version of BPDUs
 - d. BPDUs relayed from the root bridge
- 7. Which of the following commands can enable STP Loop Guard on a switch port?
 - a. `spanning-tree loop guard`
 - b. `spanning-tree guard loop`
 - c. `spanning-tree loop-guard`
 - d. `spanning-tree loopguard enable`

- 8.** STP Loop Guard detects which of the following conditions?
 - a.** The sudden appearance of superior BPDUs
 - b.** The sudden lack of BPDUs
 - c.** The appearance of duplicate BPDUs
 - d.** The appearance of two root bridges

- 9.** Which of the following features can actively test for the loss of the receive side of a link between switches?
 - a.** POST
 - b.** BPDU
 - c.** UDLD
 - d.** STP

- 10.** UDLD must detect a unidirectional link before which of the following?
 - a.** The Max Age timer expires.
 - b.** STP moves the link to the Blocking state.
 - c.** STP moves the link to the Forwarding state.
 - d.** STP moves the link to the Listening state.

- 11.** What must a switch do when it receives a UDLD message on a link?
 - a.** Relay the message on to other switches
 - b.** Send a UDLD acknowledgment
 - c.** Echo the message back across the link
 - d.** Drop the message

- 12.** Which of the following features effectively disables spanning-tree operation on a switch port?
 - a.** STP PortFast
 - b.** STP BPDU filtering
 - c.** STP BPDU Guard
 - d.** STP Root Guard

- 13.** To reset switch ports that have been put into the errdisable mode by UDLD, which one of the following commands should be used?
 - a.** `clear errdisable udd`
 - b.** `udd reset`
 - c.** `no udd`
 - d.** `show udd errdisable`

Foundation Topics

Protecting Against Unexpected BPDUs

A network running STP uses BPDUs to communicate between switches (bridges). Switches become aware of each other and of the topology that interconnects them. After a root bridge is elected, BPDUs are generated by the root and are relayed down through the spanning-tree topology. Eventually, all switches in the STP domain receive the root's BPDUs so that the network converges and a stable loop-free topology forms.

To maintain an efficient topology, the placement of the root bridge must be predictable. Hopefully, you configured one switch to become the root bridge and a second one to be the secondary root. What happens when a “foreign” or rogue switch is connected to the network, and that switch suddenly is capable of becoming the root bridge? Cisco added two STP features that help prevent the unexpected: Root Guard and BPDU Guard.

Root Guard

After an STP topology has converged and becomes loop free, switch ports are assigned the following roles:

- **Root port**—The one port on a switch that is closest (with the lowest root path cost) to the root bridge.
- **Designated port**—The port on a LAN segment that is closest to the root. This port relays, or transmits, BPDUs down the tree.
- **Blocking port**—Ports that are neither root nor designated ports.
- **Alternate port**—Ports that are candidate root ports (they are also close to the root bridge) but are in the Blocking state. These ports are identified for quick use by the STP UplinkFast feature.
- **Forwarding port**—Ports where no other STP activity is detected or expected. These are ports with normal end-user connections.

The root bridge always is expected to be seen on the root port and the alternative ports because these are “closest” (have the best-cost path) to it.

Suppose that another switch is introduced into the network with a bridge priority that is more desirable (lower) than that of the current root bridge. The new switch then would become the root bridge, and the STP topology might reconverge to a new shape. This is entirely permissible by the STP because the switch with the lowest bridge ID always wins the root election.

However, this is not always desirable for you, the network administrator, because the new STP topology might be something totally unacceptable. In addition, while the topology is reconverging, your production network might become unavailable.

The Root Guard feature was developed as a means to control where candidate root bridges can be connected and found on a network. Basically, a switch learns the current root



bridge's bridge ID. If another switch advertises a *superior BPDU*, or one with a better bridge ID, on a port where Root Guard is enabled, the local switch will not allow the new switch to become the root. As long as the superior BPDUs are being received on the port, the port will be kept in the *root-inconsistent* STP state. No data can be sent or received in that state, but the switch can listen to BPDUs received on the port to detect a new root advertising itself.

In essence, Root Guard designates that a port can only forward or relay BPDUs; the port can't be used to receive BPDUs. Root Guard prevents the port from ever becoming a root port where BPDUs normally would be received from the root bridge.

You can enable Root Guard only on a per-port basis. By default, it is disabled on all switch ports. To enable it, use the following interface configuration command:

```
Switch(config-if)# spanning-tree guard root
```

When the superior BPDUs no longer are received, the port is cycled through the normal STP states to return to normal use.

Use Root Guard on switch ports where you never expect to find the root bridge for a VLAN. In fact, Root Guard affects the entire port so that a root bridge never can be allowed on *any* VLAN on the port. When a superior BPDU is heard on the port, the entire port, in effect, becomes blocked.

Tip: You can display switch ports that Root Guard has put into the root-inconsistent state with the following command:

```
Switch# show spanning-tree inconsistentports
```

BPDU Guard

Recall that the traditional STP offers the PortFast feature, in which switch ports are allowed to immediately enter the Forwarding state as soon as the link comes up. Normally, PortFast provides quick network access to end-user devices, where bridging loops never are expected to form. Even while PortFast is enabled on a port, STP still is running and can detect a bridging loop. However, a loop can be detected only in a finite amount of time—the length of time required to move the port through the normal STP states.

Note: Remember that enabling PortFast on a port is not the same as disabling the STP on it.

By definition, if you enable PortFast, you do not expect to find anything that can cause a bridging loop—especially another switch or device that produces BPDUs. Suppose that a switch is connected by mistake to a port where PortFast is enabled. Now there is a potential for a bridging loop to form. An even greater consequence is that the potential now exists for the newly connected device to advertise itself and become the new root bridge.

The BPDU Guard feature was developed to further protect the integrity of switch ports that have PortFast enabled. If any BPDU (whether superior to the current root or not) is



received on a port where BPDU Guard is enabled, that port immediately is put into the errdisable state. The port is shut down in an error condition and must be either manually re-enabled or automatically recovered through the errdisable timeout function.

By default, BPDU Guard is disabled on all switch ports. You can configure BPDU Guard as a global default, affecting all switch ports with a single command. All ports that have PortFast enabled also have BPDU Guard automatically enabled. You can use the following global configuration command to enable BPDU Guard as the default:

```
Switch(config)# spanning-tree portfast bpduguard default
```

You also can enable or disable BPDU Guard on a per-port basis, using the following interface configuration command:

```
Switch(config-if)# [no] spanning-tree bpduguard enable
```

When the BPDUs no longer are received, the port still remains in the errdisable state. See Chapter 3, “Switch Port Configuration,” for more information about recovering from the errdisable state.

You should use BPDU Guard on all switch ports where STP PortFast is enabled. This prevents any possibility that a switch will be added to the port, either intentionally or by mistake. An obvious application for BPDU Guard is on access-layer switch ports where users and end devices connect. BPDUs normally would not be expected there and would be detected if a switch or hub inadvertently were connected.

Naturally, BPDU Guard does not prevent a bridging loop from forming if an Ethernet hub is connected to the PortFast port. This is because a hub doesn't transmit BPDUs itself; it merely repeats Ethernet frames from its other ports. A loop could form if the hub became connected to two locations in the network, providing a path for frames to be looped without any STP activity.

You never should enable BPDU Guard on any switch uplink where the root bridge is located. If a switch has multiple uplinks, any of those ports could receive legitimate BPDUs from the root—even if they are in the Blocking state as a result of the UplinkFast feature. If BPDU Guard is enabled on an uplink port, BPDUs will be detected and the uplink will be put into the Errdisable state. This will preclude that uplink port from being used as an uplink into the network.

Protecting Against Sudden Loss of BPDUs

STP BPDUs are used as probes to learn about a network topology. When the switches participating in STP converge on a common and consistent loop-free topology, BPDUs still must be sent by the root bridge and must be relayed by every other switch in the STP domain. The STP topology's integrity then depends on a continuous and regular flow of BPDUs from the root.

What happens if a switch doesn't receive BPDUs in a timely manner or when it doesn't receive any? The switch can view that condition as acceptable—perhaps an upstream switch or an upstream link is dead. In that case, the topology must have changed, so blocked ports eventually can be unblocked again.

However, if the absence of BPDUs is actually a mistake and BPDUs are not being received even though there is no topology change, bridging loops easily can form.

Cisco has added two STP features that help detect or prevent the unexpected loss of BPDUs:

- Loop Guard
- Unidirectional Link Detection (UDLD)

Loop Guard

Suppose that a switch port is receiving BPDUs and the switch port is in the Blocking state. The port makes up a redundant path; it is blocking because it is neither a root port nor a designated port. It will remain in the Blocking state as long as a steady flow of BPDUs is received.

If BPDUs are being sent over a link but the flow of BPDUs stops for some reason, the last-known BPDU is kept until the Max Age timer expires. Then that BPDU is flushed, and the switch thinks there is no longer a need to block the port. After all, if no BPDUs are received, there must not be another STP device connected there.

The switch then moves the port through the STP states until it begins to forward traffic—and forms a bridging loop. In its final state, the port becomes a designated port where it begins to relay or send BPDUs downstream, when it actually should be receiving BPDUs from upstream.

To prevent this situation, you can use the Loop Guard STP feature. When enabled, Loop Guard keeps track of the BPDU activity on nondesignated ports. While BPDUs are received, the port is allowed to behave normally. When BPDUs go missing, Loop Guard moves the port into the loop-inconsistent state. The port is effectively blocking at this point to prevent a loop from forming and to keep it in the nondesignated role.



When BPDUs are received on the port again, Loop Guard allows the port to move through the normal STP states and become active. In this fashion, Loop Guard automatically governs ports without the need for manual intervention.

By default, Loop Guard is disabled on all switch ports. You can enable Loop Guard as a global default, affecting all switch ports, with the following global configuration command:

```
Switch(config)# spanning-tree loopguard default
```

You also can enable or disable Loop Guard on a specific switch port by using the following interface-configuration command:

```
Switch(config-if)# [no] spanning-tree guard loop
```

Although Loop Guard is configured on a switch port, its corrective blocking action is taken on a per-VLAN basis. In other words, Loop Guard doesn't block the entire port; only the offending VLANs are blocked.

You can enable Loop Guard on all switch ports, regardless of their functions. The switch figures out which ports are nondesignated and monitors the BPDU activity to keep them nondesignated. Nondesignated ports are generally the alternative root ports and ports that normally are blocking.

UDLD

In a campus network, switches are connected by bidirectional links, where traffic can flow in two directions. Clearly, if a link has a physical layer problem, the two switches it connects detect a problem, and the link is shown as not connected.

What would happen if just one side of the link (receive or transmit) had an odd failure, such as malfunctioning transmit circuitry in a gigabit interface converter (GBIC) or small form factor pluggable (SFP) modules? In some cases, the two switches still might see a functional bidirectional link, although traffic actually would be delivered in only one direction. This is known as a *unidirectional link*.

A unidirectional link poses a potential danger to STP topologies because BPDUs will not be received on one end of the link. If that end of the link normally would be in the Blocking state, it will not be that way for long. A switch interprets the absence of BPDUs to mean that the port can be moved safely through the STP states so that traffic can be forwarded. However, if that is done on a unidirectional link, a bridging loop forms and the switch never realizes the mistake.



To prevent this situation, you can use the Cisco-proprietary Unidirectional Link Detection (UDLD) STP feature. When enabled, UDLD interactively monitors a port to see whether the link is truly bidirectional. A switch sends special Layer 2 UDLD frames identifying its switch port at regular intervals. UDLD expects the far-end switch to echo those frames back across the same link, with the far-end switch port's identification added.

If a UDLD frame is received in return and both neighboring ports are identified in the frame, the link must be bidirectional. However, if the echoed frames are not seen, the link must be unidirectional for some reason.

Naturally, an echo process such as this requires *both ends* of the link to be configured for UDLD. Otherwise, one end of the link will not echo the frames back to the originator. In addition, each switch at the end of a link sends its own UDLD messages independently, expecting echoes from the far end. This means that two echo processes are occurring on any given link.

UDLD messages are sent at regular intervals, as long as the link is active. You can configure the message interval UDLD uses. (The default is 15 seconds.) The objective behind UDLD is to detect a unidirectional link condition before STP has time to move a blocked port into the Forwarding state. To do this, the target time must be less than the Max Age timer plus two intervals of the Forward Delay timer, or 50 seconds. UDLD can detect a unidirectional link after about three times the UDLD message interval (45 seconds total, using the default).

UDLD has two modes of operation:

- **Normal mode**—When a unidirectional link condition is detected, the port is allowed to continue its operation. UDLD merely marks the port as having an undetermined state and generates a syslog message.
- **Aggressive mode**—When a unidirectional link condition is detected, the switch takes action to reestablish the link. UDLD messages are sent out once a second for 8

seconds. If none of those messages is echoed back, the port is placed in the Errdisable state so that it cannot be used.

You configure UDLD on a per-port basis, although you can enable it globally for all fiber-optic switch ports (either native fiber or fiber-based GBIC or SFP modules). By default, UDLD is disabled on all switch ports. To enable it globally, use the following global configuration command:

```
Switch(config)# udld {enable | aggressive | message time seconds}
```

For normal mode, use the **enable** keyword; for aggressive mode, use the **aggressive** keyword. You can use the **message time** keywords to set the message interval to *seconds*, ranging from 7 to 90 seconds. (The default interval varies according to switch platform. For example, the Catalyst 3550 default is 7 seconds; the Catalyst 4500 and 6500 default is 15 seconds.)

You also can enable or disable UDLD on individual switch ports, if needed, using the following interface configuration command:

```
Switch(config-if)# udld {enable | aggressive | disable}
```

Here, you can use the **disable** keyword to completely disable UDLD on a fiber-optic interface.

Note: The default UDLD message interval times differ among Catalyst switch platforms. Although two neighbors might have mismatched message time values, UDLD still works correctly. This is because each of the two neighbors simply echoes UDLD messages back as they are received, without knowledge of their neighbor's own time interval. The time interval is used only to decide when to send UDLD messages and as a basis for detecting a unidirectional link from the absence of echoed messages.

If you decide to change the default message time, make sure that UDLD still can detect a fault *before* STP decides to move a link to the Forwarding state.

You safely can enable UDLD on all switch ports. The switch globally enables UDLD only on ports that use fiber-optic media. Twisted-pair or copper media does not suffer from the physical layer conditions that allow a unidirectional link to form. However, you can enable UDLD on nonfiber links individually, if you want.

At this point, you might be wondering how UDLD can be enabled gracefully on the two end switches. Recall that in aggressive mode, UDLD disables the link if the neighbor does not reflect the messages back within a certain time period. If you are enabling UDLD on a production network, is there a chance that UDLD will disable working links before you can get the far end configured?

The answer is no. UDLD makes some intelligent assumptions when it is enabled on a link for the first time. First, UDLD has no record of any neighbor on the link. It starts sending out messages, hoping that a neighboring switch will hear them and echo them back. Obviously, the device at the far end also must support UDLD so that the messages will be echoed back.

If the neighboring switch does not yet have UDLD enabled, no messages will be echoed. UDLD will keep trying (indefinitely) to detect a neighbor and will not disable the link. After the neighbor has UDLD configured also, both switches become aware of each other and the bidirectional state of the link through their UDLD message exchanges. From then on, if messages are not echoed, the link can accurately be labeled as unidirectional.

Finally, be aware that if UDLD detects a unidirectional condition on a link, it takes action on only that link. This becomes important in an EtherChannel: If one link within the channel becomes unidirectional, UDLD flags or disables only the offending link in the bundle, not the entire EtherChannel. UDLD sends and echoes its messages on each link within an EtherChannel channel independently.

Using BPDU Filtering to Disable STP on a Port

Ordinarily, STP operates on all switch ports in an effort to eliminate bridging loops before they can form. BPDUs are sent on all switch ports—even ports where PortFast has been enabled. BPDUs also can be received and processed if any are sent by neighboring switches.



You always should allow STP to run on a switch to prevent loops. However, in special cases when you need to prevent BPDUs from being sent or processed on one or more switch ports, you can use BPDU filtering to effectively disable STP on those ports.

By default, BPDU filtering is disabled on all switch ports. You can configure BPDU filtering as a global default, affecting all switch ports with the following global configuration command:

```
Switch(config)# spanning-tree portfast bpdupfilter default
```

The **default** keyword indicates that BPDU filtering will be enabled automatically on all ports that have PortFast enabled. If PortFast is disabled on a port, then BPDU filtering will not be enabled there.

You also can enable or disable BPDU filtering on specific switch ports by using the following interface configuration command:

```
Switch(config-if)# spanning-tree bpdupfilter {enable | disable}
```

Be very careful to enable BPDU filtering only under controlled circumstances in which you are absolutely sure that a switch port will have a single host connected and that a loop will be impossible. Enable BPDU filtering only if the connected device cannot allow BPDUs to be accepted or sent. Otherwise, you should permit STP to operate on the switch ports as a precaution.

Troubleshooting STP Protection

With several different types of STP protection features available, you might need to know which (if any) has been configured on a switch port. Table 9-2 lists and describes the EXEC commands useful for verifying the features presented in this chapter.

Table 9-2 *Commands for Verifying and Troubleshooting STP Protection Features*

Display Function	Command Syntax
List the ports that have been labeled in an inconsistent state.	Switch# show spanning-tree inconsistentports
Look for detailed reasons for inconsistencies.	Switch# show spanning-tree interface <i>type mod/num</i> [detail]
Display the global BPDU Guard, BPDU filter, and Loop Guard states.	Switch# show spanning-tree summary
Display the UDLD status on one or all ports.	Switch# show udld [<i>type mod/num</i>]
Reenable ports that UDLD aggressive mode has errdisabled.	Switch# udld reset

Exam Preparation Tasks



Review All Key Topics

Review the most important topics in the chapter, noted with the Key Topic icon in the outer margin of the page. Table 9-3 lists a reference of these key topics and the page numbers on which each is found.

Table 9-3 *Key Topics for Chapter 9*

Key Topic Element	Description	Page Number
Paragraph	Discusses the Root Guard feature	180
Paragraph	Discusses the BPDU Guard feature	181
Paragraph	Discusses the Loop Guard feature	183
Paragraph	Discusses the UDLD feature	184
Paragraph	Explains BPDU filtering	186

Complete Tables and Lists from Memory

Print a copy of Appendix C, “Memory Tables,” (found on the CD), or at least the section for this chapter, and complete the tables and lists from memory. Appendix D, “Memory Tables Answer Key,” also on the CD, includes completed tables and lists to check your work.

Define Key Terms

Define the following key terms from this chapter, and check your answers in the glossary:

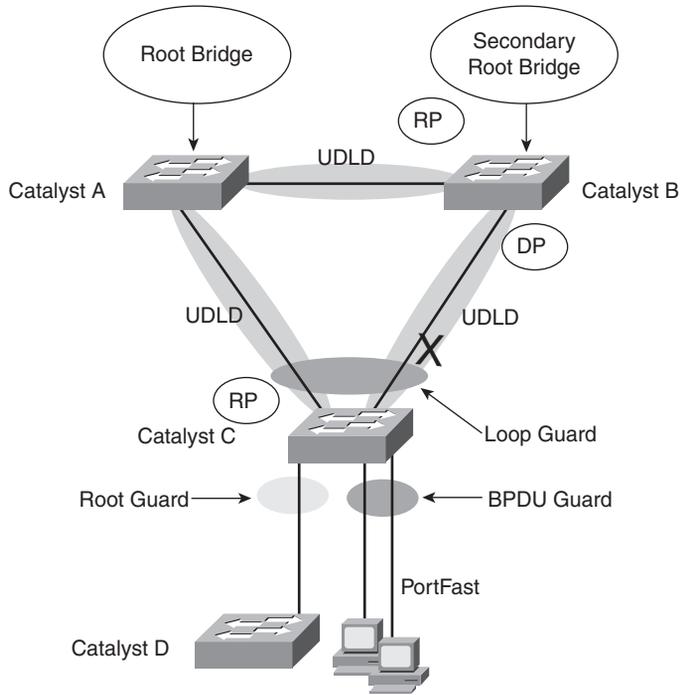
Root Guard, superior BPDU, BPDU Guard, Loop Guard, UDLD, BPDU filtering

Use Command Reference to Check Your Memory

This section includes the most important configuration and EXEC commands covered in this chapter. It might not be necessary to memorize the complete syntax of every command, but you should remember the basic keywords that are needed.

With so many similar and mutually exclusive STP protection features available, you might have a hard time remembering which ones to use where. Use Figure 9-1 as a quick reference.

Figure 9-1 shows two backbone switches (Catalyst A and B), along with an access-layer switch (Catalyst C), with redundant uplinks. Users are connected to the access switch, where PortFast is in use. An additional access switch (Catalyst D) has an uplink to access-layer switch C. All switch-to-switch links are fiber-based Gigabit Ethernet. Obviously, a root bridge never should appear out of Catalyst D.



Root guard: Apply to ports where root is never expected.

BPDU guard: Apply to all user ports where PortFast is enabled.

Loop guard: Apply to nondesignated ports but okay to apply to all ports.

UDLD: Apply to all fiber-optic links between switches (must be enabled on both ends).

Permissible combinations on a switch port:

- Loop guard and UDLD
- Root guard and UDLD

Not permissible on a switch port:

- Root guard and Loop guard
- Root guard and BPDU guard

Figure 9-1 Guidelines for Applying STP Protection Features in a Network

To test your memory of the STP protection feature commands, cover the rightmost columns of Tables 9-4 and 9-5 with a piece of paper, read the description on the left side, then see how much of the command you can remember.

Remember that the CCNP exam focuses on practical or hands-on skills that are used by a networking professional.

Table 9-4 STP Protection Configuration Commands

Task	Global Command Syntax	Interface Command Syntax
Enable Root Guard	—	Switch(config-if)# spanning-tree guard root
Enable BPDU Guard	Switch(config)# spanning-tree portfast bpduguard default	Switch(config-if)# spanning-tree bpduguard enable
Enable Loop Guard	Switch(config)# spanning-tree loopguard default	Switch(config-if)# spanning-tree guard loop
Enable UDLD	Switch(config)# udld {enable aggressive message time seconds}	Switch(config-if)# udld {enable aggressive disable}
Enable BPDU filtering	Switch(config)# spanning-tree bpdufilter default	Switch(config-if)# spanning-tree bpdufilter enable

Table 9-5 STP Protection Activity Commands

Task	Command Syntax
Look for ports that have been put in an inconsistent state	Switch# show spanning-tree inconsistentports
Display the global BPDU Guard, BPDU filter, and Loop Guard states	Switch# show spanning-tree summary
Show UDLD status	Switch# show udld [type mod/num]
Reenable all ports that UDLD has errdisabled	Switch# udld reset

Index

10GbE (10-Gigabit Ethernet), 47–48
10GEC (10-Gigabit EtherChannel),
108
10-Gigabit EtherChannel (10GEC),
108
10-Gigabit Ethernet (10GbE), 47–48
20/80 rule, 70
80/20 rule, 69

A

aaa authentication dot1x default group
radius command, 390
Accelerated CEF (aCEF), 225–226
access control lists. *See* ACLs (access
control lists)
access layer in hierarchical network
design, 251
access points (WLANs)
autonomous mode AP, 344–346
cells (coverage areas), 341–344
explained, 338–344
aCEF (Accelerated CEF), 225–226
ACLs (access control lists)
QoS ACLs (access control lists)
Layer 2 switching, 24
multilayer switching (MLS),
26
security ACLs (access control lists)
Layer 2 switching, 23
multilayer switching (MLS), 26
VLAN access lists (VACL), 396–397
action command, 408
activating practice exam content, 414
active hosts, determining, 33
active HSRP routers, 269
active virtual forwarder, 282–283
active virtual gateway, 281–282
Address Resolution Protocol. *See* ARP
(Address Resolution Protocol)
adjacency table, 226–229
advertisements (VTP), 89–92
client requests for, 91–92
origination of, 90
aggregation with EtherChannel,
108–112
alternate ports in RSTP (Rapid
Spanning Tree Protocol), 197
APs. *See* access points (WLANs)
architecture of WLANs, 344–354
Cisco Unified Wireless Network
Architecture
explained, 346–349
LAP (lightweight access point),
350–351
roaming in, 354–361

- traffic patterns*, 352–354
- WLC functions*, 349–350
- traditional architecture, 344–346
- ARP (Address Resolution Protocol),
 - dynamic ARP inspection, 383–385
- arp access-list command, 391
- ARP poisoning, 383
- ARP spoofing, 383
- ARP throttling, 228
- associating
 - ports with private VLANs, 400–401
 - secondary VLANs with primary VLAN SVI, 401–402
- associations (WLANs), 338
- authentication
 - MD5 authentication, 271–272
 - plain-text authentication, 271
 - port-based authentication, 376–378
 - in WLANs, 353
- auto qos voip command, 322, 328
- autonegotiation, 44–45
- autonomous mode AP, 344–346
 - configuring switchports for, 361–362
- Auto-QoS, configuring, 321–324
- availability. *See* redundancy
- AVF (active virtual forwarder), 282–283
- AVG (active virtual gateway), 281–282

B

- baby giant frames, 74
- BackboneFast feature (STP), 170–171
- backup ports in RSTP (Rapid Spanning Tree Protocol), 197
- bandwidth
 - basic Ethernet, 42–43
 - Fast Ethernet, 43–44
 - full-duplex Fast Ethernet, 44–45
 - Gigabit Ethernet, 45–47
- banner motd command, 385
- basic service set (BSS), 338–339
- best practices for security, 385–388
- best-effort delivery, 314
- big-endian format, 74
- Blocking state (STP ports), 137
- BPDU (bridge protocol data units), 130–131
 - in RSTP (Rapid Spanning Tree Protocol), 197–198
 - securing, 387
 - sudden loss of, 182–186
 - unexpected BPDUs, 180–182
- BPDU filtering, 186
- BPDU Guard feature (STP), 181–182
- bridge IDs, 131
 - for Catalyst switches, 158
 - manually setting, 158

bridge priorities, setting, 158

bridge protocol data units. *See* BPDU (bridge protocol data units)

bridging loops

in EtherChannel, 112

explained, 126–129

preventing, 129–130. *See also* protecting STP (Spanning Tree Protocol)

BSS (basic service set), 338–339

bundling

with EtherChannel, 108–112

ports with EtherChannel, 109

C

cabling

basic Ethernet, 43, 48–49

Fast Ethernet, 44, 48–49

Gigabit Ethernet, 46, 49–50

CAM (content-addressable memory), 27–28

Layer 2 switching, 23

monitoring, 32–34

campus networks, defined, 247

campuswide VLANs, 69–70

canonical format, 74

Canonical Format Indicator (CFI), 74

CAPWAP (Control and Provisioning Wireless Access Points protocol), 348

carrier sense multiple access collision detect (CSMA/CD), 42

Catalyst switches, STP bridge IDs for, 158

CDP, securing, 387–388

CEF (Cisco Express Forwarding), 221–230. *See also* topology-based MLS

adjacency table, 226–229

configuring, 229–230

FIB (Forwarding Information Base), 222–226

packet rewrite, 229

verifying, 232–233

cells (WLAN coverage areas), 341–344

CFI (Canonical Format Indicator), 74

channel-group mode command, 121

channel-protocol lacp command, 121

channel-protocol pagp command, 121

Cisco Express Forwarding (CEF). *See* CEF (Cisco Express Forwarding); topology-based MLS

Cisco Hybrid Remote Edge Access Point (HREAP), 351

Cisco Inline Power (ILP), 304

Cisco Learning Network, 416

Cisco Unified Wireless Network Architecture

explained, 346–349

LAP (lightweight access point), configuring, 350–351

roaming in, 354–361

intercontroller roaming, 356–361

intracontroller roaming, 355–356

mobility groups, 361

traffic patterns, 352–354

WLC functions, 349–350

class of service (CoS), 315

classes, packet precedence, 317

clear mac address-table dynamic command, 37

CLI (command-line interface), exam topics not requiring, 6–7

client mode (VTP), 88, 94

client requests for VTP advertisements, 91–92

collapsed core block in modular network design, 259–260

- collision domains, 20
- collisions, 42, 336–338
- Common Spanning Tree (CST), 147
- community VLANs, 398
- conceding router election in HSRP (Hot Standby Router Protocol), 272–273
- Configuration BPDU, 130–131
- configuration revision numbers (VTP), 89
 - checking settings, 92
- configuring. *See also* tuning
 - Auto-QoS, 321–324
 - CEF (Cisco Express Forwarding), 229–230
 - DHCP relay, 235–236
 - DHCP servers, 235
 - EtherChannel, 114–116
 - LACP (Link Aggregation Control Protocol), 115–116*
 - PAgP (Port Aggregation Protocol), 114–115*
 - interVLAN routing, 219–221
 - Layer 2 port configuration, 219–220*
 - Layer 3 port configuration, 220*
 - SVI port configuration, 221*
 - LAP (lightweight access point), 350–351
 - load-balancing in EtherChannel, 111–112
 - MST (Multiple Spanning Tree Protocol), 209–210
 - PoE (Power over Ethernet), 307
 - port-based authentication, 376–378
 - ports
 - duplex mode, 52–53*
 - enabling the port, 55*
 - error condition management, 53–55*
 - identifying descriptions, 52*
 - selecting for configuration, 50–51*
 - speed, 52*
 - troubleshooting connectivity, 55–56*
 - private VLANs, 399–402
 - redundancy mode (hardware redundancy), 290–292
 - root bridges, 157–161
 - RSTP (Rapid Spanning Tree Protocol), 202–203
 - static VLANs, 66–68
 - supervisor synchronization, 293
 - switchports for WLANs, 361–364
 - for autonomous APs, 361–362*
 - for LAPs, 362–363*
 - for WLCs, 363–364*
 - trust boundary, 319–321
 - VLAN access lists (VACL), 396–397
 - VLAN trunks, 75–78
 - voice VLANs, 308–311
 - VTP (VLAN Trunking Protocol), 92–97
 - example of, 96*
 - management domains, 93*
 - modes, 93–95*
 - versions, 95–96*
 - viewing status, 96–97*
- connectors
 - basic Ethernet, 48–49
 - cautions concerning, 50
 - Fast Ethernet, 48–49
 - Gigabit Ethernet, 49–50
- consistency checks (VTP), 95
- content-addressable memory. *See* CAM (content-addressable memory)

Control and Provisioning Wireless
Access Points protocol (CAPWAP),
348

convergence (RSTP), 198–201

port types, 198–199

synchronization, 199–201

convergence (STP)

redundant link convergence, 167–171

BackboneFast feature, 170–171

PortFast feature, 167–168

UplinkFast feature, 168–170

tuning, 164–166

core blocks in modular network design,
259–262

core layer in hierarchical network
design, 249–252

CoS (class of service), 315, 321

CSMA/CD (carrier sense multiple access
collision detect), 42

CST (Common Spanning Tree), 147,
207–209

customization of STP (Spanning Tree
Protocol), 161–164

tuning port ID, 163–164

tuning root path cost, 161–162

D

DAI (dynamic ARP inspection),
383–385

dCEF (Distributed CEF), 226

DCF (distributed coordination function),
337

debug cdp packets command, 306

debug ilpower controller command,
306

debug spanning-tree switch state
command, 139

default gateway, 268

default-router command, 238

define interface-range command, 58

delay, 313

demand-based switching. *See* route
caching MLS

deploying VLANs (virtual LANs),
69–70

description command, 58

design phase (planning skills), 10

designated ports

electing, 135–136

in RSTP (Rapid Spanning Tree Protocol),
197

DHCP (Dynamic Host Configuration
Protocol), multilayer switching (MLS)
and, 233–236

configuring DHCP relay, 235–236

configuring DHCP server, 235

DHCP snooping, 379–381

differentiated service codepoint (DSCP),
316–318

differentiated services model (DiffServ),
314–318

Layer 2 classification, 315

Layer 3 classification, 316–318

direct topology changes in STP
(Spanning Tree Protocol), 142–143

Disabled state (STP ports), 137

disabling STP (Spanning Tree Protocol),
186

discard adjacencies, 228

Discarding state (RSTP ports), 197

Distributed CEF (dCEF), 226

distributed coordination function (DCF),
337

distribution layer in hierarchical network
design, 251

documenting results of implementation
plan, 12

domains, in VTP (VLAN Trunking Protocol), 88, 93

dot1x host-mode multi-host command, 390

dot1x port-control command, 390

dot1x system-auth-control command, 390

double tagging. *See* Inter-Switch Link (ISL) protocol

downloading practice exam content, 414

DRM (dual-router mode), 290

drop adjacencies, 228

DSCP (differentiated service codepoint), 316–318

DTP (Dynamic Trunking Protocol), 74, 402–404

dual core in modular network design, 261–262

dual-router mode (DRM), 290

duplex command, 58

duplex mode

- configuring ports, 52–53
- mismatches between ports, 55–56

dynamic ARP inspection, 383–385

Dynamic Host Configuration Protocol. *See* DHCP (Dynamic Host Configuration Protocol)

Dynamic Trunking Protocol (DTP), 74

dynamic VLANs, 68–69

E

EAPOL (Extensible Authentication Protocol over LANs), 376

edge ports (RSTP), 198

electing

- designated ports, 135–136
- root bridges, 131–132

root ports, 133–135

routers in HSRP (Hot Standby Router Protocol), 269–271

enable secret command, 385

enabling

- GLBP (Gateway Load Balancing Protocol), 284–288
- HTTPS interface, 386
- STP (Spanning Tree Protocol), 154
- VTP pruning, 99–100

encryption in WLANs, 353

end-to-end VLANs, 69–70

errdisable detect cause command, 58

errdisable recovery cause command, 58

errdisable recovery interval command, 58

errdisable state, 53–55

error condition management, configuring ports, 53–55

ESS (extended service set), 339–340

EtherChannel

- configuring, 114–116
 - LACP (Link Aggregation Control Protocol)*, 115–116
 - PAgP (Port Aggregation Protocol)*, 114–115
- explained, 108
- load-balancing in, 108–110
 - configuring*, 111–112
- negotiation protocols, 112–114
- troubleshooting, 116–119

Ethernet

- 10-Gigabit Ethernet (10GbE), 47–48
- advantages of, 42
- basic Ethernet, 42–43
- cabling and connectors, 48–50
- Fast Ethernet, 43–44
- full-duplex Fast Ethernet, 44–45

- Gigabit Ethernet, 45–47
 - port bundling, 109
- Ethernet switches. *See* switches
- exam engine
 - installing, 413–415
 - modes of, 416
- exam preparation, planning skills and, 13
- exam topics, planning skills needed. *See* planning skills
- extended service set (ESS), 339–340
- extended-range VLANs, 67
- Extensible Authentication Protocol over LANs (EAPOL), 376
- external AC adapters, 304

F

- Fast EtherChannel (FEC), 45, 108
- Fast Ethernet, 43–44
 - cabling and connectors, 48–49
 - full-duplex Fast Ethernet, 44–45
- Feature Manager (FM), 28
- FEC (Fast EtherChannel), 45, 108
- FHRP (first-hop redundancy protocols), 268
- FIB (Forwarding Information Base), 222–226
- first-hop redundancy protocols (FHRP), 268
- flat network topology, 65
- flooding, unknown unicast flooding, 22
- flow-based switching. *See* route caching MLS
- FM (Feature Manager), 28
- Forward Delay timer, 137, 140, 165
- forwarding
 - frames, in Layer 2 switches, 22–24

- packets
 - in multilayer switching (MLS)*, 25–26, 268
 - QoS (*quality of service*), explained, 313–314
- Forwarding Information Base (FIB), 222–226
- Forwarding state (RSTP ports), 197
- Forwarding state (STP ports), 137
- frame distribution. *See* load-balancing
- frame identification, VLANs (virtual LANs), 71–74
- frames
 - baby giant frames, 74
 - forwarding in Layer 2 switches, 22–24
- full-duplex, 43
- full-duplex Fast Ethernet, 44–45
- full-duplex ports (RSTP), 199

G

- gateway addressing in HSRP (Hot Standby Router Protocol), 273–274
- Gateway Load Balancing Protocol. *See* GLBP (Gateway Load Balancing Protocol)
- GEC (Gigabit EtherChannel), 46, 108
- Gigabit EtherChannel (GEC), 46, 108
- Gigabit Ethernet, 45–47
 - cabling and connectors, 49–50
- GLBP (Gateway Load Balancing Protocol), 280–289
 - active virtual forwarder, 282–283
 - active virtual gateway, 281–282
 - enabling, 284–288
 - load-balancing types, 283–284
 - verifying redundancy, 289
- `glbp ip` command, 296

glbp load-balancing command, 296
 glbp preempt command, 296
 glbp priority command, 296
 glbp weighting command, 296
 glbp weighting track command, 296

H

half-duplex, 42
 half-duplex ports (RSTP), 199
 hardware redundancy, 289–294

- configuring redundancy mode, 290–292
- modes of, 289–290
- nonstop forwarding (NSF), 293–294
- supervisor synchronization, 293

 Hello Time timer, 140, 164
 hierarchical network design, 247–252

- access layer, 251
- core layer, 251–252
- distribution layer, 251
- network segmentation, 247–248
- predictability, 249–250

 host dependent load balancing, 284
 host location, determining by MAC address, 32–33
 host mode (private VLANs), 398
 hosts

- active hosts, determining, 33
- multiple hosts, finding on interface, 33

 Hot Standby Router Protocol. *See* HSRP (Hot Standby Router Protocol)
 HREAP (Cisco Hybrid Remote Edge Access Point), 351
 HSRP (Hot Standby Router Protocol), 269–277

- conceding router election, 272–273

gateway addressing, 273–274
 load-balancing, 274–277
 MD5 authentication, 271–272
 plain-text authentication, 271
 router election, 269–271

HTTPS interface, enabling, 386

I

IBSS (Independent basic service set), 338–339
 IEEE 802.11 standards. *See* WLANs (wireless LANs)
 IEEE 802.1D standard, 126. *See also* STP (Spanning Tree Protocol)
 IEEE 802.1Q protocol, 73–74, 147, 204, 315
 IEEE 802.1s standard. *See* MST (Multiple Spanning Tree Protocol)
 IEEE 802.1w standard, 196. *See also* RSTP (Rapid Spanning Tree Protocol)
 IEEE 802.1x standard, 376–378
 IEEE 802.3af standard, 304–305
 ILP (Cisco Inline Power), 304
 implementation plan phase (planning skills), 10–12
 Independent basic service set (IBSS), 338–339
 indirect link failures, 170
 indirect topology changes in STP (Spanning Tree Protocol), 143–145
 inline power. *See* PoE (Power over Ethernet)
 insignificant topology changes in STP (Spanning Tree Protocol), 145–146
 installing exam engine, 413–415
 integrated services model (IntServ), 314
 intercontroller roaming, 356–361

interface command, 58, 83
 interface range command, 58
 interface range macro command, 58
 interface switchport trunk pruning vlan command, 103
 interface vlan command, 238
 interfaces. *See also* ports
 active hosts, determining, 33
 in interVLAN routing, 218–219
 multiple hosts, finding, 33
 Internal Spanning Tree (IST) instances, 207
 internal tagging. *See* IEEE 802.1Q protocol
 Inter-Switch Link (ISL) protocol, 72–73, 315
 interVLAN routing, 218–221
 configuring, 219–221
 Layer 2 port configuration, 219–220
 Layer 3 port configuration, 220
 SVI port configuration, 221
 interface types, 218–219
 verifying, 230–232
 intracontroller roaming, 355–356
 ip arp inspection filter vlan command, 391
 ip arp inspection trust command, 391
 ip arp inspection validate command, 391
 ip arp inspection vlan command, 391
 ip dhcp excluded-address command, 238
 ip dhcp pool command, 238
 ip dhcp snooping command, 390
 ip dhcp snooping limit rate command, 390
 ip dhcp snooping trust command, 390
 ip helper-address command, 238

ip http access-class command, 386
 ip http secure server command, 386
 IP precedence, mapping to DSCP fields, 316–317
 ip source binding vlan interface command, 391
 IP source guard, 381–383
 IP telephony
 PoE (Power over Ethernet), 304–308
 configuring, 307
 detecting powered devices, 304–305
 supplying power to devices, 305–306
 verifying, 307–308
 voice QoS, 312–326
 voice VLANs, 308–312
 configuring, 308–311
 verifying, 311–312
 ip verify source command, 391
 ISL (Inter-Switch Link) protocol, 72–73, 315
 isolated VLANs, 398
 IST (Internal Spanning Tree) instances, 207

J

jitter, 313

L

L2 forwarding tables

 Layer 2 switching, 23
 multilayer switching (MLS), 26

L3 forwarding tables, multilayer switching (MLS), 26

LACP (Link Aggregation Control Protocol), 113–116

lacp port-priority command, 116, 121

lacp system-priority command, 121

LAN PHY, 47

LAP (lightweight access point), 348

- configuring, 350–351
- configuring switchports for, 362–363

latency, 313

Layer 2 port configuration, interVLAN routing, 219–220

Layer 2 QoS classification, 315

Layer 2 roaming, 343

Layer 2 switching, 20–24. *See also* STP (Spanning Tree Protocol)

Layer 3 port configuration, interVLAN routing, 220

Layer 3 QoS classification, 316–318

Layer 3 roaming, 343

Learning state (RSTP ports), 197

Learning state (STP ports), 137

lease command, 238

lightweight access point (LAP), 348

- configuring, 350–351
- configuring switchports for, 362–363

Lightweight Access Point Protocol (LWAPP), 348

Link Aggregation Control Protocol (LACP), 113–116

listen HSRP routers, 269

Listening state (STP ports), 137

little-endian format, 74

load-balancing. *See also* GLBP (Gateway Load Balancing Protocol)

- in EtherChannel, 108–112
- in HSRP (Hot Standby Router Protocol), 274–277

local VLANs, 70

logical network segments, physical network segments versus, 65

Loop Guard feature (STP), 183

loops. *See* bridging loops

loss (of packets), 313

LWAPP (Lightweight Access Point Protocol), 348

M

MAC addresses

- determining by host location, 32–33
- port security, 373–376

mac address-table static command, 37

management domains, in VTP (VLAN Trunking Protocol), 88, 93

man-in-the-middle attacks. *See* spoofing attack prevention

masks (TCAM), 29

master routers in VRRP (Virtual Router Redundancy Protocol), 277

match command, 408

Max Age timer, 140, 165

MD5 authentication, 271–272

membership in VLANs (virtual LANs), 65–69

- dynamic VLANs, 68–69
- static VLANs, 66–68

microcells (WLAN coverage areas), 344

MLS. *See* multilayer switching (MLS)

mls qos command, 328

mls qos trust command, 328

mls qos trust device cisco-phone command, 328

mobility groups, 356–361

modes in VTP (VLAN Trunking Protocol), 88–89, 93–95

modular network design, 252–262

- core blocks, 259–262

redundant paths versus, 252–254

switch blocks, 254–259

monitoring

STP (Spanning Tree Protocol), 171–172

switching tables, 32–35

MST (Multiple Spanning Tree Protocol), 204–210

configuring, 209–210

regions, 206

spanning-tree instances in, 207–209

MST instances (MSTI), 208–209

MSTI (MST instances), 208–209

multilayer switching (MLS), 24–27

CEF (Cisco Express Forwarding), 221–230

adjacency table, 226–229

configuring, 229–230

FIB (Forwarding Information Base), 222–226

packet rewrite, 229

verifying, 232–233

DHCP (Dynamic Host Configuration Protocol) and, 233–236

configuring DHCP relay, 235–236

configuring DHCP server, 235

interVLAN routing, 218–221

configuring, 219–221

interface types, 218–219

verifying, 230–232

Netflow LAN switching, 221–222

router redundancy, 268–289

GLBP (Gateway Load Balancing Protocol), 280–289

HSRP (Hot Standby Router Protocol), 269–277

VRRP (Virtual Router Redundancy Protocol), 277–280

multiple hosts, finding on interface,

Multiple Spanning Tree Protocol. *See* MST (Multiple Spanning Tree Protocol)

N

name command, 83, 212

native VLANs, 73, 308

negotiation protocols for EtherChannel, 112–114

Netflow LAN switching, 221–222. *See also* route caching MLS

network command, 238

network connectors. *See* connectors

network design

hierarchical network design, 247–252

access layer, 251

core layer, 251–252

distribution layer, 251

network segmentation, 247–248

predictability, 249–250

modular network design, 252–262

core blocks, 259–262

redundant paths versus, 252–254

switch blocks, 254–259

network engineers, role of, 12

network lifecycle, 7–8

network segmentation in hierarchical network design, 247–248

network services, types of, 250

next hop, 268

no ip http server command, 386

no shutdown command, 58

no switchport command, 238

no vrrp preempt command, 278, 297

nonstop forwarding (NSF), 293–294

NSF (nonstop forwarding), 293–294

null adjacencies, 228

P

- packet forwarding. *See* forwarding, packets
- packet rewrite, 229
- packets, forwarding in multilayer switching (MLS), 25–26
- PAgP (Port Aggregation Protocol), 113–115
- passwords
 - for secure VTP, 94
 - security best practices, 385
- path cost, 133, 161–162
- permit ip host mac host command, 391
- Per-VLAN Spanning Tree (PVST), 147
- Per-VLAN Spanning Tree Plus (PVST+), 147, 204
- Physical Media Dependent (PMD) interfaces, 10-Gigabit Ethernet (10GbE), 47–48
- physical network segments, logical network segments versus, 65
- picocells (WLAN coverage areas), 344
- plain-text authentication in HSRP (Hot Standby Router Protocol), 271
- planning skills, 5–13
 - company staff example, 9
 - design phase, 10
 - documenting results, 12
 - exam preparation and, 13
 - exam topics not requiring CLI, 6–7
 - implementation plan phase, 10–11
 - need for, 8
 - PPDIOO network lifecycle, 7–8
 - verification plan phase, 11–12
- PMD (Physical Media Dependent) interfaces, 10-Gigabit Ethernet (10GbE), 47–48
- PoE (Power over Ethernet), 304–308
 - configuring, 307
 - detecting powered devices, 304–305
 - supplying power to devices, 305–306
 - verifying, 307–308
- point-to-point ports (RSTP), 199
- Port Aggregation Protocol (PAgP), 113–115
- port IDs, tuning, 163–164
- port operations in TCAM (ternary content-addressable memory), 31–32
- port priority, 113
- port security, 373–376
- port state
 - finding, 55
 - in RSTP (Rapid Spanning Tree Protocol), 197
 - in STP (Spanning Tree Protocol), 137–139
- port VLAN ID (PVID), 308
- port-based authentication, 376–378
- port-based membership in static VLANs, 66
- port-channel load-balance command, 121
- PortFast feature (STP), 167–168
 - BPDU Guard feature (STP) and, 181–182
- ports. *See also* interfaces
 - associating with private VLANs, 400–401
 - bundling, with EtherChannel, 109
 - configuring
 - duplex mode*, 52–53
 - enabling the port*, 55
 - error condition management*, 53–55
 - identifying descriptions*, 52
 - selecting for configuration*, 50–51

- speed*, 52
- troubleshooting connectivity*, 55–56
- designated ports. *See* designated ports
- initialization delays, 167
- root ports. *See* root ports
- in RSTP (Rapid Spanning Tree Protocol), 196–199
- power classes (IEEE 802.3af standard)**, 305
- power inline command**, 328
- Power over Ethernet**. *See* PoE (Power over Ethernet)
- power supply redundancy**, 289–294
- powered devices**
 - detecting, 304–305
 - supplying power to, 305–306
- PPDIOO network lifecycle**, 7–8
- practice exam content, activating**, 414
- predictability in hierarchical network design**, 249–250
- preparation**. *See* exam preparation
- prepare, plan, design, implement, operate, optimize (PPDIOO) network lifecycle**, 7–8
- preventing**
 - bridging loops, 129–130
 - spoofing attacks, 378–385
 - DHCP snooping*, 379–381
 - dynamic ARP inspection*, 383–385
 - IP source guard*, 381–383
- private VLANs**, 397–402
- private-vlan association command**, 408
- private-vlan command**, 408
- private-vlan mapping command**, 408
- private-vlan primary command**, 408

- process switching**, 27
- promiscuous mode (private VLANs)**, 398
- protect mode (port security)**, 374
- protecting STP (Spanning Tree Protocol)**
 - against sudden loss of BPDUs, 182–186
 - troubleshooting protection, 187
 - against unexpected BPDUs, 180–182
- pruning (VTP)**, 97–100
- punt adjacencies**, 228
- PVID (port VLAN ID)**, 308
- PVLAN**. *See* private VLANs
- PVST (Per-VLAN Spanning Tree)**, 147
- PVST+ (Per-VLAN Spanning Tree Plus)**, 147, 204

Q

- QoS (quality of service)**
 - explained, 313–314
 - voice QoS, 312–326
 - Auto-QoS*, 321–324
 - best-effort delivery*, 314
 - differentiated services model*, 314–318
 - implementation*, 318–319
 - integrated services model*, 314
 - trust boundary configuration*, 319–321
 - verifying*, 324–326
- QoS ACLs (access control lists)**
 - Layer 2 switching, 24
 - multilayer switching (MLS), 26
- quality of service**. *See* QoS (quality of service)

R

- RACLs (router access control lists). *See* ACLs (access control lists)
- range of WLANs, 341–344
- Rapid PVST+ (RPVST+), 196, 203–204
- Rapid Spanning Tree Protocol. *See* RSTP (Rapid Spanning Tree Protocol)
- redundancy
 - hardware redundancy, 289–294
 - configuring redundancy mode*, 290–292
 - modes of*, 289–290
 - nonstop forwarding (NSF)*, 293–294
 - supervisor synchronization*, 293
 - router redundancy, 268–289
 - GLBP (Gateway Load Balancing Protocol)*, 280–289
 - HSRP (Hot Standby Router Protocol)*, 269–277
 - VRRP (Virtual Router Redundancy Protocol)*, 277–280
- redundant paths
 - modular network design versus, 252–254
 - in STP (Spanning Tree Protocol), 130, 167–171
 - in switch blocks, 256–259
- regions (MST), 206
- requesting VTP advertisements, 91–92
- Resource Reservation Protocol (RSVP), 314
- restrict mode (port security), 374
- results (TCAM), 29
- revision command, 212
- revision numbers (VTP), 89, 92
- RPR+ (route processor redundancy plus) 453
- RLQ (Root Link Query) protocol, 170
- roaming, 343
 - in Cisco Unified Wireless Network Architecture, 354–361
 - intercontroller roaming*, 356–361
 - intracontroller roaming*, 355–356
 - mobility groups*, 356–361
- root bridges
 - configuring, 157–161
 - electing, 131–132
 - placement of, 154–157
 - poor choices for, 154
- Root Guard feature (STP), 180–181
- Root Link Query (RLQ) protocol, 170
- root path cost, 133, 161–162
- root ports
 - electing, 133–135
 - in RSTP (Rapid Spanning Tree Protocol), 197, 199
- root-inconsistent STP state, 181
- round robin load balancing, 284
- route caching MLS, 24, 221–222
- route processor redundancy (RPR), 290
- route processor redundancy plus (RPR+), 290
- router access control lists. *See* ACLs (access control lists)
- router redundancy, 268–289
 - GLBP (Gateway Load Balancing Protocol)*, 280–289
 - HSRP (Hot Standby Router Protocol)*, 269–277
 - VRRP (Virtual Router Redundancy Protocol)*, 277–280
- RPR (route processor redundancy), 290
- RPR+ (route processor redundancy plus), 290

RPVST+ (Rapid PVST+), 196, 203–204

RSTP (Rapid Spanning Tree Protocol), 196–204

BPDU in, 197–198

configuring, 202–203

convergence, 198–201

port types, 198–199

synchronization, 199–201

port behavior, 196–197

topology changes, 201–202

RSVP (Resource Reservation Protocol), 314

runts, 56

S

SDM (Switching Database Manager), 28

secondary VLANs, associating with primary VLAN SVI, 401–402

secure VTP, passwords for, 94

security

best practices, 385–388

port security, 373–376

port-based authentication, 376–378

private VLANs, 397–402

spoofing attack prevention, 378–385

DHCP snooping, 379–381

dynamic ARP inspection, 383–385

IP source guard, 381–383

VLAN access lists (VACL), 396–397

for VLAN trunks, 402–406

switch spoofing, 402–404

VLAN hopping, 404–406

security ACLs (access control lists)

Layer 2 switching, 23

multilayer switching (MLS), 26

segmentation. *See* network segmentation

selecting ports for configuration, 50–51

server mode (VTP), 88, 93

service password-encryption command, 385

service provider networks, private VLANs and, 398

service set identifier (SSID), 338

mapping to VLANs, 340–341

service sets (WLANs), 338

show adjacency command, 239

show auto qos command, 328

show cef not-cef-switched command, 239

show dot1x all command, 378

show dtp command, 81, 83

show etherchannel detail command, 119

show etherchannel load-balance command, 119

show etherchannel port command, 117, 119

show etherchannel port-channel command, 112, 119

show etherchannel summary command, 117, 119

show interface command, 239

show interface etherchannel command, 118

show interface pruning command, 101

show interface status err-disabled EXEC command, 55

show interface status EXEC command, 55

show interface switchport command, 80, 83, 101, 239, 328

show interface trunk command, 77, 80, 83

show interface vlan command, 239

show interfaces EXEC command, 55

show ip cef command, 239

- show lacp sys-id command, 119
- show mac address-table count command, 37
- show mac address-table dynamic address command, 37
- show mac address-table dynamic interface command, 37
- show mls qos interface command, 328
- show neighbor command, 119
- show power inline command, 328
- show running-config interface command, 118
- show spanning-tree backbonefast command, 172
- show spanning-tree bridge command, 171
- show spanning-tree command, 171
- show spanning-tree detail command, 171
- show spanning-tree inconsistentports command, 181, 187, 190
- show spanning-tree interface command, 139, 172, 187
- show spanning-tree root command, 171
- show spanning-tree summary command, 171, 187, 190
- show spanning-tree uplinkfast command, 172
- show udld command, 187, 190
- show user all command, 386
- show vlan brief command, 101
- show vlan command, 68
- show vlan id command, 79, 83
- show vtp counters command, 97, 101
- show vtp status command, 92, 96, 101
- shutdown command, 58, 387
- shutdown mode (port security), 374
- simulation mode (exam engine), 416
- spanning-tree mst max-age command
- single tagging. *See* IEEE 802.1Q protocol
- single-router mode (SRM), 290
- size
 - of CAM tables, checking, 34
 - of core blocks, 262
 - of switch blocks, 255–256
- SNMP access, securing, 387
- Spanning Tree Protocol. *See* STP (Spanning Tree Protocol)
- spanning-tree backbonefast command, 174
- spanning-tree bpdudfilter enable command, 190
- spanning-tree bpduguard enable command, 190
- spanning-tree command, 174
- spanning-tree cost command, 174
- spanning-tree forward-time command, 174
- spanning-tree guard loop command, 190
- spanning-tree guard root command, 190
- spanning-tree hello-time command, 174
- spanning-tree instances in MST (Multiple Spanning Tree Protocol), 207–209
- spanning-tree link-type point-to-point command, 212
- spanning-tree loops. *See* bridging loops
- spanning-tree max-age command, 174
- spanning-tree mode mst command, 212
- spanning-tree mst configuration command, 212
- spanning-tree mst cost command, 210
- spanning-tree mst forward-time command, 210
- spanning-tree mst hello-time command, 210
- spanning-tree mst max-age command, 210

- spanning-tree mst port-priority command, 210
- spanning-tree mst priority command, 210
- spanning-tree mst root command, 210
- spanning-tree portfast command, 174, 212
- spanning-tree port-priority command, 174
- spanning-tree uplinkfast command, 174
- spanning-tree vlan command, 174
- spanning-tree vlan root command, 160, 174
- speed
 - configuring ports, 52
 - mismatches between ports, 55–56
- speed command, 58
- split-MAC architecture, 348
- spoofing attack prevention, 378–385
 - DHCP snooping, 379–381
 - dynamic ARP inspection, 383–385
 - IP source guard, 381–383
- SRM (single-router mode), 290
- SSH, Telnet versus, 386–387
- SSID (service set identifier), 338
 - mapping to VLANs, 340–341
- SSO (stateful switchover), 290
- stale entries, 27
- standards. *See names of specific standards*
- standby addresses in HSRP (Hot Standby Router Protocol), 273
- standby authentication command, 296
- standby HSRP routers, 269
- standby ip command, 296
- standby preempt command, 296
- standby priority command, 296
- standby timers command, 296
- standby track command, 296
- stateful switchover (SSO), 290
- static VLANs, 66–68
- sticky MAC addresses, 373
- store-and-forward switching, 20
- STP (Spanning Tree Protocol)
 - BPDU (bridge protocol data units), 130–131
 - bridge priorities, setting, 158
 - bridging loops, preventing, 129–130
 - convergence, tuning, 164–166
 - customization, 161–164
 - tuning port ID*, 163–164
 - tuning root path cost*, 161–162
 - designated ports, electing, 135–136
 - disabling, 186
 - enabling, 154
 - IEEE 802.1D standard, 126
 - manually computing, 139
 - monitoring, 171–172
 - MST (Multiple Spanning Tree Protocol). *See MST (Multiple Spanning Tree Protocol)*
 - port states, 137–139
 - protecting
 - against sudden loss of BPDUs*, 182–186
 - troubleshooting protection*, 187
 - against unexpected BPDUs*, 180–182
 - redundant link convergence, 167–171
 - BackboneFast feature*, 170–171
 - PortFast feature*, 167–168
 - UplinkFast feature*, 168–170
 - root bridges
 - configuring*, 157–161
 - electing*, 131–132
 - placement of*, 154–157
 - poor choices for*, 154
 - root ports, electing, 133–135

- RSTP (Rapid Spanning Tree Protocol).
 - See RSTP (Rapid Spanning Tree Protocol)
- securing, 387
- tie-breaking process, 135
- timers, 139–141
 - tuning*, 164–166
- topology changes, 141–146
- types of, 146–148
- study mode (exam engine), 416
- study plan, 415–416
- subset advertisements (VTP), 90–91
- sudden loss of BPDUs, protecting against, 182–186
- summary advertisements (VTP), 90
- superior BPDUs, 181
- supervisor engine redundancy, 289–294
- supervisor synchronization, configuring, 293
- SVI (switched virtual interface), 219
- SVI port configuration, interVLAN routing, 221
- switch blocks in modular network design, 254–259
- switch console, securing, 386
- switch spoofing, 402–404
- switched virtual interface (SVI), 219
- switches
 - Layer 2 switching, 20–24
 - multilayer switching (MLS), 24–27
 - process switching, 27
 - tables in
 - CAM (content-addressable memory)*, 27–28
 - monitoring*, 32–35
 - TCAM (ternary content-addressable memory)*, 28–32
- Switching Database Manager (SDM), 28
- switchport access vlan command, 68, 83
- switchport command, 68, 75, 238
- switchport host command, 387
- switchport mode access command, 68, 83, 387
- switchport mode command, 76, 83
- switchport mode private-vlan command, 408
- switchport nonegotiate command, 76
- switchport port-security command, 390
- switchport port-security mac-address command, 390
- switchport port-security maximum command, 390
- switchport port-security violation command, 390
- switchport priority extend command, 328
- switchport private-vlan host-association command, 408
- switchport private-vlan mapping command, 408
- switchport trunk allowed vlan command, 75–76, 83, 99
- switchport trunk encapsulation command, 75, 83
- switchport trunk native vlan command, 75, 83
- switchport voice vlan command, 328
- switchports, configuring for WLANs, 361–364
 - for autonomous APs, 361–362
 - for LAPs, 362–363
 - for WLCs, 363–364
- synchronization
 - in RSTP convergence, 199–201
 - supervisor synchronization, configuring, 293
- synchronization problems (VTP), 90
- system banners, 385
- system priority, 113

T

Tag Control Information (TCI) field, 74
Tag Protocol Identifier (TPID), 74
tagging. *See* frame identification
TCAM (ternary content-addressable memory), 28–32
 example of, 30–31
 Layer 2 switching, 23
 monitoring, 35
 port operations in, 31–32
 structure of, 28–30
TCI (Tag Control Information) field, 74
TCN BPDU, 141–146
telephony. *See* IP telephony
Telnet, SSH versus, 386–387
ternary content-addressable memory.
 See TCAM (ternary content-addressable memory)
throttling adjacency, 228
tie-breaking process in STP (Spanning Tree Protocol), 135
timers in STP (Spanning Tree Protocol), 139–141, 164–166
Token Ring, VTP support for, 96
topology changes
 in RSTP (Rapid Spanning Tree Protocol), 201–202
 in STP (Spanning Tree Protocol), 141–146
topology-based MLS, 24–25
TPID (Tag Protocol Identifier), 74
track interface command, 296
traditional WLAN architecture, 344–346
traffic patterns in Cisco Unified Wireless Networks, 352–354
transparent bridging, 20–22, 126–127

transparent mode (VTP), 88–89, 94–95
troubleshooting
 EtherChannel, 116–119
 port connectivity, 55–56
 STP protection, 187
 VLAN trunks, 79–81
 VLANs (virtual LANs), 79–81
 VTP (VLAN Trunking Protocol), 100–101
trunk links. *See* VLAN trunks
trust boundary, configuring, 319–321
tuning. *See also* configuring
 convergence (STP), 164–166
 port IDs, 163–164
 root path cost, 161–162
 STP timers, 164–166

U

UDLD (Unidirectional Link Detection) feature (STP), 184–186
udld command, 190
udld reset command, 187, 190
unexpected BPDUs, protecting against, 180–182
Unidirectional Link Detection (UDLD) feature (STP), 184–186
unidirectional links, 54, 184
unknown unicast flooding, 22, 97–99, 127
unrecognized Type-Length-Value, VTP support for, 96
unused switch ports, securing, 387
UplinkFast feature (STP), 168–170

V

VACL (VLAN access lists), 396–397
values (TCAM), 29

verification plan phase (planning skills),
11–12

verifying

- CEF (Cisco Express Forwarding),
232–233
- GLBP (Gateway Load Balancing
Protocol) redundancy, 289
- interVLAN routing, 230–232
- PoE (Power over Ethernet), 307–308
- voice QoS, 324–326
- voice VLANs, 311–312

versions (VTP), configuring, 95–96

VID (VLAN identifier), 74

violations of port security, handling, 374

virtual LANs. *See* VLANs (virtual LANs)

Virtual Router Redundancy Protocol.
See VRRP (Virtual Router
Redundancy Protocol)

virtual terminal access, securing, 386

VLAN access lists (VACL), 396–397

vlan access-map command, 408

vlan command, 83, 408

vlan database EXEC command, 93

vlan filter vlan-list command, 408

VLAN hopping, 404–406

VLAN identifier (VID), 74

VLAN Trunking Protocol (VTP), 67, 74,
88–92

advertisements, 89–92

configuring, 92–97

example of, 96

management domains, 93

modes, 93–95

versions, 95–96

viewing status, 96–97

domains, 88

modes, 88–89

pruning, 97–100

synchronization problems, 90

troubleshooting, 100–101

VLAN trunks, 70–74

configuring, 75–78

DTP (Dynamic Trunking Protocol), 74

frame identification, 71–74

IEEE 802.1Q protocol, 73–74

Inter-Switch Link (ISL) protocol, 72–73

securing, 402–406

switch spoofing, 402–404

VLAN hopping, 404–406

troubleshooting, 79–81

VLANs (virtual LANs)

deploying, 69–70

exam topics, 6

explained, 65–66

interVLAN routing, 218–221

configuring, 219–221

interface types, 218–219

verifying, 230–232

mapping to SSIDs, 340–341

membership, 65–69

dynamic VLANs, 68–69

static VLANs, 66–68

private VLANs, 397–402

troubleshooting, 79–81

voice VLANs, 308–312

configuring, 308–311

verifying, 311–312

voice QoS

Auto-QoS, 321–324

best-effort delivery, 314

differentiated services model, 314–318

implementation, 318–319

integrated services model, 314

trust boundary configuration, 319–321

verifying, 324–326

voice VLAN ID (VVID), 308

voice VLANs, 308–312

- configuring, 308–311
- verifying, 311–312

VoIP (Voice over IP). *See* IP telephony

VRRP (Virtual Router Redundancy Protocol), 277–280

vrrp authentication command, 278, 297

vrrp ip command, 278, 297

vrrp preempt command, 278, 297

vrrp priority command, 278, 297

vrrp timers advertise command, 278, 297

vrrp timers learn command, 278, 297

VTP (VLAN Trunking Protocol), 67, 74, 88–92

- advertisements, 89–92
- configuring, 92–97
 - example of*, 96
 - management domains*, 93
 - modes*, 93–95
 - versions*, 95–96
 - viewing status*, 96–97
- domains, 88
- modes, 88–89
- pruning, 97–100
- synchronization problems, 90
- troubleshooting, 100–101

vtp domain command, 103

vtp mode command, 103

vtp mode transparent global configuration command, 67

vtp password command, 103

vtp pruning command, 103

vtp version command, 103

VVID (voice VLAN ID), 308

W

“wall warts,” 304

WAN PHY, 47

web interface, securing, 386

weighted load balancing, 284

wired LANs, wireless LANs versus, 335

wireless LAN controller. *See* WLC (wireless LAN controller)

WLANs (wireless LANs)

- access points, explained, 338–344
- architecture of, 344–354
 - Cisco Unified Wireless Network Architecture*, 346–354
 - traditional architecture*, 344–346
- cells (coverage areas), 341–344
- collisions, avoiding, 336–338
- switchport configuration, 361–364
 - for autonomous APs*, 361–362
 - for LAPs*, 362–363
 - for WLCs*, 363–364
- wired LANs versus, 335

WLC (wireless LAN controller), 348

- configuring switchports for, 363–364
- functions of, 349–350
- intercontroller roaming, 356–361
- intracontroller roaming, 355–356
- mobility groups, 356–361