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Exam **640-460**

CCNA Voice



**CD Features a Complete
Practice Exam**

**Dave Bateman
William Burton**

CCNA Voice Exam Cram

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ISBN-13: 978-0-7897-3799-1

ISBN-10: 0-7897-3799-x

Library of Congress Cataloging-in-Publication Data:

Bateman, David, 1964-

CCNA voice exam cram / David Bateman and William Burton.

p. cm.

Includes index.

ISBN-13: 978-0-7897-3799-1 (pbk. w/cd)

ISBN-10: 0-7897-3799-X (pbk. w/cd)

1. Internet telephony—Examinations—Study guides. I. Burton, William, 1948- II. Title.

TK5105.8865.B373 2009

004.69'5—dc22

2008051503

Printed in the United States of America

First Printing: January 2009

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Introduction

Welcome to *CCNA Voice Exam Cram*. Whether this book is your first or your fifteenth *Exam Cram* series book, you'll find information here that will help ensure your success as you pursue knowledge, experience, and certification. This book aims to help you get ready to take and pass the Cisco CCNA Voice exam number 640-460.

This introduction explains the Cisco certification programs in general and talks about how the *Exam Cram* series can help you prepare for the Cisco CCNA Voice exam. Chapters 1 through 15 are designed to remind you of everything you'll need to know to pass the 640-460 certification exam. The two practice exams at the end of the book should give you a reasonably accurate assessment of your knowledge, and we've provided the answers and their explanations for these practice exams. Read the book and understand the material, and you'll stand a very good chance of passing the real test.

Exam Cram books help you understand and appreciate the subjects and materials you need to know to pass Cisco certification exams. *Exam Cram* books are aimed strictly at test preparation and review. They do not teach you everything you need to know about a subject. Instead, the authors streamline and highlight the pertinent information by presenting and dissecting the questions and problems they've discovered that you're likely to encounter on a Cisco test.

Nevertheless, to completely prepare yourself for any Cisco test, we recommend that you begin by taking the "Self Assessment" that immediately follows this introduction. The self-assessment tool will help you evaluate your knowledge base against the requirements for the Cisco CCVA exam under both ideal and real circumstances. This can also be the first step in earning more advanced voice certifications.

Based on what you learn from the self-assessment, you might decide to begin your studies with classroom training or some background reading. On the other hand, you might decide to pick up and read one of the many study guides available from Que or a third-party vendor.

We also strongly recommend that you spend some time installing, configuring, and working with Cisco Unified Communications Manager Express, Cisco Unity Express, and the UC500 Smart Business Communications System, because the CCNA Voice exam is focused on these products and the knowledge and skills they can provide for you. Nothing beats hands-on experience and familiarity when it comes to understanding the questions you're likely to encounter on a certification test. Book learning is essential, but without a doubt, hands-on experience is the best teacher of all!

Cisco Certifications Overview

The first step in general Cisco career certifications begins either with CCENT as an interim step to Associate level or directly with CCNA for network operations or CCDA for network design. A variety of specialist-focused certifications are also available to show knowledge in specific technologies, solutions, or job roles. The following sections describe the general certification levels and paths.

General Certifications: Three Levels of Certification

The three levels of certification for general certifications are

- ▶ **Associate:** The first step in Cisco networking begins at the Associate level, which also includes CCENT, an interim step to Associates for those with little job experience. Think of the Associate level as the apprentice or foundation level of networking certification.
- ▶ **Professional:** This is the advanced or journeyman level of certification.
- ▶ **Expert:** This is CCIE, the highest level of achievement for network professionals, certifying an individual as an expert or master.

General Certifications: Six Different Paths

The widely respected IT certification programs available through Cisco Career Certifications bring valuable, measurable rewards to networking professionals, their managers, and the organizations that employ them. The following is the list of these six certification technologies:

- ▶ **Routing and Switching:** This path is for professionals who install and support Cisco technology-based networks in which LAN and WAN routers and switches reside.
- ▶ **Design:** This path is aimed at professionals who design Cisco technology-based networks in which LAN and WAN routers and switches reside.
- ▶ **Network Security:** This path is directed toward network professionals who design and implement Cisco Secure networks.
- ▶ **Service Provider:** This path is aimed at professionals working with infrastructure or access solutions in a Cisco end-to-end environment primarily within the telecommunications arena.

- ▶ **Storage Networking:** This path is for professionals who implement storage solutions over extended network infrastructure using multiple transport options.
- ▶ **Voice:** This path is directed toward network professionals who install and maintain voice solutions over IP networks.

Taking a Certification Exam

After you prepare for your exam, you need to register with a Pearson VUE testing center. At the time of this writing, the cost to take the CCNA Voice exam is \$250 for individuals. If you don't pass, you can take the exam again for the same cost as the first attempt, for each attempt until you pass. In the United States and Canada, tests are administered by Pearson VUE. Here's how you can contact them:

- ▶ **Prometric:** You can sign up for a test through the company's website, <http://www.2test.com> or <http://www.prometric.com>. Within the United States and Canada, you can register by phone at 800-755-3926. If you live outside this region, you should check the Prometric website for the appropriate phone number.
- ▶ **Pearson VUE:** You can contact Virtual University Enterprises (VUE) to locate a nearby center that administers the test and to make an appointment. The sign-up web page address for the exam is <http://www.vue.com/cisco>. You can also use this web page (click the Contact button, click the View Telephone Directory by Sponsor link, and then click Cisco) to obtain a telephone number for the company, if you can't or don't want to sign up for the exam on the web page.

To sign up for a test, you must provide payment as approved by Pearson VUE.

To schedule an exam, call the appropriate phone number or visit the Pearson Vue website at least one day in advance. To cancel or reschedule an exam in the United States or Canada, you must call before 3 p.m. Eastern time the day before the scheduled test time (or you might be charged, even if you don't show up to take the test). To schedule a test, have the following information ready:

- ▶ Your name, organization, and mailing address.
- ▶ Your Cisco test ID. (In the United States, this could be your Social Security number; citizens of other countries should call ahead to find out what type of identification is required to register for a test.)

- ▶ The name and number of the exam you want to take.
- ▶ A method of payment. (A credit card is the most convenient method, but alternate means can be arranged in advance, if necessary.)

After you sign up for a test, you are told when and where the test is scheduled. You should arrive at least 15 minutes early. You must supply two forms of identification, one of which must be a photo ID, to be admitted into the testing room. Be prepared for a biometric fingerprint scan and the taking of a digital picture each time you take an exam.

Tracking Certification Status

After you pass the exam, you are certified. Official certification is normally granted after six to eight weeks, so you shouldn't expect to get your credentials overnight. The package for official certification that arrives includes a Welcome Kit that contains a number of elements (see the Cisco website for other benefits of specific certifications):

- ▶ A certificate that is suitable for framing, along with a wallet card.
- ▶ A license to use the related certification logo. This means you can use the logo in advertisements, promotions, and documents and on letterhead, business cards, and so on. Along with the license comes a logo sheet, which includes camera-ready artwork. (Note that before you use any of the artwork, you must sign and return a licensing agreement that indicates you'll abide by its terms and conditions.)

Many people believe that the benefits of certification go well beyond the perks that Cisco certifications provide to newly anointed members of this elite group. We're starting to see more job listings that request or require applicants to have Cisco and other related certifications, and many individuals who complete Cisco certification programs can qualify for increases in pay and responsibility. As an official recognition of hard work and broad knowledge, a certification credential is a badge of honor in many IT organizations.

About This Book

We've structured the topics in this book to build on one another. Therefore, some topics in later chapters make the most sense after you've read earlier chapters. That's why we suggest that you read this book from front to back for your

initial test preparation. If you need to brush up on a topic or if you have to bone up for a second try, you can use the index or table of contents to go straight to the topics and questions that you need to study. Beyond helping you prepare for the test, we think you'll find this book useful as a tightly focused reference to some of the most important aspects of the Cisco CCVA certification.

Chapter Format and Conventions

Each topical *Exam Cram* chapter follows a regular structure and contains graphical cues about important or useful information. Here's the structure of a typical chapter:

- ▶ **Opening hot lists:** Each chapter begins with a list of the terms, tools, and techniques that you must learn and understand before you can be fully conversant with that chapter's subject matter. The hot lists are followed with one or two introductory paragraphs to set the stage for the rest of the chapter.
- ▶ **Topical coverage:** After the opening hot lists and introductory text, each chapter covers a series of topics related to the chapter's subject. Throughout that section, we highlight topics or concepts that are likely to appear on a test, using a special element called an Exam Alert:

EXAM ALERT

This is what an Exam Alert looks like. Normally, an alert stresses concepts, terms, software, or activities that are likely to relate to one or more certification-test questions. For that reason, we think any information in an alert is worthy of unusual attentiveness on your part.

You should pay close attention to material flagged in Exam Alerts; although all the information in this book pertains to what you need to know to pass the exam, Exam Alerts contain information that is really important. You'll find what appears in the meat of each chapter to be worth knowing, too, when preparing for the test. Because this book's material is condensed, we recommend that you use this book along with other resources to achieve the maximum benefit.

In addition to the alerts, we provide tips and notes that will help you build a better foundation for security knowledge. Although the tip information might not be on the exam, it is certainly related, and it will help you become a better-informed test taker.

TIP

This is how tips are formatted. Keep your eyes open for these, and you'll become a Cisco Certified Network Associate - Voice guru in no time!

NOTE

This is how notes are formatted. Notes direct your attention to important pieces of information that relate to the Cisco Certified Network Associate - Voice certification.

- ▶ **Exam prep questions:** Although we talk about test questions and topics throughout the book, the section at the end of each chapter presents a series of mock test questions and explanations of both correct and incorrect answers.
- ▶ **Details and resources:** Most chapters end with a section titled “Suggested Reading and Resources” that provides direct pointers to third-party resources that offer more details on the chapter's subject. In addition, that section tries to rank, or at least rate, the quality and thoroughness of the topic's coverage by each resource. If you find a resource you like in that collection, you should use it, but you shouldn't feel compelled to use all the resources. On the other hand, we recommend only resources that we use on a regular basis, so none of our recommendations will be a waste of your time or money (but purchasing them all at once probably represents an expense that many network administrators and certification candidates might find hard to justify).

The bulk of the book follows this chapter structure, but we'd like to point out a few other elements:

- ▶ “Practice Exam 1” and “Practice Exam 2” and the answer explanations provide good reviews of the material presented throughout the book to ensure that you're ready for the exam.
- ▶ The Glossary defines important terms used in this book.
- ▶ The tear-out Cram Sheet attached next to the inside front cover of this book represents a condensed and compiled collection of facts and tips that we think are essential for you to memorize before taking the test. Because you can dump this information out of your head onto a sheet of paper before taking the exam, you can master this information by brute force; you need to remember it only long enough to write it down when you walk into the testing room. You might even want to look at it in the car or in the lobby of the testing center just before you walk in to take the exam.

- The MeasureUp Practice Tests CD-ROM that comes with each Exam Cram and Exam Prep title features a powerful, state-of-the-art test engine that prepares you for the actual exam. MeasureUp Practice Tests are developed by certified IT professionals and are trusted by certification students around the world. For more information, visit <http://www.measureup.com>.

Exam Topics

Table I-1 lists the skills measured by the CCNA Voice 640-460 exam and the chapter in which the topic is discussed. Some topics are covered in multiple chapters.

TABLE I-1 Cisco 640-460 Exam Topics

Exam Topic	Chapter
Describe PSTN Components and Technologies	
Describe the services provided by the PSTN	1, 2, 3
Describe time-division and statistical multiplexing	1, 2, 3
Describe supervisory, informational, and address signaling	1, 2, 3
Describe numbering plans	1, 2, 3
Describe analog circuits	1, 2, 3
Describe digital voice circuits	1, 2, 3
Describe PBX, trunk lines, key systems, and tie lines	1, 2, 3
Describe VoIP Components and Technologies	
Describe the process of voice packetization	4
Describe RTP and RTCP	4
Describe the function of and differences between codecs	4
Describe H.323, MGCP, SIP, and SCCP signaling protocols	4, 5
Describe and Configure Gateways, Voice Ports, and Dial Peers to Connect to the PSTN and Service Provider Networks	
Describe the function and application of a dial plan	6
Describe the function and application of voice gateways	6
Describe the function and application of voice ports in a gateway	6
Describe the function and operation of call legs	6
Describe and configure voice dial peers	6
Describe the differences between PSTN and Internet telephony service provider circuits	6

TABLE I-1 *continued*

Exam Topic	Chapter
Describe and Configure a Cisco Network to Support VoIP	
Describe the purpose of VLANs in a VoIP environment	7
Describe the environmental considerations to support VoIP	7
Configure switched infrastructure to support voice and data VLANs	7
Describe the purpose and operation of PoE	7
Identify the factors that impact voice quality	8
Describe how QoS addresses voice quality issues	8
Identify where QoS is deployed in the UC infrastructure	8
Implement UC500 Using Cisco Configuration Assistant	
Describe the function and operation of Cisco Configuration Assistant	14, 15
Configure UC500 device parameters	14, 15
Configure UC500 network parameters	14, 15
Configure UC500 dial plan and voicemail parameters	14, 15
Configure UC500 SIP trunk parameters	14, 15
Configure UC500 voice system features	14, 15
Configure UC500 user parameters	14, 15
Implement Cisco Unified Communications Manager Express to Support Endpoints Using CLI	
Describe the appropriate software components needed to support endpoints	9, 10, 12
Describe the requirements and correct settings for DHCP, NTP, and TFTP	10, 12
Configure DHCP, NTP, and TFTP	10, 12
Describe the differences between key system and PBX mode	10, 12
Describe the differences between the different types of ephones and ephone-dns	10, 12
Configure Cisco Unified Communications Manager Express endpoints	10, 12, 13
Configure call transfer per design specifications	10, 12
Configure voice productivity features, including hunt groups, call park, call pickup, paging groups, and paging/intercom	10, 12, 13
Configure Music on Hold	10, 12
Implement Voicemail Features Using Cisco Unity Express	
Describe the Cisco Unity Express hardware platforms	11
Configure the foundational elements required for Cisco Unified Communications Manager Express to support Cisco Unity Express	11
Describe the features available in Cisco Unity Express	11
Configure Auto Attendant services using Cisco Unity Express	11
Configure basic voicemail features using Cisco Unity Express	11

TABLE I-1 *continued*

Exam Topic	Chapter
Describe the Components of the Cisco Unified Communications Architecture	
Describe the function of the infrastructure in a UC environment	A
Describe the function of endpoints in a UC environment	A
Describe the function of the call processing agent in a UC environment	A
Describe the function of messaging in a UC environment	A
Describe the function of Auto Attendants and IVRs in a UC environment	A
Describe the function of a contact center in a UC environment	A
Describe the applications available in the UC environment, including Mobility, Presence, and Telepresence	A
Describe how the Unified Communications components work together to create the Cisco Unified Communications Architecture	A

7

CHAPTER SEVEN

Configuring the Network to Support VoIP

Terms you need to understand:

- ✓ Dynamic Host Control Protocol (DHCP)
- ✓ DHCP relay
- ✓ Domain Name System (DNS)
- ✓ Cisco Discovery Protocol (CDP)
- ✓ Network Time Protocol (NTP)
- ✓ IEEE 802.1af
- ✓ Power over Ethernet (PoE)
- ✓ IEEE 802.1Q
- ✓ IEEE 802.1p
- ✓ Virtual LAN (VLAN)
- ✓ Trivial File Transfer Protocol (TFTP)
- ✓ Extensible Markup Language (XML)

Techniques you need to master:

- ✓ Configure and understand VLANs
- ✓ Understand how CDP is used in Cisco VoIP solutions
- ✓ Create DHCP scopes on the Cisco IOS router platform
- ✓ Configure DHCP relay on the Cisco IOS router platform
- ✓ Understand the importance of NTP
- ✓ Configure NTP
- ✓ Understand the Cisco IP phone bootup process
- ✓ Identify the XML configuration files and understand their use

To deploy Cisco Unified Communications Manager Express, network services need to be established and properly configured on all routers and switches for Cisco IP phones to function. This chapter describes the typical boot process for Cisco IP phones and indicates the best practices related to configuring the network to support Voice over IP (VoIP).

Understanding the Theory of Voice VLANs

A Cisco IP phone can act as a three-port switch. Just like a switch, the phone can support 802.1Q frames between itself and another switch, and more than one VLAN can be supported between the Cisco Unified IP phone and an access switch. Figure 7.1 illustrates how the Cisco IP phone acts as a three-port switch.

NOTE

Not all Cisco IP phones provide a switch port for PC access, and switch port maximum speed is model dependent.

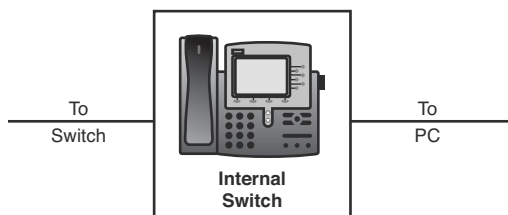


FIGURE 7.1 Cisco IP phones include a three-port switch.

The following are the three ports of the Cisco IP phone:

- ▶ The external port that connects to a 10/100/1000 Ethernet switch
- ▶ The external 10/100/1000 Ethernet port for PC connections
- ▶ An internal 10/100/1000 Ethernet port for VoIP traffic

EXAM ALERT

Cisco IP phone switch ports do not support Inter-Switch Link (ISL) encapsulation, only 802.1Q.

The benefits of this type of configuration include the following:

- ▶ Cisco IP phones can be deployed on the network without IP address scalability problems. IP subnets usually have more than 50 percent—and often more than 80 percent—of their IP addresses allocated. A separate VLAN and its separate IP subnet to carry the voice traffic allow a large number of new devices, such as IP phones, to be introduced into the network without extensive modifications to the existing IP address scheme.
- ▶ Voice and data VLANs allow the logical separation of data and voice traffic due to different characteristics. This separation allows you to handle each traffic type individually, applying different quality of service (QoS) policies to each VLAN for monitoring and managing them separately.

The following are IP addressing recommendations when adding Cisco IP phones to an existing data network:

- ▶ Continue to use existing addressing for data devices (PCs, workstations, and so on).
- ▶ Add Cisco IP phones and use DHCP to provision IP addresses and operating parameters.
- ▶ Use new subnets for Cisco IP phones if they are available in the existing address space, or use private addressing such as the 10.0.0.0 network (see RFC 1918 for details) if subnets are not available in the existing address space.

With IP phones residing in a separate VLAN—a voice VLAN—it is easier for you to automate the process of deploying IP phones. The IP phone communicates with the switch, using the Cisco Discovery Protocol (CDP), to request the voice VLAN if present. The switch CDP response provides the phone with the appropriate 802.1Q VLAN ID, known as the voice VLAN ID (VVID). The PC traffic travels across the same connection without the 802.1Q tag inserted.

Configuring Voice VLANs

This and the following sections define how VoIP and data traffic can use the same physical link while operating on separate Layer 2 VLANs. Figure 7.2 shows the PC communicating using untagged frames on VLAN 12 and the IP phone communicating on VLAN 112 with 802.1Q frames. The VLANs are configured on the infrastructure switch, as shown in Figure 7.1.

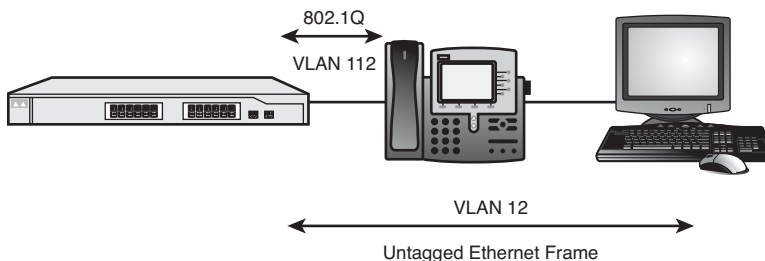


FIGURE 7.2 Voice and data VLANs coexist on a single physical connection.

Listing 7.1 shows a sample switch port configuration.

Listing 7.1 Switch Port Configuration

```
Switch(config)# interface FastEthernet0/1
Switch(config-if)# switchport access vlan 12
Switch(config-if)# switchport mode access
Switch(config-if)# switchport voice vlan 112
Switch(config-if)# spanning-tree portfast
```

The `switchport access vlan` command statically configures the access VLAN for the PC traffic.

The `switchport mode access` command statically configures the port in access mode.

The `switchport voice vlan vlan-id` command identifies the VLAN provided by the switch to the Cisco IP phone using CDP so that the Cisco IP phone can insert the voice VLAN ID and the 802.1P class of service (CoS) values for the VoIP control and media frames. By default, the IP phone sets the CoS setting in the 802.1Q header to a priority of 5 for voice streaming traffic and a priority of 3 for the call control traffic.

The `spanning-tree portfast` command eliminates the normal 30- to 50-second spanning tree delay before traffic is forwarded on a switch port.

You can verify your voice VLAN configuration on the Cisco Catalyst switch using the `show interface mod/port switchport` command, as shown in Listing 7.2.

Listing 7.2 Using the show interface *mod/port* switchport Command

```
Switch# show interface fa0/17 switchport
```

```
Name: Fa0/17Switchport: Enabled
Administrative mode: static access
Operational Mode: static access
Administrative Trunking Encapsulation: negotiate
```

Listing 7.2 Continued

```
Operational Trunking Encapsulation: native
Negotiation of Trunking: Off
Access Mode VLAN: 12 (VLAN0012)
Trunking Native Mode VLAN: 1 (default)
Voice VLAN: 112 (VLAN0112)
Trunking VLANs Enabled: ALL
Pruning VLANs Enabled: 2-1001
Appliance trust: none
```

EXAM ALERT

There are only two VLANs allowed on a switch port configured for IP phones: the access VLAN with standard untagged Ethernet frames and the voice VLAN with 802.1Q-tagged Ethernet frames.

For IP communications to access the voice and data VLANs, you need to provide a Layer 3 IP interface. There are three methods used to provide this access: an external router connected to a switch, a Layer 3 switch, and a router with built-in switch ports.

VLANs and an External Router

The commands used to connect an external router to access the voice and data VLANs created in the preceding section follow in Listing 7.3.

Listing 7.3 External Router—Layer 3 VLAN Configuration

```
CMRouter(config)# interface fa0/0.12
CMRouter(config-if)# encapsulation dot1q 12
CMRouter(config-if)# ip address 10.1.12.1 255.255.255.0
CMRouter(config)# interface fa0/0.112
CMRouter(config-if)# encapsulation dot1q 112
CMRouter(config-if)# ip address 10.1.112.1 255.255.255.0
```

Router with Built-in Switch Ports

Listing 7.4 shows the commands used to connect a Layer 3 switch or a router with internal switch ports to access the voice and data VLANs created previously.

Listing 7.4 Router with Built-in Switch—Layer 3 VLAN Configuration

```
CMRouter(config)# interface vlan 12
CMRouter(config-if)# ip address 10.1.12.1 255.255.255.0
CMRouter(config)# interface vlan 112
CMRouter(config-if)# ip address 10.1.112.1 255.255.255.0
```

Power over Ethernet

To simplify deployment and ensure that the Cisco IP phones are powered even in emergencies, power to operate the phones is sourced from the wiring closets by either powered switches or power patch panels running on uninterruptible power supplies (UPSs). Figure 7.3 shows the two methods commonly used to provide power to IP phones.

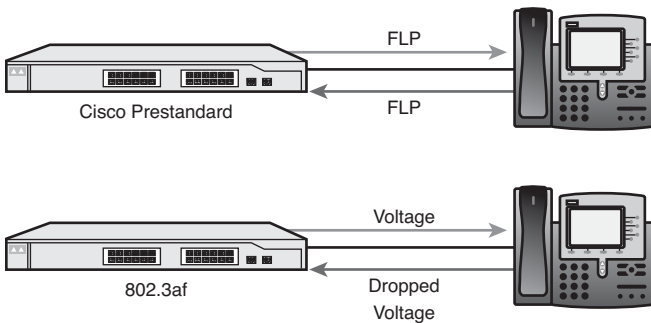


FIGURE 7.3 Power is supplied from the access switch.

Prestandard power uses a relay in the Cisco IP phone that bridges the transmit pair and the receive pair so that the Fast Link Pulse (FLP) can be detected by the Cisco Catalyst switch. After the switch detects the FLP, the switch applies inline power to the Cisco IP phone to activate the relay so that transmit and receive pairs can power the phone and enable communications.

Cisco prestandard power can be supplied on two pairs of a standard four-pair Ethernet cable. Option 1 is pins 1 and 2 and pins 3 and 6, and option 2 is pins 4 and 5 and pins 7 and 8.

Make sure that all the components in your wiring plant are certified to carry the power and voltage levels required to power Cisco IP phones. Components such as cables and patch panels should be Cat 5e or better.

With the IEEE standard 802.3af and the extended 802.3af plus, the method of detecting a powered device connected to Catalyst switches has been modified to measure resistance by sending low power to the powered device, measuring the result, verifying the result by slightly increasing the power, and remeasuring. After the powered device is verified, full power is applied.

EXAM ALERT

You should understand the two methods of delivering power to the Cisco IP phones: Cisco prestandard and IEEE 802.3af.

Essential Network Services: DHCP and NTP

DHCP is a common protocol and is familiar to many network administrators. With DHCP, a scope is defined per subnet and is used to assign IP addresses, along with a subnet mask, from a pool of available addresses. You should assign other values, such as the default gateway and Domain Name System (DNS) server (optional), to the scope by setting option values. Cisco IP phones look for option 150 (multiple servers) or option 66 (single server) from their DHCP server. These options provide the IP address of the TFTP server where the IP phone configuration files are stored. You must configure option 150 with the IP address of the TFTP server for the IP phones to receive their configuration file and successfully boot.

NOTE

The router or server that provides call control typically provides the TFTP function used in a Cisco Unified Communications deployment. Option 150 is the preferred practice.

NTP is used to synchronize the date and time on your network devices and for IP telephony to display the time on the IP phone and record the date and time for voicemail messages.

DHCP Services

You can deploy DHCP on any platform that supports customized scope options. These platforms include Windows, Linux, Novell, UNIX, and other operating systems.

When you set up the DHCP service for IP phones, you can define the address pools in the following ways:

- ▶ **Single DHCP IP address pool:** Define a single DHCP IP address pool if the router is a DHCP server and if you can use a single shared address pool for all your DHCP clients.
- ▶ **Separate DHCP IP address pool for each Cisco IP phone:** Define a separate pool for each Cisco IP phone if the router is a DHCP server and you need different settings on non-IP phone devices, such as personal computers, on the same subnet.

NOTE

You should avoid separate DHCP scopes for individual devices if possible because of the added configuration complexity.

- **DHCP relay server:** Define a DHCP relay server if the router is not a DHCP server and you want to relay DHCP requests from IP phones to a DHCP server on a different subnet.

Listing 7.5 shows router-based DHCP services.

Listing 7.5 Cisco IOS DHCP Configuration

```
CME(config)# ip dhcp excluded-address 10.112.0.1 10.112.0.10
CMERouter(config)# ip dhcp pool mypool
CMERouter(dhcp-config)# network 10.112.0.0 255.255.255.0
CMERouter(dhcp-config)# option 150 ip 10.112.0.1
CMERouter(dhcp-config)# default-router 10.112.0.1
CMERouter(dhcp-config)# dns-server 10.100.0.1 10.100.0.2
CMERouter(dhcp-config)# exit
```

EXAM ALERT

The DHCP pool name is case sensitive.

DHCP Relay Service

Implement DHCP relay when the DHCP server is not on the network where the DHCP clients exist. The Cisco IP phones use a broadcast DHCP request-and-response process, and broadcasts are only valid on the local subnet (VLAN). The solution is to convert and track the DHCP broadcast request to either a unicast or a directed broadcast. The broadcast traverses the network to reach the destination server or subnet and relays the response to the original requesting device. Figure 7.4 shows a router acting as the relay agent, accepting the IP phone broadcasts, obtaining the DHCP information from the server, and forwarding the response to the IP phone.

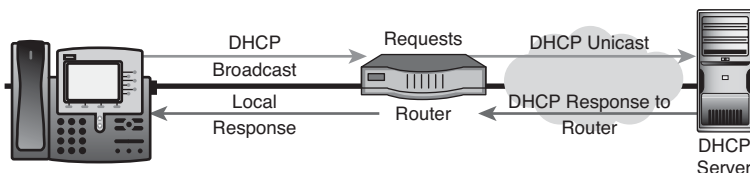


FIGURE 7.4 DHCP relay services.

For the Cisco router to support DHCP relay services, it must have the DHCP service enabled. The Cisco IOS DHCP server is enabled by default. If it has previously been disabled, use the `service dhcp` command in global configuration mode to enable this feature.

The `ip helper-address ip-address` command enables the selective forwarding of certain types of broadcasts, including Bootstrap Protocol (BOOTP) and DHCP. The `ip-address` parameter specifies the DHCP server to which the messages are forwarded. If you have multiple servers, you can configure one helper address for each server. For the IP phone to obtain IP address information, configure the `relay` command on each router interface local to the IP phones pointing to the remote DHCP server.

Listing 7.6 shows the configuration commands to implement DHCP relay services.

Listing 7.6 Implementing DHCP Relay Services

```
CMERouter(config)# service dhcp
CMERouter(config)# interface fastethernet 0/0
CMERouter(config-if)# ip helper-address 10.200.0.1
```

This listing configures an IP helper address of 10.200.0.1 on the Fast Ethernet 0/0 (fa0/0) interface. This interface connects to a network that has IP phones but does not have a DHCP server. This command causes the DHCP broadcasts that enter the router on the Fast Ethernet 0/0 interface to be forwarded to DHCP server 10.200.0.1. Each request is tracked by the router so that DHCP responses are forwarded to the correct local Cisco IP phone.

Network Time Protocol

NTP synchronizes network infrastructure (routers and switches) and computers (PCs and servers) to a single clock on the network, known as the *clock master*. NTP is essential to Cisco Unified Communications deployments.

An NTP network usually gets its time from an authoritative time source. This source can be a radio clock or an atomic clock attached to a time server. NTP then distributes this time across the network. An NTP client initiates a transaction with its server with a polling interval that ranges from 64 to 1,024 seconds. This interval dynamically changes over time, depending on the network conditions between the NTP server and the client. No more than one NTP transaction per minute is needed to synchronize two machines.

One of the strengths of NTP is that it uses Coordinated Universal Time (UTC), which is easily accessed through the GPS satellite system. Because UTC is the

same worldwide, networks synchronized to UTC avoid interoperability problems with other networks. This synchronization is particularly important when administrators are troubleshooting IP telephony traffic and need to compare log files from various networks. The time of the internal clock of the Cisco Unified Communications call control platform and the network infrastructure components should be synchronized with an NTP server.

The `clock timezone zone hours-offset` command sets the time zone and number of hours that the time zone is offset from the UTC (formerly Greenwich Mean Time [GMT]). This command allows the Cisco router to define the operating time zone. If daylight saving time occurs in the area where the system is located, you must configure it using the `clock summer-time zone recurring [start-date end-date]` command.

Because Cisco Unified Communications call control can run on multiple platforms, the method for enabling NTP varies. To keep the correct time based on the time of a more authoritative source than its own system, perform the following:

- ▶ **Cisco IOS router:** The `ntp server ip-address` command configures the Cisco router to synchronize with the NTP server specified by the `ip-address` parameter.
- ▶ **LINUX-based servers:** Linux-based versions of Cisco Unified Communications Manager have a web-based interface that you can use to set the NTP server to which they can synchronize.
- ▶ **Windows-based servers:** Windows-based versions of Cisco Unified Communications Manager can be set from the command line.

Listing 7.7 sets a Cisco router to Pacific Standard Time with daylight saving time configured and synchronizes the router's system time to an NTP server with an IP address of 10.1.2.3.

Listing 7.7 Configuring NTP and Clock Settings

```
Router(config)# clock timezone PST -8
Router(config)# clock summer-time PDT recurring first sunday april 02:00
last sunday october 02:00
Router(config)# ntp server 10.1.2.3
```

Understanding the Phone Bootup Process

After completing the configuration of the switch and activating DHCP, the Cisco IP phone proceeds through the standard bootup cycle.

After an IP phone receives power, the following happens:

1. Power-on self-test (POST): The phone performs a set of tests to ensure basic functionality.
2. The phone begins the boot process.
3. The phone uses Cisco Discovery Protocol to learn the voice VLAN.
4. The phone initializes a basic IP stack.
5. The IP phone (DHCP client) sends a DHCPDISCOVER request to the 255.255.255.255 broadcast address.
6. A DHCP server returns a DHCPOFFER message and assigns the following for the requested scope: a free IP address, the subnet mask, the default gateway, the DNS server (optional), and the TFTP server (option 150) for the scope. This information is sent to the DHCP client (the IP phone) using the broadcast address 255.255.255.255 (the router uses the IP phone MAC address at Layer 2).
7. The IP phone takes the values received from the DHCP response and applies them to the IP stack of the IP phone.
8. The IP phone uses the value received in option 150 to attempt to retrieve a configuration file from the TFTP server.

The IP phone is prepared and ready to operate on the network, but it needs its unique identity and operating parameters. When the TFTP request for configuration files is issued, there is a sequence of requests issued in an attempt to register with a call agent and operate. The following sections cover the configuration files.

Installing Cisco IP Phone Firmware and XML Configuration Files

Certain files are necessary for the proper operation of a Cisco IP phone or analog device so that it can register successfully with a Cisco Unified Communications call control device. These files are not installed on the Cisco router and must be installed from an external source. The file types are as follows:

- ▶ **Firmware:** The firmware is loaded into flash memory on the IP phone and can survive a reboot.
- ▶ **SEPAAAAABBBBCCCC.cnf.xml:** This XML configuration file is specific to one device, and the AAAABBBBCCCC part of the name is the MAC address of the device.
- ▶ **XMLDefault.cnf.xml:** This XML configuration file specifies the proper firmware and the call agent's address and port, which the new phone needs to register.

The following sections describe each file type in greater detail.

Firmware

Install the firmware required by the Cisco IP phones in the flash memory of the Cisco Unified Communications Manager Express systems. There are two commands required to provide access to these firmware files:

- ▶ **tftp-server flash:firmware-file-name:** Use this global command to make the file available.
- ▶ **load phone-type firmware-file:** Use this telephony-service command to associate a type of phone with a firmware file.

All the necessary firmware files for Cisco IP phones are stored internally in the flash memory of the Cisco Unified Communications Manager Express router, so an external database or file server is not required. During registration, Cisco IP phones use TFTP to download firmware files from the router's flash memory. All Cisco Unified Communications Manager Express configuration and language files are located in the memory of the router in the `system:/its/` directory.

To make the firmware file(s) available through a TFTP server, use the `tftp-server flash:firmware-file-name(s)` command on the Cisco Unified

Communications Manager Express router. The load *phone-type firmware-file* command under telephony service is also required to associate the model of IP phone with the appropriate firmware file(s).

For Cisco Unified Communications Manager, the firmware files are installed on the server(s) in the cluster that run the TFTP service.

Device Configuration XML File

The XML file SEPAAAABBBBCCCC.cnf.xml (where AAAABBBBCCCC is the MAC address of the IP phone) contains the call agent IP address and port, firmware, locale, directory URL, and many other pieces of information. This file is present when the IP phone has been added to the configuration.

Listing 7.8 shows a configuration file that contains the phone model (7931), IP address (10.6.150.1), and port (2000) for registering; the firmware filename; the language (English United States); and additional information for proper IP phone operation.

Listing 7.8 SEPAAAABBBBCCCC.cnf.xml File (AAAABBBBCCCC = the MAC Address)

```
<device>
<versionStamp>{7931 Aug 06 2008 14:23:48}</versionStamp>
<devicePool>
<dateTimeSetting>
<dateTemplate>M/D/YA</dateTemplate>
<timeZone>Eastern Standard/Daylight Time</timeZone>
</dateTimeSetting>
<callManagerGroup>
<members>
<member priority="0">
<callManager>
<ports>
<ethernetPhonePort>2000</ethernetPhonePort>
</ports>
<processNodeName>10.6.150.1</processNodeName>
</callManager>
</member>
</members>
</callManagerGroup>
</devicePool>
<commonProfile>
<callLogBlfEnabled>3</callLogBlfEnabled>
</commonProfile>
<loadInformation>SCCP31.8-3-3S</loadInformation>
<userLocale>
<name>English_United_States</name>
<langCode>en</langCode>
```


Listing 7.8 *Continued*

```

</userLocale>
<networkLocale>United_States</networkLocale>
<networkLocaleInfo>
<name>United_States</name>
</networkLocaleInfo>
<idleTimeout>0</idleTimeout>
<authenticationURL>http://10.6.4.2/voiceview/authentication/authenticate.do
  </authenticationURL>
<directoryURL>http://10.6.150.1:80/localhostdirectory</directoryURL>
<idleURL></idleURL>
<informationURL></informationURL>
<messagesURL></messagesURL>
<proxyServerURL></proxyServerURL>
<servicesURL>http://10.6.150.1:80/CMEserverForPhone/serviceurl</servicesURL>
<capfAuthMode>0</capfAuthMode>
<capfList>
<capf>
<phonePort>3804</phonePort>
<processNodeName></processNodeName>
</capf>
</capfList>
<deviceSecurityMode>1</deviceSecurityMode>
</device>

```

Default XML File

IP phones and devices that do not find the more specific SEPAAAAABBBBCCCC.cnf.xml file can use the XMLDefault.cnf.xml file if they have never registered before and an autoregistration method has been enabled. IP phones that download this XML file through TFTP learn the IP address and port to send Skinny Client Control Protocol (SCCP) messages to when attempting to register. The IP phones also learn the version of firmware that is required to function properly with the Cisco Unified Communications call control product to which the phone is registering. Cisco IP phone models 7931 and 7961 are highlighted.

Listing 7.9 shows a default configuration file.

Listing 7.9 XMLDefault.cnf.xml File

```

<Default>
<callManagerGroup>
<members>
<member priority="0">
<callManager>
<ports>
<ethernetPhonePort>2000</ethernetPhonePort>

```

Listing 7.9 Continued

```

</ports>
<processNodeName>10.6.150.1</processNodeName>
</callManager>
</member>
</members>
</callManagerGroup>
<loadInformation124 model="Cisco IP Phone 7914 14-Button Line Expansion
Module"></loadInformation124>
<loadInformation227 model="Cisco IP Phone 7915 12-Button Line Expansion
Module"></loadInformation227>
<loadInformation228 model="Cisco IP Phone 7915 24-Button Line Expansion
Module"></loadInformation228>
<loadInformation229 model="Cisco IP Phone 7916 12-Button Line Expansion
Module"></loadInformation229>
<loadInformation230 model="Cisco IP Phone 7916 24-Button Line Expansion
Module"></loadInformation230>
<loadInformation30008 model="Cisco IP Phone 7902"></loadInformation30008>
<loadInformation20000 model="Cisco IP Phone 7905"></loadInformation20000>
<loadInformation369 model="Cisco IP Phone 7906"></loadInformation369>
<loadInformation6 model="Cisco IP Phone 7910"></loadInformation6>
<loadInformation307 model="Cisco IP Phone 7911"></loadInformation307>
<loadInformation30007 model="Cisco IP Phone 7912"></loadInformation30007>
<loadInformation30002 model="Cisco IP Phone 7920"></loadInformation30002>
<loadInformation365 model="Cisco IP Phone 7921"></loadInformation365>
<loadInformation348 model="Cisco IP Phone 7931">SCCP31.8-3-3S
</loadInformation348>
<loadInformation9 model="Cisco IP Conference Station 7935">
</loadInformation9>
<loadInformation30019 model="Cisco IP Phone 7936"></loadInformation30019>
<loadInformation431 model="Cisco IP Conference Station 7937">
</loadInformation431>
<loadInformation8 model="Cisco IP Phone 7940"></loadInformation8>
<loadInformation115 model="Cisco IP Phone 7941"></loadInformation115>
<loadInformation309 model="Cisco IP Phone 7941GE"></loadInformation309>
<loadInformation434 model="Cisco IP Phone 7942"></loadInformation434>
<loadInformation435 model="Cisco IP Phone 7945"></loadInformation435>
<loadInformation7 model="Cisco IP Phone 7960"></loadInformation7>
<loadInformation30018 model="Cisco IP Phone 7961">SCCP41.8-3-3S
</loadInformation30018>
<loadInformation308 model="Cisco IP Phone 7961GE"></loadInformation308>
<loadInformation404 model="Cisco IP Phone 7962"></loadInformation404>
<loadInformation436 model="Cisco IP Phone 7965"></loadInformation436>
<loadInformation30006 model="Cisco IP Phone 7970"></loadInformation30006>
<loadInformation119 model="Cisco IP Phone 7971"></loadInformation119>
<loadInformation437 model="Cisco IP Phone 7975"></loadInformation437>
<loadInformation302 model="Cisco IP Phone 7985"></loadInformation302>
</Default>

```

Exam Prep Questions

1. What are the reasons for using 802.1Q? (Choose two.)
 - ☐ A. Standards based multi-VLAN trunking
 - ☐ B. To allow clients to see the 802.1Q header
 - ☐ C. To provide inter-VLAN communications over a bridge
 - ☐ D. To load-balance traffic between parallel links using STP
 - ☐ E. To provide a voice and data VLAN on a shared connection

2. Which of the following describes the endless flooding or looping of frames in a Layer 2 switched environment?
 - ☐ A. Flood storm
 - ☐ B. Loop overload
 - ☐ C. Broadcast storm
 - ☐ D. Broadcast overload

3. Which command correctly connects an Ethernet subinterface to VLAN 50 using 802.1Q trunking?
 - ☐ A. Router(config) # **encapsulation 50 dot1q**
 - ☐ B. Router(config) # **encapsulation 802.1q 50**
 - ☐ C. Router(config-if) # **encapsulation dot1q 50**
 - ☐ D. Router(config-if) # **encapsulation 50 802.1q**

4. Which of the following is a Cisco recommendation for IP addressing deployment?
 - ☐ A. Statically apply IP addresses to IP phones to ensure stability.
 - ☐ B. Apply public IP addresses to IP phones so that they can be reached from the PSTN.
 - ☐ C. Add IP phones with DHCP as the mechanism for obtaining IP addresses.
 - ☐ D. Deploy IP phones on the same subnet as data devices.

5. Why would you need to implement a DHCP relay server?
- ☐ A. If the DHCP server does not have a local interface on the network with the DHCP clients
 - ☐ B. Because the DHCP request and response process is not broadcast
 - ☐ C. To relay the proprietary DHCP request of an IP phone to the standard DHCP request understood by the Cisco IOS Software
 - ☐ D. If an IP phone, a data device, and a DHCP server all reside on the same subnet
6. Which protocol do IP phones use during registration to download firmware files from the flash memory of the router?
- ☐ A. HTTP
 - ☐ B. DHCP
 - ☐ C. FTP
 - ☐ D. TFTP
7. Which of the following statements accurately describe NTP? (Choose all that apply.)
- ☐ A. NTP is used to synchronize syslog time stamps.
 - ☐ B. NTP is used to synchronize call detail records.
 - ☐ C. NTP is used to minimize errors during TFTP downloads.
 - ☐ D. The time displayed on the IP phones must come from an NTP server.
 - ☐ E. Cisco Unified Communications Manager Express can synchronize its clock to an NTP server.
 - ☐ F. NTP requires the purchase of an atomic or radio clock.
8. Which of the following filenames could be used by a Cisco IP phone to synchronize its firmware with the call agent? (Choose two.)
- ☐ A. XMLdefault.cnf.xml
 - ☐ B. ephone-1.cnf.xml
 - ☐ C. SEP001BD5086771.cnf.xml
 - ☐ D. SEP001BB35853C.cnf.xml
 - ☐ E. XMLDefault.cnf.xml

9. Which of the following commands would be used to deliver firmware file SCCP41.8-3-3S.loads at the request of a Cisco IP phone?
- ☐ A. `ftp-server flash:/SCCP41.8-3-3S.loads`
 - ☐ B. `tftp-server flash:/SCCP41.8-3-3S.loads`
 - ☐ C. `tftp-server flash:/SCCP41.8-3-3S`
 - ☐ D. `tftp-server SCCP41.8-3-3S.loads`
10. DHCP services can be configured on which of the following devices? (Choose two.)
- ☐ A. Cisco IOS routers
 - ☐ B. Cisco IP phones
 - ☐ C. Cisco IOS Layer 3 switches
 - ☐ D. Cisco IOS Layer 2 switches

Answers to Exam Prep Questions

1. **A and E.** 802.1Q is a standards-based trunking protocol and shares a single physical connection for voice and data traffic. End users typically are not permitted to access the network over multiple VLANs, so answer B is incorrect. Answer C is incorrect; VLANs isolate traffic at Layer 2. Multiple VLANs are not used for load balancing because end stations can only access one VLAN at a time, so answer D is incorrect.
2. **C.** Broadcast storm describes the endless flooding of frames in a Layer 2 switched environment. Answers A, B, and D are incorrect. None of those terms have meaning in the Ethernet switch environment.
3. **C.** The `encapsulation` command followed by the *encapsulation type* and the *VLAN number*. Answers A and B are incorrect; the answers are in global mode, not interface mode. Answer D has the parameters of the `encapsulation` command backward.
4. **C.** Deploy IP phones using DHCP. Statically applying IP addresses is time consuming and error prone, so answer A is incorrect. Using public IP addresses for phones opens a security threat, so answer B is incorrect. Answer D is incorrect; the goal is to separate voice and data traffic.
5. **A.** No direct connection to the DHCP server. The IP phone DHCP request is a broadcast, so answer B is incorrect. The IP phone uses standard DHCP services, so answer C is incorrect. If the DHCP server is directly attached to the same IP subnet or VLAN, there is no reason to use DHCP relay, so answer D is incorrect.

6. **D.** TFTP is used to provision Cisco IP phones. HTTP, DHCP, and FTP are not used during the automatic provisioning and registration process, so answers B, C, and D are incorrect.
7. **A, B, and E.** NTP is the source for syslog and CDR time stamps, and for Cisco Unified Communications call agent synchronization. NTP is not used during TFTP downloads to minimize errors, so answer C is incorrect. The time displayed on the IP phones comes from the call agent, so answer D is incorrect. There are many free-access NTP servers on the Internet that have atomic clocks and are typically used as NTP sources, so answer F is incorrect.
8. **C and E.** `SEP<12 hex digit MAC address>.cnf.xml` and `XMLDefault.cnf.xml` (case sensitive) are valid files. Answer A is incorrect; file requests are case sensitive and the *d* in default is lowercase. Answer B is an invalid filename and is incorrect. Answer D has only 11 hex digits for the MAC address, not the normal 12, and is incorrect.
9. **B.** The complete filename using the TFTP protocol. FTP service is not supported for firmware upgrades, so answer A is incorrect. The complete filename including extension must be referenced by the `tftp -server` command. The full directory and filename must be defined, not default locations.
10. **A and C.** Layer 3 devices can provide DHCP services. Answer B is incorrect; IP phones cannot provide DHCP services. Answer D is incorrect; Layer 2 devices cannot provide DHCP services.

Suggested Reading and Resources

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