



CCNA Routing and Switching: Switched Networks Instructor Lab Manual

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Sent or Received (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Describe convergence of data, voice, and video in the context of switched networks.

Students will be able to explain how switches can help LAN end devices send and receive data, voice, and video data.

Scenario

Individually, or in groups (per the instructor's decision), discuss various ways hosts send and receive data, voice, and streaming video.

- Develop a matrix (table) listing network data types that can be sent and received. Provide five examples.

Your matrix table might look something like this:

Sent	Received
Client requests a web page from a web server.	Web server send web page to requesting client.

Save your work in either hard- or soft-copy format. Be prepared to discuss your matrix and statements in a class discussion.

Resources

Internet connectivity

Reflection

- If you are receiving data, how do you think a switch assists in that process?

Students should mention that switches process data to and from end devices - many users can be sending and receiving data at the same time.

- If you are sending network data, how do you think a switch assists in that process?

Switches allow multiple recipients to send and receive data simultaneously. Compared to hubs, a switch allows for better used of the bandwidth.

Matrix Answers (will vary)

Instructor Note: This is a representative model that might be “built” as a result of this activity:

Sent	Received
Client requests a web page from a web server.	Automatic updates to your cell telephone applications Web server send web page to requesting client.
Client requests a file from a FTP server.	FTP server sends the requested file to the client.
Client requests a streaming video from a server.	Server transmits video to requesting clients.
Bob sends instant message to Mary.	Mary receives instant from Bob.
Ethernet switch receives an Ethernet frame on ingress port 1.	Ethernet switch forwards frame out egress port 4.
Bob sends VoIP packets from his IP phone.	Mary receives VoIP packets on her IP phone.

Lab – Selecting Switching Hardware (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Part 1: Explore Cisco Switch Products

Part 2: Select an Access Layer Switch

Part 3: Select a Distribution/Core Layer Switch

Background / Scenario

As a Network Engineer, you are part of a team that selects appropriate devices for your network. You need to consider the network requirements for the company as they migrate to a converged network. This converged network supports voice over IP (VoIP), video streaming, and expansion of the company to support a larger customer base.

For a small- to medium-sized company, Cisco hierarchical network design suggests only using a two-tier LAN design. This design consists of an access layer and a collapsed core/distribution layer. Network switches come in different form factors, and with various features and functions. When selecting a switch, the team must choose between fixed configuration or modular configuration, and stackable or non-stackable switches.

Based on a given set of requirements, you will identify the Cisco switch models and features to support the requirements. The scope of this lab will limit the switch models to campus LAN only.

Required Resources

PC with Internet access

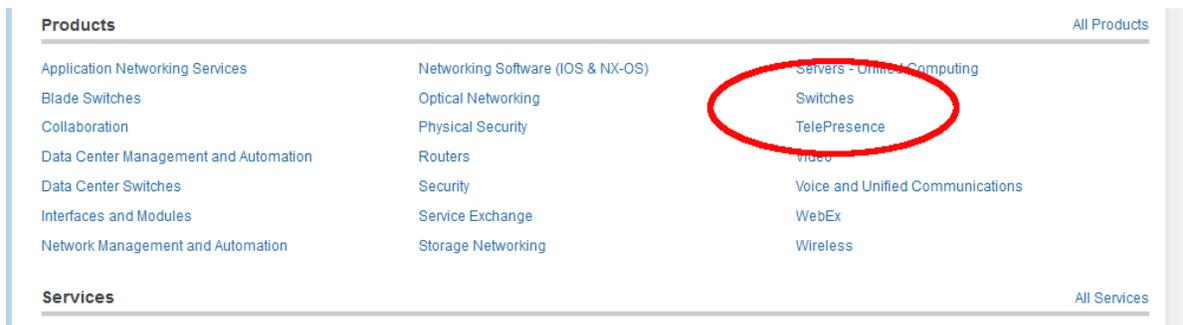
Part 1: Explore Cisco Switch Products

In Part 1, you will navigate the Cisco website and explore available switch products.

Step 1: Navigate the Cisco website.

At www.cisco.com, a list of available products and information about these products is available.

- a. From the home page, click **Products & Services > Switches**.



Step 2: Explore switch products.

In the Feature Products section, a list of different categories of switches is displayed. In this lab, you will explore the campus LAN switches. You can click different links to gather information about the different switch models. On this page, the information is organized in different ways. You can view all available switches by

Lab – Selecting Switching Hardware

clicking **View All Switches**. If you click **Compare Series**, the switches are organized by types: modular vs. fixed configuration.

Featured Products [View All Switches](#) | [For Small Business](#) | [Compare Series](#)



Campus LAN – Core and Distribution Switches
Scale network performance and reliability with industry- leading network services, integrated service modules, and validated design guides.

[Show Products](#) +



Campus LAN – Access Switches
Adapt your network to meet evolving business requirements and optimize new application deployments with Cisco access switches.

[Show Products](#) +



Campus LAN – Compact Switches
Securely and easily deploy services anywhere. These fanless, sleek, compact switches are ideal for spaces with limited wiring and cabling infrastructure, such as kiosks, conference rooms, and call centers.

[Show Products](#) +

- a. Click the heading **Campus LAN – Core and Distribution Switches**.

List a few models and some of features in the table below.

Model	Uplink Speed	Number of Ports/Speed	Other Features
Catalyst 4500-X	8 x 10 GE (hot swap module)	Up to 40 1G/10G ports	hot swappable power supplies, cooling fans and network modules, 1 RU, QoS, Fixed configuration
Catalyst 4500E	1G or 10G	Up to 196 1G ports and up to 100 10G ports	PoE+, hot swappable power supplies, cooling fans and network modules, Modular configuration

- b. Click the heading **Campus LAN – Access Switches**.

List a few models and some of features in the table below.

Model	Uplink Speed	Number of Ports/Speed	Other Features
Catalyst 2960	2x1GE uplink	8, 24, and 48 FE ports	PoE+, advanced QoS, rate-limiting, ACLs, IPv6, multicast, Fixed configuration
Catalyst 3560-X and 3750-X	4x1GE or 10GE uplink ports (optional)	12, 24, and 48 FE/GE ports	QoS, PoE+, hot swappable power supplies, cooling fans and network modules, StackPower and StackWise, Fixed configuration

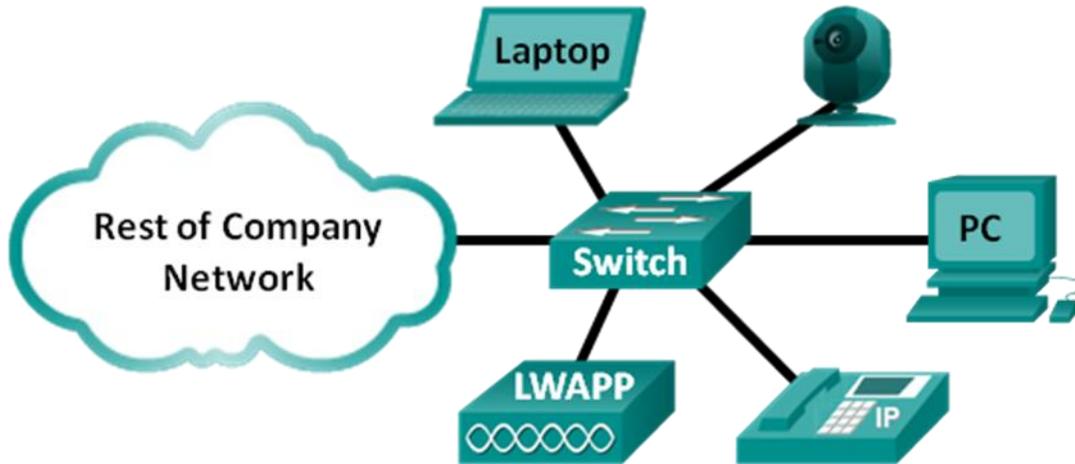
- c. Click the heading **Campus LAN – Compact Switches**.
List a few models and some of features in the table below.

Model	Uplink Speed	Number of Ports/Speed	Other Features
Catalyst 3560-C	2x1GE uplink	8-12 FE/GE ports	Collocate with users, PoE+, Fixed configuration
Catalyst 2960-C	2x1GE uplink	8-12 FE/GE ports	Collocate with users, PoE / PoE pass-through, Fixed configuration

Part 2: Select an Access Layer Switch

The main function of an access layer switch is to provide network access to end user devices. This switch connects to the core/distribution layer switches. Access switches are usually located in the intermediate distribution frame (IDF). An IDF is mainly used for managing and interconnecting the telecommunications cables between end user devices and a main distribution frame (MDF). There are typically multiple IDFs with uplinks to a single centralized MDF.

An access switch should have the following capabilities: low cost per switch port, high port density, scalable uplinks to higher layers, and user access functions and resiliency. In Part 2, you will select an access switch based on the requirements set by the company. You have reviewed and become familiar with Cisco switch product line.



- a. Company A requires a replacement access switch in the wiring closet. The company requires the switch to support VoIP and multicast, accommodate future growth of users and increased bandwidth usage. The switch must support a minimum of 35 current users and have a high-speed uplink. List a few of models that meet those requirements.

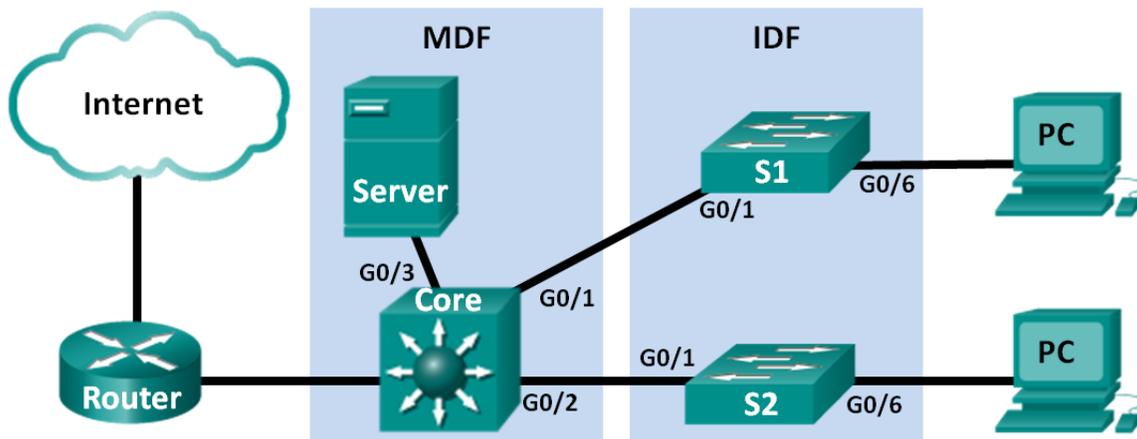
Answers will vary. 2960-S or 3560-X with 48 port capacity and at least two 1G/10G uplinks

- b. Company B would like to extend services to a conference room on an as-needed basis. The switch will be placed on the conference room table, and switch security is a priority.

Answers will vary. A Compact LAN switch such as the 2960-C

Part 3: Select a Distribution/Core Layer Switch

The distribution/core switch is the backbone of the network for the company. A reliable network core is of paramount importance for the function of the company. A network backbone switch provides both adequate capacity for current and future traffic requirements and resilience in the event of failure. They also require high throughput, high availability, and advanced quality of service (QoS). These switches usually reside in the main wiring closet (MDF) along with high speed servers, routers, and the termination point of your ISP.



Lab – Selecting Switching Hardware

- a. Company C will replace a backbone switch in the next budget cycle. The switch must provide redundancy features to minimize possible downtime in the event that an internal component fails. What features can accommodate these requirements for the replacement switch?

Answers will vary. Hotswappable power supplies, cooling fans and network modules, redundant power supplies, StackWise and StackPower

- b. Which Cisco Catalyst switches would you recommend?

Answers will vary. 3750-X, 4500-X, 4500-E

- c. As Company C grows, high speed, such as 10 GB Ethernet, up to 8 uplink ports, and a modular configuration for the switch will become necessary. Which switch models would meet the requirement?

Answers will vary. 4500, 6500

Reflection

What other factors should be considered during the selection process aside from network requirements and costs?

Space/form factor, power consumption, modular upgrade, longevity of switch, IOS features for the switch

It's Network Access Time (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Describe features available for switches to support requirements of a small- to medium-sized business network.

Students will design two networks using Packet Tracer to suffice requirements shown in a LAN and WAN scenarios.

Scenario

Use Packet Tracer for this activity. Work with a classmate to create two network designs to accommodate the following scenarios:

Scenario 1 – Classroom Design (LAN)

- 15 student end devices represented by 1 or 2 PCs.
- 1 instructor end device; a server is preferred.
- Device capability to stream video presentations over LAN connection. Internet connectivity is not required in this design.

Scenario 2 – Administrative Design (WAN)

- All requirements as listed in Scenario 1.
- Add access to and from a remote administrative server for video presentations and pushed updates for network application software.

Both the LAN and WAN designs should fit on to one Packet Tracer file screen. All intermediary devices should be labeled with the switch model (or name) and the router model (or name).

Save your work and be ready to justify your device decisions and layout to your instructor and the class.

Reflection

1. What are some problems that may be encountered if you receive streaming video from your instructor's server through a low-end switch?

Answers will vary – bandwidth might be too low for the video stream to many recipients causing lag time – distortion may result in picture, audio, etc. Some stations could be “kicked out” as a result of traffic overload depending on the application program being used to stream the video, etc. There is also the possibility of “sniffing or snooping” depending on how the switch is configured.

2. How would the traffic flow be determined: multicast or broadcast – in transmission?

When users have to “log in” to the application to receive the video transmission, this would be considered a multicast. If students are set up collectively into a group by the server to push the stream, it would be considered a broadcast on the LAN side.

3. What would influence your decision on the type of switch to use for voice, streaming video and regular data transmissions?
-

It's Network Access Time

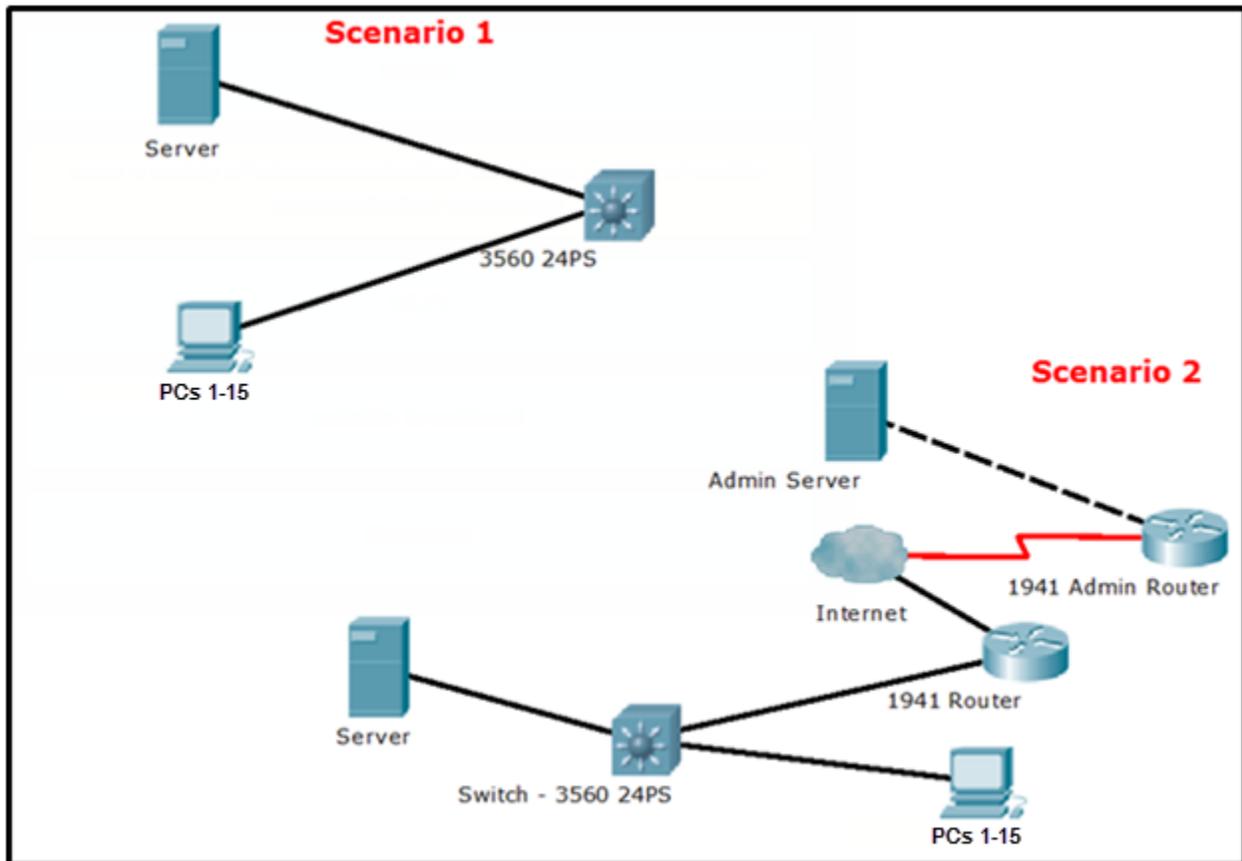
Answers will vary – if the switch will be also used for WAN streams and other intensive download traffic, a higher level switch would be used.

- As you learned in the first course of the Academy, video and voice use a special TCP/IP model, transport layer protocol. What protocol is used in this layer and why is it important to voice and video streaming?

(UDP is the protocol used for voice and video – it allows for a continuous stream of data to flow without interruption to report delays back to the sender. There is no guaranteed delivery of data from source to destination hosts)

Packet Tracer Example (answers will vary)

Instructor Note: This is a representative model that might be “built” as a result of this activity:



Identify elements of the model that map to IT-related content:

- Voice, video and regular data can traverse networks using different devices, such as routers and switches.
- The type of switch that is used as an intermediary device provides different functional capacities.
- The type of network traffic will impact the switch's performance in sending and delivering data.
- Sufficient bandwidth is necessary to handle different types of traffic; therefore, network switch types/models and their capabilities are important to the switch model and type.
- Security impacts the switch selection. If the switch will be accessible physically, remotely or over the network locally, it will need to have security configured to include ACLs and/or port security.

Stand By Me (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Describe the role of unicast, broadcast, and multicast in a switched network.

Instructor Notes:

- Students are given three scenarios where activity-based numbers will need to be recorded. At the end of the activity, students will answer questions about how this introductory process relates to sending and receiving messages on a switch.
- Please make sure that **only one student receives number 505C** (which signifies a unicast transmission recipient).

501A	501B	501C	501D	501E
502A	502B	502C	502D	502E
503A	503B	503C	503D	503E
504A	504B	504C	504D	504E
505A	505B	505C	505D	505E

Scenario

When you arrived to class today, you were given a number by your instructor to use for this introductory class activity.

Once class begins, your instructor will ask certain students with specific numbers to stand. Your job is to record the standing students' numbers for each scenario.

Scenario 1

Students with numbers **starting** with the number **5** should stand. Record the numbers of the standing students. **All students will stand and all the numbers will be recorded by each student. This represents a broadcast transmission.**

Scenario 2

Students with numbers **ending** in **B** should stand. Record the numbers of the standing students. **More than one student should stand, but not all students will stand. All numbers of standing students will be recorded by all students. This represents a multicast transmission.**

Scenario 3

The student with the number **505C** should stand. Record the number of the standing student. **Only one student will stand and all students will record that number. This represents a unicast transmission.**

At the end of this activity, divide into small groups and record answers to the Reflection questions on the PDF for this activity.

Reflection

1. Why do you think you were asked to record the students' numbers when and as requested?

Recording was necessary to see how groups are formed in networking. Recording helps you to identify to which group the students belong. Recording helps to keep a list of who has been seen in certain groups.

Stand By Me

2. What is the significance of the number 5 in this activity? How many people were identified with this number?

All students received a number beginning with 5, as this indicates a full group of students. This is similar to a network broadcast situation.

3. What is the significance of the letter B in this activity? How many people were identified with this number?

The letter B allows a smaller grouping of students to be identified – very similar to a multicast situation.

4. Why did only one person stand for 505C?

This number is unique to the class – therefore, it indicates a unicast form of network transmission.

5. How do you think this activity represents data travelling on local area networks?

When a switch first sees hosts on its network, it will record responses from those hosts in respect to unicasts, multicasts, and broadcasts (flooding). That is how it builds its MAC address table. Once the MAC addresses have been recorded by the switch, specific types of traffic can be switched (unicasts, broadcasts, and multicasts). The significance of the numbers illustrates unicast, multicast, and broadcast selection methods.

Save your work and be prepared to share it with another student or the entire class. (Instructor choice)

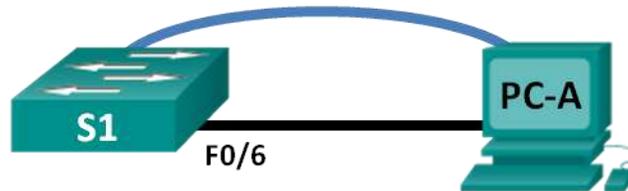
Instructor Note: Identify elements of the model that map to IT-related content:

- Switches record MAC addresses, just as the numbers were recorded during this introductory activity.
- LAN switch unicasts can be sent to and/or received by hosts.
- LAN switch multicasts can be sent to and/or received by hosts.
- LAN broadcasts can be sent to and/or received by hosts.

Lab – Configuring Basic Switch Settings (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
S1	VLAN 99	192.168.1.2	255.255.255.0	192.168.1.1
PC-A	NIC	192.168.1.10	255.255.255.0	192.168.1.1

Objectives

Part 1: Cable the Network and Verify the Default Switch Configuration

Part 2: Configure Basic Network Device Settings

- Configure basic switch settings.
- Configure the PC IP address.

Part 3: Verify and Test Network Connectivity

- Display device configuration.
- Test end-to-end connectivity with ping.
- Test remote management capabilities with Telnet.
- Save the switch running configuration file.

Part 4: Manage the MAC Address Table

- Record the MAC address of the host.
- Determine the MAC addresses that the switch has learned.
- List the **show mac address-table** command options.
- Set up a static MAC address.

Background / Scenario

Cisco switches can be configured with a special IP address known as switch virtual interface (SVI). The SVI or management address can be used for remote access to the switch to display or configure settings. If the VLAN 1 SVI is assigned an IP address, by default, all ports in VLAN 1 have access to the SVI management IP address.

In this lab, you will build a simple topology using Ethernet LAN cabling and access a Cisco switch using the console and remote access methods. You will examine default switch configurations before configuring basic switch settings. These basic switch settings include device name, interface description, local passwords,

Lab – Configuring Basic Switch Settings

message of the day (MOTD) banner, IP addressing, setting up a static MAC address, and demonstrating the use of a management IP address for remote switch management. The topology consists of one switch and one host using only Ethernet and console ports.

Note: The switch used is a Cisco Catalyst 2960 with Cisco IOS Release 15.0(2) (lanbasek9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Note: Make sure that the switch has been erased and has no startup configuration. Refer to Appendix A for the procedures to initialize and reload devices.

Required Resources

- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 1 PC (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term, and Telnet capability)
- Console cable to configure the Cisco IOS device via the console port
- Ethernet cable as shown in the topology

Part 1: Cable the Network and Verify the Default Switch Configuration

In Part 1, you will set up the network topology and verify default switch settings.

Step 1: Cable the network as shown in the topology.

- a. Cable the console connection as shown in the topology. Do not connect the PC-A Ethernet cable at this time.

Note: If you are using Netlab, you can shut down F0/6 on S1 which has the same effect as not connecting PC-A to S1.

- b. Create a console connection to the switch from PC-A using Tera Term or other terminal emulation program.

Why must you use a console connection to initially configure the switch? Why is it not possible to connect to the switch via Telnet or SSH?

No IP addressing parameters are configured yet. A Cisco 2960 switch first placed into service has no networking configured.

Step 2: Verify the default switch configuration.

In this step, you will examine the default switch settings, such as current switch configuration, IOS information, interface properties, VLAN information, and flash memory.

You can access all the switch IOS commands in privileged EXEC mode. Access to privileged EXEC mode should be restricted by password protection to prevent unauthorized use because it provides direct access to global configuration mode and commands used to configure operating parameters. You will set passwords later in this lab.

The privileged EXEC mode command set includes those commands contained in user EXEC mode, as well as the **configure** command through which access to the remaining command modes is gained. Use the **enable** command to enter privileged EXEC mode.

Lab – Configuring Basic Switch Settings

- a. Assuming the switch had no configuration file stored in nonvolatile random-access memory (NVRAM), you will be at the user EXEC mode prompt on the switch with a prompt of Switch>. Use the **enable** command to enter privileged EXEC mode.

```
Switch> enable
Switch#
```

Notice that the prompt changed in the configuration to reflect privileged EXEC mode.

Verify a clean configuration file with the **show running-config** privileged EXEC mode command. If a configuration file was previously saved, it must be removed. Depending on switch model and IOS version, your configuration may look slightly different. However, there should be no configured passwords or IP address. If your switch does not have a default configuration, erase and reload the switch.

Note: Appendix A details the steps to initialize and reload the devices.

- b. Examine the current running configuration file.

```
Switch# show running-config
```

How many FastEthernet interfaces does a 2960 switch have? _____ **24**

How many Gigabit Ethernet interfaces does a 2960 switch have? _____ **2**

What is the range of values shown for the vty lines? _____ **0-4 and 5-15 or 0-15**

- c. Examine the startup configuration file in NVRAM.

```
Switch# show startup-config
startup-config is not present
```

Why does this message appear? _____

Nothing yet has been saved to NVRAM.

- d. Examine the characteristics of the SVI for VLAN 1.

```
Switch# show interface vlan1
```

Is there an IP address assigned to VLAN 1? _____ **No**

What is the MAC address of this SVI? Answers will vary. _____

0CD9:96E2:3D40 in this case.

Is this interface up?

Cisco switches have the **no shutdown** command configured by default on VLAN 1, but VLAN 1 won't reach the up/up state until a port is assigned to it and this port is also up. If there is no port in the up state in VLAN 1, then the VLAN 1 interface will be up, line protocol down. By default, all ports are assigned initially to VLAN 1.

- e. Examine the IP properties of the SVI VLAN 1.

```
Switch# show ip interface vlan1
```

What output do you see?

Vlan1 is up, line protocol is down
Internet protocol processing disabled

Lab – Configuring Basic Switch Settings

- f. Connect PC-A Ethernet cable to port 6 on the switch and examine the IP properties of the SVI VLAN 1. Allow time for the switch and PC to negotiate duplex and speed parameters.

Note: If you are using Netlab, enable interface F0/6 on S1.

```
Switch# show ip interface vlan1
```

What output do you see?

```
Vlan1 is up, line protocol is up
Internet protocol processing disabled
```

- g. Examine the Cisco IOS version information of the switch.

```
Switch# show version
```

What is the Cisco IOS version that the switch is running? _____

Answers may vary. 15.0(2)SE3

What is the system image filename? _____

Answers may vary. c2960-lanbasek9-mz.150-2.SE3.bin

What is the base MAC address of this switch? Answers will vary.

Answers will vary. 0C:D9:96:E2:3D:00.

- h. Examine the default properties of the FastEthernet interface used by PC-A.

```
Switch# show interface f0/6
```

Is the interface up or down? _____ It should be up unless there is a cabling problem.

What event would make an interface go up? _____

Connecting a host or other device

What is the MAC address of the interface? _____ 0CD9:96E2:3D06 (Varies)

What is the speed and duplex setting of the interface? _____ Full-duplex, 100Mb/s

- i. Examine the default VLAN settings of the switch.

```
Switch# show vlan
```

What is the default name of VLAN 1? _____ default

Which ports are in this VLAN? _____

all ports; F0/1 – F0/24; G0/1, G0/2

Is VLAN 1 active? _____ Yes

What type of VLAN is the default VLAN? _____ enet (Ethernet)

- j. Examine flash memory.

Issue one of the following commands to examine the contents of the flash directory.

```
Switch# show flash
```

```
Switch# dir flash:
```

Files have a file extension, such as .bin, at the end of the filename. Directories do not have a file extension.

What is the filename of the Cisco IOS image? _____

c2960-lanbasek9-mz.150-2.SE.bin (may vary)

Part 2: Configure Basic Network Device Settings

In Part 2, you configure basic settings for the switch and PC.

Step 1: Configure basic switch settings including hostname, local passwords, MOTD banner, management address, and Telnet access.

In this step, you will configure the PC and basic switch settings, such as hostname and an IP address for the switch management SVI. Assigning an IP address on the switch is only the first step. As the network administrator, you must specify how the switch is managed. Telnet and SSH are the two most common management methods. However, Telnet is not a secure protocol. All information flowing between the two devices is sent in plain text. Passwords and other sensitive information can be easily looked at if captured by a packet sniffer.

- Assuming the switch had no configuration file stored in NVRAM, verify you are at privileged EXEC mode. Enter **enable** if the prompt has changed back to Switch>.

```
Switch> enable
Switch#
```

- Enter global configuration mode.

```
Switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#
```

The prompt changed again to reflect global configuration mode.

- Assign the switch hostname.

```
Switch(config)# hostname S1
S1(config)#
```

- Configure password encryption.

```
S1(config)# service password-encryption
S1(config)#
```

- Assign **class** as the secret password for privileged EXEC mode access.

```
S1(config)# enable secret class
S1(config)#
```

- Prevent unwanted DNS lookups.

```
S1(config)# no ip domain-lookup
S1(config)#
```

- Configure a MOTD banner.

```
S1(config)# banner motd #
Enter Text message. End with the character '#'.
Unauthorized access is strictly prohibited. #
```

- Verify your access settings by moving between modes.

```
S1(config)# exit
S1#
```

Lab – Configuring Basic Switch Settings

```
*Mar 1 00:19:19.490: %SYS-5-CONFIG_I: Configured from console by console
S1# exit
S1 con0 is now available
```

Press RETURN to get started.

```
Unauthorized access is strictly prohibited.
S1>
```

Which shortcut keys are used to go directly from global configuration mode to privileged EXEC mode?

_____ **Ctrl-Z**

- i. Go back to privileged EXEC mode from user EXEC mode. Enter **class** as the password when prompted.

```
S1> enable
Password:
S1#
```

Note: The password does not display when entering.

- j. Enter global configuration mode to set the SVI IP address of the switch. This allows remote management of the switch.

Before you can manage S1 remotely from PC-A, you must assign the switch an IP address. The default configuration on the switch is to have the management of the switch controlled through VLAN 1. However, a best practice for basic switch configuration is to change the management VLAN to a VLAN other than VLAN 1.

For management purposes, use VLAN 99. The selection of VLAN 99 is arbitrary and in no way implies that you should always use VLAN 99.

First, create the new VLAN 99 on the switch. Then set the IP address of the switch to 192.168.1.2 with a subnet mask of 255.255.255.0 on the internal virtual interface VLAN 99.

```
S1# configure terminal
S1(config)# vlan 99
S1(config-vlan)# exit
S1(config)# interface vlan99
%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan99, changed state to down
S1(config-if)# ip address 192.168.1.2 255.255.255.0
S1(config-if)# no shutdown
S1(config-if)# exit
S1(config)#
```

Notice that the VLAN 99 interface is in the down state even though you entered the **no shutdown** command. The interface is currently down because no switch ports are assigned to VLAN 99.

- k. Assign all user ports to VLAN 99.

```
S1(config)# interface range f0/1 - 24,g0/1 - 2
S1(config-if-range)# switchport access vlan 99
S1(config-if-range)# exit
```

Lab – Configuring Basic Switch Settings

```
S1(config)#  
%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed state to down  
%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan99, changed state to up
```

To establish connectivity between the host and the switch, the ports used by the host must be in the same VLAN as the switch. Notice in the above output that the VLAN 1 interface goes down because none of the ports are assigned to VLAN 1. After a few seconds, VLAN 99 comes up because at least one active port (F0/6 with PC-A attached) is now assigned to VLAN 99.

- I. Issue **show vlan brief** command to verify that all the user ports are in VLAN 99.

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	
99	VLAN0099	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gi0/1, Gi0/2
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

- m. Configure the IP default gateway for S1. If no default gateway is set, the switch cannot be managed from a remote network that is more than one router away. It does respond to pings from a remote network. Although this activity does not include an external IP gateway, assume that you will eventually connect the LAN to a router for external access. Assuming that the LAN interface on the router is 192.168.1.1, set the default gateway for the switch.

```
S1(config)# ip default-gateway 192.168.1.1  
S1(config)#
```

- n. Console port access should also be restricted. The default configuration is to allow all console connections with no password needed. To prevent console messages from interrupting commands, use the **logging synchronous** option.

```
S1(config)# line con 0  
S1(config-line)# password cisco  
S1(config-line)# login  
S1(config-line)# logging synchronous  
S1(config-line)# exit  
S1(config)#
```

- o. Configure the virtual terminal (vty) lines for the switch to allow Telnet access. If you do not configure a vty password, you are unable to telnet to the switch.

```
S1(config)# line vty 0 15  
S1(config-line)# password cisco  
S1(config-line)# login  
S1(config-line)# end
```

Lab – Configuring Basic Switch Settings

```
S1#
*Mar  1 00:06:11.590: %SYS-5-CONFIG_I: Configured from console by console
Why is the login command required? _____
Without the login command, the switch will not prompt for a password to be entered.
```

Step 2: Configure an IP address on PC-A.

Assign the IP address and subnet mask to the PC as shown in the Addressing Table. An abbreviated version of the procedure is described here. A default gateway is not required for this topology; however, you can enter **192.168.1.1** to simulate a router attached to S1.

- 1) Click the Windows **Start** icon > **Control Panel**.
- 2) Click **View By:** and choose **Small icons**.
- 3) Choose **Network and Sharing Center > Change adapter settings**.
- 4) Select **Local Area Network Connection**, right click and choose **Properties**.
- 5) Choose **Internet Protocol Version 4 (TCP/IPv4) > Properties**.
- 6) Click the **Use the following IP address** radio button and enter the IP address and subnet mask.

Part 3: Verify and Test Network Connectivity

In Part 3, you will verify and document the switch configuration, test end-to-end connectivity between PC-A and S1, and test the switch's remote management capability.

Step 1: Display the switch configuration.

From your console connection on PC-A, display and verify your switch configuration. The **show run** command displays the entire running configuration, one page at a time. Use the spacebar to advance paging.

- a. A sample configuration displays here. The settings you configured are highlighted in yellow. The other configuration settings are IOS defaults.

```
S1# show run
Building configuration...

Current configuration : 2206 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
```

Lab – Configuring Basic Switch Settings

```
!  
!  
no ip domain-lookup  
!  
<output omitted>  
!  
interface FastEthernet0/24  
  switchport access vlan 99  
!  
interface GigabitEthernet0/1  
  switchport access vlan 99  
!  
interface GigabitEthernet0/2  
  switchport access vlan 99  
!  
interface Vlan1  
  no ip address  
  no ip route-cache  
!  
interface Vlan99  
  ip address 192.168.1.2 255.255.255.0  
  no ip route-cache  
!  
ip default-gateway 192.168.1.1  
ip http server  
ip http secure-server  
!  
banner motd ^C  
Unauthorized access is strictly prohibited. ^C  
!  
line con 0  
  password 7 104D000A0618  
  logging synchronous  
  login  
line vty 0 4  
  password 7 14141B180F0B  
  login  
line vty 5 15  
  password 7 14141B180F0B  
  login  
!  
end
```

S1#

- b. Verify the management VLAN 99 settings.

```
S1# show interface vlan 99
```

```
Vlan99 is up, line protocol is up
```

```
Hardware is EtherSVI, address is 0cd9.96e2.3d41 (bia 0cd9.96e2.3d41)
```

Lab – Configuring Basic Switch Settings

```
Internet address is 192.168.1.2/24
MTU 1500 bytes, BW 1000000 Kbit, DLY 10 usec,
    reliability 255/255, txload 1/255, rxload 1/255
Encapsulation ARPA, loopback not set
ARP type: ARPA, ARP Timeout 04:00:00
Last input 00:00:06, output 00:08:45, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: fifo
Output queue: 0/40 (size/max)
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
  175 packets input, 22989 bytes, 0 no buffer
    Received 0 broadcasts (0 IP multicast)
  0 runts, 0 giants, 0 throttles
  0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
  1 packets output, 64 bytes, 0 underruns
  0 output errors, 0 interface resets
  0 output buffer failures, 0 output buffers swapped out
```

What is the bandwidth on this interface? _____ 1000000 Kb/s (1 Gb/sec)

What is the VLAN 99 state? _____ up

What is the line protocol state? _____ up

Step 2: Test end-to-end connectivity with ping.

- From the command prompt on PC-A, ping your own PC-A address first.

```
C:\Users\User1> ping 192.168.1.10
```

- From the command prompt on PC-A, ping the SVI management address of S1.

```
C:\Users\User1> ping 192.168.1.2
```

Because PC-A needs to resolve the MAC address of S1 through ARP, the first packet may time out. If ping results continue to be unsuccessful, troubleshoot the basic device configurations. You should check both the physical cabling and logical addressing if necessary.

Step 3: Test and verify remote management of S1.

You will now use Telnet to remotely access the switch. In this lab, PC-A and S1 reside side by side. In a production network, the switch could be in a wiring closet on the top floor while your management PC is located on the ground floor. In this step, you will use Telnet to remotely access switch S1 using its SVI management address. Telnet is not a secure protocol; however, you will use it to test remote access. With Telnet, all information, including passwords and commands, are sent across the session in plain text. In subsequent labs, you will use SSH to remotely access network devices.

Instructor Note: Tera Term or other terminal emulation programs with Telnet capability may be used if Telnet from the Windows command prompt is not allowed at your institution.

Note: If you are using Windows 7, the administrator may need to enable the Telnet protocol. To install the Telnet client, open a cmd window and type **pkgmgr /iu:"TelnetClient"**. An example is shown below.

```
C:\Users\User1> pkgmgr /iu:"TelnetClient"
```

Lab – Configuring Basic Switch Settings

- a. With the cmd window still open on PC-A, issue a Telnet command to connect to S1 via the SVI management address. The password is **cisco**.

```
C:\Users\User1> telnet 192.168.1.2
```

- b. After entering the password **cisco**, you will be at the user EXEC mode prompt. Access privileged EXEC mode.
- c. Type **exit** to end the Telnet session.

Step 4: Save the switch running configuration file.

Save the configuration.

```
S1# copy running-config startup-config
Destination filename [startup-config]? [Enter]
Building configuration...
[OK]
S1#
```

Part 4: Manage the MAC Address Table

In Part 4, you will determine the MAC address that the switch has learned, set up a static MAC address on one interface of the switch, and then remove the static MAC address from that interface.

Step 1: Record the MAC address of the host.

From a command prompt on PC-A, issue **ipconfig /all** command to determine and record the Layer 2 (physical) addresses of the PC NIC.

```
PC-A: 00-50-56-BE-6C-89 (answers will vary)
```

Step 2: Determine the MAC addresses that the switch has learned.

Display the MAC addresses using the **show mac address-table** command.

```
S1# show mac address-table
```

How many dynamic addresses are there? _____ 1 (can vary)

How many MAC addresses are there in total? _____ 24 (can vary)

Does the dynamic MAC address match the PC-A MAC address? _____ Yes

Step 3: List the show mac address-table options.

- a. Display the MAC address table options.

```
S1# show mac address-table ?
```

How many options are available for the **show mac address-table** command? _____ 12 (can vary)

- b. Issue the **show mac address-table dynamic** command to display only the MAC addresses that were learned dynamically.

```
S1# show mac address-table dynamic
```

How many dynamic addresses are there? _____ 1 (can vary)

- c. View the MAC address entry for PC-A. The MAC address formatting for the command is xxxx.xxxx.xxxx.

Lab – Configuring Basic Switch Settings

```
S1# show mac address-table address <PC-A MAC here>
```

Step 4: Set up a static MAC address.

- a. Clear the MAC address table.

To remove the existing MAC addresses, use the **clear mac address-table dynamic** command from privileged EXEC mode.

```
S1# clear mac address-table dynamic
```

- b. Verify that the MAC address table was cleared.

```
S1# show mac address-table
```

How many static MAC addresses are there? _____

at least 20 (other static entries could have been manually created)

Instructor Note: The first 20 static addresses in the MAC address table are built-in.

How many dynamic addresses are there? _____

0 (may be 1, depending on how quickly addresses are re-acquired by the switch)

- c. Examine the MAC table again.

More than likely, an application running on your PC has already sent a frame out the NIC to S1. Look at the MAC address table again in privileged EXEC mode to see if S1 has relearned the MAC address for PC-A.

```
S1# show mac address-table
```

How many dynamic addresses are there? _____ 1

Why did this change from the last display? _____

The switch dynamically reacquired the PC MAC address.

If S1 has not yet relearned the MAC address for PC-A, ping the VLAN 99 IP address of the switch from PC-A, and then repeat the **show mac address-table** command.

- d. Set up a static MAC address.

To specify which ports a host can connect to, one option is to create a static mapping of the host MAC address to a port.

Set up a static MAC address on F0/6 using the address that was recorded for PC-A in Part 4, Step 1. The MAC address 0050.56BE.6C89 is used as an example only. You must use the MAC address of your PC-A, which is different than the one given here as an example.

```
S1(config)# mac address-table static 0050.56BE.6C89 vlan 99 interface  
fastethernet 0/6
```

- e. Verify the MAC address table entries.

```
S1# show mac address-table
```

How many total MAC addresses are there? _____ 21 (varies)

How many static addresses are there? _____

There are 22 static addresses. Total MAC addresses and static addresses should be the same because there are no other devices currently connected to S1.

- f. Remove the static MAC entry. Enter global configuration mode and remove the command by putting a **no** in front of the command string.

Lab – Configuring Basic Switch Settings

Note: The MAC address 0050.56BE.6C89 is used in the example only. Use the MAC address for your PC-A.

```
S1(config)# no mac address-table static 0050.56BE.6C89 vlan 99 interface
fastethernet 0/6
```

- g. Verify that the static MAC address has been cleared.

```
S1# show mac address-table
```

How many total static MAC addresses are there? _____ 20 (varies)

Reflection

1. Why should you configure the vty lines for the switch?

If you do not configure a vty password you will not be able to telnet to the switch.

2. Why change the default VLAN 1 to a different VLAN number?

For improved security.

3. How can you prevent passwords from being sent in plain text?

Issue the **service password-encryption** command.

4. Why configure a static MAC address on a port interface?

To specify which ports a host can connect to.

Appendix A: Initializing and Reloading a Router and Switch

Step 1: Initialize and reload the router.

- a. Console into the router and enable privileged EXEC mode.

```
Router> enable
Router#
```

- b. Enter the **erase startup-config** command to remove the startup configuration from NVRAM.

```
Router# erase startup-config
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
[OK]
Erase of nvram: complete
Router#
```

- c. Issue the **reload** command to remove an old configuration from memory. When prompted to Proceed with reload?, press Enter. (Pressing any other key aborts the reload.)

```
Router# reload
Proceed with reload? [confirm]
*Nov 29 18:28:09.923: %SYS-5-RELOAD: Reload requested by console. Reload Reason:
Reload Command.
```

Note: You may receive a prompt asking to save the running configuration prior to reloading the router. Respond by typing **no** and press Enter.

Lab – Configuring Basic Switch Settings

System configuration has been modified. Save? [yes/no]: **no**

- d. After the router reloads, you are prompted to enter the initial configuration dialog. Enter **no** and press Enter.

Would you like to enter the initial configuration dialog? [yes/no]: **no**

- e. Another prompt asks to terminate autoinstall. Respond by typing **yes** press Enter.

Would you like to terminate autoinstall? [yes]: **yes**

Step 2: Initialize and reload the switch.

- a. Console into the switch and enter privileged EXEC mode.

```
Switch> enable
```

```
Switch#
```

- b. Use the **show flash** command to determine if any VLANs have been created on the switch.

```
Switch# show flash
```

```
Directory of flash:/
```

```
 2 -rwx      1919   Mar 1 1993 00:06:33 +00:00 private-config.text
 3 -rwx      1632   Mar 1 1993 00:06:33 +00:00 config.text
 4 -rwx     13336   Mar 1 1993 00:06:33 +00:00 multiple-fs
 5 -rwx    11607161 Mar 1 1993 02:37:06 +00:00 c2960-lanbasek9-mz.150-2.SE.bin
 6 -rwx         616   Mar 1 1993 00:07:13 +00:00 vlan.dat
```

```
32514048 bytes total (20886528 bytes free)
```

```
Switch#
```

- c. If the **vlan.dat** file was found in flash, then delete this file.

```
Switch# delete vlan.dat
```

```
Delete filename [vlan.dat]?
```

- d. You are prompted to verify the filename. If you have entered the name correctly, press Enter; otherwise, you can change the filename.

- e. You are prompted to confirm to delete this file. Press Enter to confirm.

```
Delete flash:/vlan.dat? [confirm]
```

```
Switch#
```

- f. Use the **erase startup-config** command to erase the startup configuration file from NVRAM. You are prompted to remove the configuration file. Press Enter to confirm.

```
Switch# erase startup-config
```

```
Erasing the nvram filesystem will remove all configuration files! Continue? [confirm]
```

```
[OK]
```

```
Erase of nvram: complete
```

```
Switch#
```

- g. Reload the switch to remove any old configuration information from memory. You will then receive a prompt to confirm to reload the switch. Press Enter to proceed.

```
Switch# reload
```

```
Proceed with reload? [confirm]
```

Note: You may receive a prompt to save the running configuration prior to reloading the switch. Respond by typing **no** and press Enter.

Lab – Configuring Basic Switch Settings

System configuration has been modified. Save? [yes/no]: **no**

- h. After the switch reloads, you should see a prompt to enter the initial configuration dialog. Respond by entering **no** at the prompt and press Enter.

Would you like to enter the initial configuration dialog? [yes/no]: **no**

Switch>

Device Configs

Switch S1

```
S1#sh run
Building configuration...
Current configuration : 2359 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!interface FastEthernet0/1
  switchport access vlan 99
!
interface FastEthernet0/2
  switchport access vlan 99
!
interface FastEthernet0/3
  switchport access vlan 99
!
interface FastEthernet0/4
  switchport access vlan 99
```

Lab – Configuring Basic Switch Settings

```
!  
interface FastEthernet0/5  
  switchport access vlan 99  
!  
interface FastEthernet0/6  
  switchport access vlan 99  
!  
interface FastEthernet0/7  
  switchport access vlan 99  
!  
interface FastEthernet0/8  
  switchport access vlan 99  
!  
interface FastEthernet0/9  
  switchport access vlan 99  
!  
interface FastEthernet0/10  
  switchport access vlan 99  
!  
interface FastEthernet0/11  
  switchport access vlan 99  
!  
interface FastEthernet0/12  
  switchport access vlan 99  
!  
interface FastEthernet0/13  
  switchport access vlan 99  
!  
interface FastEthernet0/14  
  switchport access vlan 99  
!  
interface FastEthernet0/15  
  switchport access vlan 99  
!  
interface FastEthernet0/16  
  switchport access vlan 99  
!  
interface FastEthernet0/17  
  switchport access vlan 99  
!  
interface FastEthernet0/18  
  switchport access vlan 99  
!  
interface FastEthernet0/19  
  switchport access vlan 99  
!  
interface FastEthernet0/20  
  switchport access vlan 99  
!
```

Lab – Configuring Basic Switch Settings

```
interface FastEthernet0/21
  switchport access vlan 99
!
interface FastEthernet0/22
  switchport access vlan 99
!
interface FastEthernet0/23
  switchport access vlan 99
!
interface FastEthernet0/24
  switchport access vlan 99
!
interface GigabitEthernet0/1
  switchport access vlan 99
!
interface GigabitEthernet0/2
  switchport access vlan 99
!
interface Vlan1
  no ip address
!
interface Vlan99
  ip address 192.168.1.2 255.255.255.0
!
ip default-gateway 192.168.1.1
ip http server
ip http secure-server
!
!
banner motd ^C
Unauthorized access is strictly prohibited. ^C
!
line con 0
  password 7 0822455D0A16
  logging synchronous
  login
line vty 0 4
  password 7 01100F175804
  login
line vty 5 15
  password 7 01100F175804
  login
!
end
```

Lab – Configuring Switch Security Features (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/1	172.16.99.1	255.255.255.0	N/A
S1	VLAN 99	172.16.99.11	255.255.255.0	172.16.99.1
PC-A	NIC	172.16.99.3	255.255.255.0	172.16.99.1

Objectives

Part 1: Set Up the Topology and Initialize Devices

Part 2: Configure Basic Device Settings and Verify Connectivity

Part 3: Configure and Verify SSH Access on S1

- Configure SSH access.
- Modify SSH parameters.
- Verify the SSH configuration.

Part 4: Configure and Verify Security Features on S1

- Configure and verify general security features.
- Configure and verify port security.

Background / Scenario

It is quite common to lock down access and install good security features on PCs and servers. It is important that your network infrastructure devices, such as switches and routers, are also configured with security features.

In this lab, you will follow some best practices for configuring security features on LAN switches. You will only allow SSH and secure HTTPS sessions. You will also configure and verify port security to lock out any device with a MAC address not recognized by the switch.

Note: The router used with CCNA hands-on labs is a Cisco 1941 Integrated Services Router (ISR) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switch used is a Cisco Catalyst 2960 with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the router and switch have been erased and have no startup configurations. If you are unsure, contact your instructor or refer to the previous lab for the procedures to initialize and reload devices.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 1 PC (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Set Up the Topology and Initialize Devices

In Part 1, you will set up the network topology and clear any configurations if necessary.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the router and switch.

If configuration files were previously saved on the router or switch, initialize and reload these devices back to their basic configurations.

Part 2: Configure Basic Device Settings and Verify Connectivity

In Part 2, you configure basic settings on the router, switch, and PC. Refer to the Topology and Addressing Table at the beginning of this lab for device names and address information.

Step 1: Configure an IP address on PC-A.

Step 2: Configure basic settings on R1.

- Configure the device name.
- Disable DNS lookup.
- Configure interface IP address as shown in the Addressing Table.
- Assign **class** as the privileged EXEC mode password.
- Assign **cisco** as the console and vty password and enable login.
- Encrypt plain text passwords.
- Save the running configuration to startup configuration.

Step 3: Configure basic settings on S1.

A good security practice is to assign the management IP address of the switch to a VLAN other than VLAN 1 (or any other data VLAN with end users). In this step, you will create VLAN 99 on the switch and assign it an IP address.

- Configure the device name.
- Disable DNS lookup.
- Assign **class** as the privileged EXEC mode password.

Lab – Configuring Switch Security Features

- d. Assign **cisco** as the console and vty password and then enable login.
- e. Configure a default gateway for S1 using the IP address of R1.
- f. Encrypt plain text passwords.
- g. Save the running configuration to startup configuration.
- h. Create VLAN 99 on the switch and name it **Management**.

```
S1(config)# vlan 99
S1(config-vlan)# name Management
S1(config-vlan)# exit
S1(config)#
```

- i. Configure the VLAN 99 management interface IP address, as shown in the Addressing Table, and enable the interface.

```
S1(config)# interface vlan 99
S1(config-if)# ip address 172.16.99.11 255.255.255.0
S1(config-if)# no shutdown
S1(config-if)# end
S1#
```

- j. Issue the **show vlan** command on S1. What is the status of VLAN 99? _____ **Active**
- k. Issue the **show ip interface brief** command on S1. What is the status and protocol for management interface VLAN 99?

Status is up, and protocol is down.

Why is the protocol down, even though you issued the **no shutdown** command for interface VLAN 99?

No physical ports on the switch have been assigned to VLAN 99.

- l. Assign ports F0/5 and F0/6 to VLAN 99 on the switch.

```
S1# config t
S1(config)# interface f0/5
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 99
S1(config-if)# interface f0/6
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 99
S1(config-if)# end
```

- m. Issue the **show ip interface brief** command on S1. What is the status and protocol showing for interface VLAN 99? _____ **Up and up**

Note: There may be a delay while the port states converge.

Step 4: Verify connectivity between devices.

- a. From PC-A, ping the default gateway address on R1. Were your pings successful? _____ **Yes**
- b. From PC-A, ping the management address of S1. Were your pings successful? _____ **Yes**
- c. From S1, ping the default gateway address on R1. Were your pings successful? _____ **Yes**

- d. From PC-A, open a web browser and go to `http://172.16.99.11`. If it prompts you for a username and password, leave the username blank and use **class** for the password. If it prompts for secured connection, answer **No**. Were you able to access the web interface on S1? _____ **Yes**
- e. Close the browser session on PC-A.

Note: The non-secure web interface (HTTP server) on a Cisco 2960 switch is enabled by default. A common security measure is to disable this service, as described in Part 4.

Part 3: Configure and Verify SSH Access on S1

Step 1: Configure SSH access on S1.

- a. Enable SSH on S1. From global configuration mode, create a domain name of **CCNA-Lab.com**.
`S1(config)# ip domain-name CCNA-Lab.com`
- b. Create a local user database entry for use when connecting to the switch via SSH. The user should have administrative level access.

Note: The password used here is NOT a strong password. It is merely being used for lab purposes.

```
S1(config)# username admin privilege 15 secret sshadmin
```

- c. Configure the transport input for the vty lines to allow SSH connections only, and use the local database for authentication.

```
S1(config)# line vty 0 15
S1(config-line)# transport input ssh
S1(config-line)# login local
S1(config-line)# exit
```

- d. Generate an RSA crypto key using a modulus of 1024 bits.

```
S1(config)# crypto key generate rsa modulus 1024
The name for the keys will be: S1.CCNA-Lab.com

% The key modulus size is 1024 bits
% Generating 1024 bit RSA keys, keys will be non-exportable...
[OK] (elapsed time was 3 seconds)
```

```
S1(config)#
S1(config)# end
```

- e. Verify the SSH configuration and answer the questions below.

```
S1# show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
Minimum expected Diffie Hellman key size : 1024 bits
IOS Keys in SECSH format(ssh-rsa, base64 encoded):
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAQgQCKWqCN0g4XLVdJJUOr+9qoJkFqC/g0OuAV1semrR5/
xy0bbUBPywvqhwSPJtucIKxKw/YfrRCeFwY+dc+/jGSeckAHahuv0jJfOdFcgqiKGeeluAu+iQ2drE+k
butnlLTGmtNhdEJMXri/Zeo3BsFcnHp01hbB6Vsm4XRXGk7OfQ==
```

What version of SSH is the switch using? _____ **1.99**

How many authentication attempts does SSH allow? _____ **3**

Lab – Configuring Switch Security Features

What is the default timeout setting for SSH? _____ 120 seconds

Step 2: Modify the SSH configuration on S1.

Modify the default SSH configuration.

```
S1# config t
S1(config)# ip ssh time-out 75
S1(config)# ip ssh authentication-retries 2
S1# show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 75 secs; Authentication retries: 2
Minimum expected Diffie Hellman key size : 1024 bits
IOS Keys in SECSH format(ssh-rsa, base64 encoded):
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAQgQCKWqCN0g4XLVdJJUOr+9qoJkFqC/g0OuAV1semrR5/
xy0bbUBPywvqhwSPJtucIKxKw/YfrRCeFwY+dc+/jGSeckAHahuv0jJfOdFcgqiKGeeluAu+iQ2drE+k
butnlLTGmtNhdEJMxri/Zeo3BsFcnHp0lhbB6Vsm4XRXGk7OfQ==
```

How many authentication attempts does SSH allow? _____ 2

What is the timeout setting for SSH? _____ 75 seconds

Step 3: Verify the SSH configuration on S1.

- Using SSH client software on PC-A (such as Tera Term), open an SSH connection to S1. If you receive a message on your SSH client regarding the host key, accept it. Log in with **admin** for username and **cisco** for the password.

Was the connection successful? _____ Yes

What prompt was displayed on S1? Why?

S1 is showing the prompt at privileged EXEC mode because the privilege 15 option was used when configuring username and password

- Type **exit** to end the SSH session on S1.

Part 4: Configure and Verify Security Features on S1

In Part 4, you will shut down unused ports, turn off certain services running on the switch, and configure port security based on MAC addresses. Switches can be subject to MAC address table overflow attacks, MAC spoofing attacks, and unauthorized connections to switch ports. You will configure port security to limit the number of MAC addresses that can be learned on a switch port and disable the port if that number is exceeded.

Step 1: Configure general security features on S1.

- Configure a message of the day (MOTD) banner on S1 with an appropriate security warning message.
- Issue a **show ip interface brief** command on S1. What physical ports are up?

Ports F0/5 and F0/6

Lab – Configuring Switch Security Features

- c. Shut down all unused physical ports on the switch. Use the **interface range** command.

```
S1(config)# interface range f0/1 - 4
S1(config-if-range)# shutdown
S1(config-if-range)# interface range f0/7 - 24
S1(config-if-range)# shutdown
S1(config-if-range)# interface range g0/1 - 2
S1(config-if-range)# shutdown
S1(config-if-range)# end
S1#
```

- d. Issue the **show ip interface brief** command on S1. What is the status of ports F0/1 to F0/4?

Administratively down.

- e. Issue the **show ip http server status** command.

```
S1# show ip http server status
HTTP server status: Enabled
HTTP server port: 80
HTTP server authentication method: enable
HTTP server access class: 0
HTTP server base path: flash:html
HTTP server help root:
Maximum number of concurrent server connections allowed: 16
Server idle time-out: 180 seconds
Server life time-out: 180 seconds
Maximum number of requests allowed on a connection: 25
HTTP server active session modules: ALL
HTTP secure server capability: Present
HTTP secure server status: Enabled
HTTP secure server port: 443
HTTP secure server ciphersuite: 3des-ede-cbc-sha des-cbc-sha rc4-128-md5 rc4-128-sha
HTTP secure server client authentication: Disabled
HTTP secure server trustpoint:
HTTP secure server active session modules: ALL
```

What is the HTTP server status? _____ Enabled

What server port is it using? _____ 80

What is the HTTP secure server status? _____ Enabled

What secure server port is it using? _____ 443

- f. HTTP sessions send everything in plain text. You will disable the HTTP service running on S1.

```
S1(config)# no ip http server
```

- g. From PC-A, open a web browser session to <http://172.16.99.11>. What was your result?

The web page could not open. HTTP connections are now refused by S1.

- h. From PC-A, open a secure web browser session at <https://172.16.99.11>. Accept the certificate. Log in with no username and a password of **class**. What was your result?

Secure web session was successful.

- i. Close the web session on PC-A.

Step 2: Configure and verify port security on S1.

- a. Record the R1 G0/1 MAC address. From the R1 CLI, use the **show interface g0/1** command and record the MAC address of the interface.

```
R1# show interface g0/1
GigabitEthernet0/1 is up, line protocol is up
  Hardware is CN Gigabit Ethernet, address is 30f7.0da3.1821 (bia
3047.0da3.1821)
```

What is the MAC address of the R1 G0/1 interface?

In the example above, it is 30f7.0da3.1821

- b. From the S1 CLI, issue a **show mac address-table** command from privileged EXEC mode. Find the dynamic entries for ports F0/5 and F0/6. Record them below.

F0/5 MAC address: _____ 30f7.0da3.1821

F0/6 MAC address: _____ 00e0.b857.1ccd

- c. Configure basic port security.

Note: This procedure would normally be performed on all access ports on the switch. F0/5 is shown here as an example.

- 1) From the S1 CLI, enter interface configuration mode for the port that connects to R1.

```
S1(config)# interface f0/5
```

- 2) Shut down the port.

```
S1(config-if)# shutdown
```

- 3) Enable port security on F0/5.

```
S1(config-if)# switchport port-security
```

Note: Entering the **switchport port-security** command sets the maximum MAC addresses to 1 and the violation action to shutdown. The **switchport port-security maximum** and **switchport port-security violation** commands can be used to change the default behavior.

- 4) Configure a static entry for the MAC address of R1 G0/1 interface recorded in Step 2a.

```
S1(config-if)# switchport port-security mac-address xxxx.xxxx.xxxx
```

(xxxx.xxxx.xxxx is the actual MAC address of the router G0/1 interface)

Note: Optionally, you can use the **switchport port-security mac-address sticky** command to add all the secure MAC addresses that are dynamically learned on a port (up to the maximum set) to the switch running configuration.

- 5) Enable the switch port.

```
S1(config-if)# no shutdown
```

```
S1(config-if)# end
```

- d. Verify port security on S1 F0/5 by issuing a **show port-security interface** command.

```
S1# show port-security interface f0/5
```

Lab – Configuring Switch Security Features

```
Port Security           : Enabled
Port Status             : Secure-up
Violation Mode          : Shutdown
Aging Time              : 0 mins
Aging Type              : Absolute
SecureStatic Address Aging : Disabled
Maximum MAC Addresses   : 1
Total MAC Addresses     : 1
Configured MAC Addresses : 1
Sticky MAC Addresses    : 0
Last Source Address:Vlan : 0000.0000.0000:0
Security Violation Count : 0
```

What is the port status of F0/5?

The status is Secure-up, which indicates that the port is secure, but the status and protocol are up.

- e. From R1 command prompt, ping PC-A to verify connectivity.

```
R1# ping 172.16.99.3
```

- f. You will now violate security by changing the MAC address on the router interface. Enter interface configuration mode for G0/1 and shut it down.

```
R1# config t
R1(config)# interface g0/1
R1(config-if)# shutdown
```

- g. Configure a new MAC address for the interface, using **aaaa.bbbb.cccc** as the address.

```
R1(config-if)# mac-address aaaa.bbbb.cccc
```

- h. If possible, have a console connection open on S1 at the same time that you do this step. You will see various messages displayed on the console connection to S1 indicating a security violation. Enable the G0/1 interface on R1.

```
R1(config-if)# no shutdown
```

- i. From R1 privileged EXEC mode, ping PC-A. Was the ping successful? Why or why not?

No, the F0/5 port on S1 is shut down because of the security violation.

- j. On the switch, verify port security with the following commands shown below.

```
S1# show port-security
Secure Port MaxSecureAddr CurrentAddr SecurityViolation Security Action
          (Count)          (Count)          (Count)
-----
Fa0/5           1             1             1             Shutdown
-----
Total Addresses in System (excluding one mac per port) :0
Max Addresses limit in System (excluding one mac per port) :8192
```

```
S1# show port-security interface f0/5
Port Security           : Enabled
Port Status             : Secure-shutdown
```

Lab – Configuring Switch Security Features

```
Violation Mode           : Shutdown
Aging Time               : 0 mins
Aging Type               : Absolute
SecureStatic Address Aging : Disabled
Maximum MAC Addresses    : 1
Total MAC Addresses      : 1
Configured MAC Addresses : 1
Sticky MAC Addresses     : 0
Last Source Address:Vlan : aaaa.bbbb.cccc:99
Security Violation Count : 1
```

S1# **show interface f0/5**

```
FastEthernet0/5 is down, line protocol is down (err-disabled)
```

```
Hardware is Fast Ethernet, address is 0cd9.96e2.3d05 (bia 0cd9.96e2.3d05)
MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
    reliability 255/255, txload 1/255, rxload 1/255
<output omitted>
```

S1# **show port-security address**

Secure Mac Address Table

```
-----
Vlan      Mac Address      Type                Ports      Remaining Age
          (mins)
-----
  99      30f7.0da3.1821   SecureConfigured   Fa0/5      -
-----
```

```
Total Addresses in System (excluding one mac per port) :0
Max Addresses limit in System (excluding one mac per port) :8192
```

- k. On the router, shut down the G0/1 interface, remove the hard-coded MAC address from the router, and re-enable the G0/1 interface.

```
R1(config-if)# shutdown
R1(config-if)# no mac-address aaaa.bbbb.cccc
R1(config-if)# no shutdown
R1(config-if)# end
```

- l. From R1, ping PC-A again at 172.16.99.3. Was the ping successful? _____ **No**

- m. On the switch, issue the **show interface f0/5** command to determine the cause of ping failure. Record your findings.

F0/5 port on S1 is still in an error disabled state.

S1# **show interface f0/5**

```
FastEthernet0/5 is down, line protocol is down (err-disabled)
```

```
Hardware is Fast Ethernet, address is 0023.5d59.9185 (bia 0023.5d59.9185)
MTU 1500 bytes, BW 10000 Kbit/sec, DLY 1000 usec,
    reliability 255/255, txload 1/255, rxload 1/255
```

- n. Clear the S1 F0/5 error disabled status.

S1# **config t**

Lab – Configuring Switch Security Features

```
S1(config)# interface f0/5
S1(config-if)# shutdown
S1(config-if)# no shutdown
```

Note: There may be a delay while the port states converge.

- o. Issue the **show interface f0/5** command on S1 to verify F0/5 is no longer in error disabled mode.

```
S1# show interface f0/5
```

```
FastEthernet0/5 is up, line protocol is up (connected)
```

```
Hardware is Fast Ethernet, address is 0023.5d59.9185 (bia 0023.5d59.9185)
MTU 1500 bytes, BW 100000 Kbit/sec, DLY 100 usec,
    reliability 255/255, txload 1/255, rxload 1/255
```

- p. From the R1 command prompt, ping PC-A again. You should be successful.

Reflection

1. Why would you enable port security on a switch?

It would help prevent unauthorized devices from accessing your network if they plugged into a switch on your network.

2. Why should unused ports on a switch be disabled?

One excellent reason is that a user could not connect a device to the switch on an unused port and access the LAN.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router R1

```
R1#sh run
Building configuration...
Current configuration : 1232 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no ip domain-lookup
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
```

Lab – Configuring Switch Security Features

```
ip address 172.16.99.1 255.255.255.0
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
no ip address
shutdown
clock rate 2000000
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
!
!
control-plane
!
!
!line con 0
password 7 030752180500
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line 67
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
line vty 0 4
password 7 13061E01080344
login
transport input all
!
scheduler allocate 20000 1000
!
```

Lab – Configuring Switch Security Features

```
end
```

Switch S1

```
S1#sh run
Building configuration...
Current configuration : 3762 bytes
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname S1
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGholQM5EnRtoyr8cHAUg.2
!
username admin privilege 15 secret 4 tnhtc92DXBhelxjYk8LWJrPV36S2i4ntXrpb4RFmfqY
!
no ip domain-lookup
ip domain-name CCNA-Lab.com
!
crypto pki trustpoint TP-self-signed-2530358400
  enrollment selfsigned
  subject-name cn=IOS-Self-Signed-Certificate-2530358400
  revocation-check none
  rsakeypair TP-self-signed-2530358400
!
crypto pki certificate chain TP-self-signed-2530358400
  certificate self-signed 01
    3082022B 30820194 A0030201 02020101 300D0609 2A864886 F70D0101 05050030
    31312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D 43657274
    69666963 6174652D 32353330 33353834 3030301E 170D3933 30333031 30303030
    35395A17 0D323030 31303130 30303030 305A3031 312F302D 06035504 03132649
    4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32 35333033
    35383430 3030819F 300D0609 2A864886 F70D0101 01050003 818D0030 81890281
    8100C0E3 1B8AF1E4 ADA4C4AD F82914AF BF8BCEC9 30CFBF54 D76B3940 38353E50
    A9AE0FCE 9CA05B91 24312B31 22D5F89D D249023E AEEC442D F55315F6 D456DA95
    16B758FB 8083B681 C1B3A3BF 99420EC7 A7E0AD11 CF031CD1 36A997C0 E72BE4DD
    1D745542 1DC958C1 443B6727 F7047747 D94B8CAD 0A99CBDC ADC914C8 D820DC30
    E6B70203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF 301F0603
    551D2304 18301680 1464D1A8 83DEE145 E35D68C1 D078ED7D 4F6F0B82 9D301D06
    03551D0E 04160414 64D1A883 DEE145E3 5D68C1D0 78ED7D4F 6F0B829D 300D0609
    2A864886 F70D0101 05050003 81810098 D65CFA1C 3942148D 8961D845 51D53202
    EA59B526 7DB308C9 F79859A0 D93D56D6 C584AB83 941A2B7F C44C0E2F DFAF6B8D
    A3272A5C 2363116E 1AA246DD 7E54B680 2ABB1F2D 26921529 E1EF4ACC A4FBD14A
    BAD41C98 E8D83DEC B85A330E D453510D 89F64023 7B9782E7 200F615A 6961827F
    8419A84F 56D71664 5123B591 A62C55
  quit
!
```

Lab – Configuring Switch Security Features

```
ip ssh time-out 75
ip ssh authentication-retries 2
!
interface FastEthernet0/1
 shutdown
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 shutdown
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
 switchport access vlan 99
 switchport mode access
 switchport port-security
 switchport port-security mac-address 30f7.0da3.1821
!
interface FastEthernet0/6
 switchport access vlan 99
 switchport mode access
!
interface FastEthernet0/7
 shutdown

interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
!
interface FastEthernet0/11
 shutdown
!
interface FastEthernet0/12
 shutdown
!
interface FastEthernet0/13
 shutdown
!
interface FastEthernet0/14
 shutdown
!
```

Lab – Configuring Switch Security Features

```
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
shutdown
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
!
interface GigabitEthernet0/1
shutdown
!
interface GigabitEthernet0/2
shutdown
!
interface Vlan1
no ip address
shutdown
!
interface Vlan99
ip address 172.16.99.11 255.255.255.0
!
ip default-gateway 172.16.99.1
no ip http server
ip http secure-server
!
banner motd ^CWarning! Unauthorized Access is Prohibited.^C
!
```

Lab – Configuring Switch Security Features

```
line con 0
password cisco
logging synchronous
login
line vty 0 4
login local
transport input ssh
line vty 5 15
login local
transport input ssh
!
end
```

Switch Trio (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Verify the Layer 2 configuration of a switch port connected to an end station.

Students will use Packet Tracer to configure the first three ports of a switch a permanent MAC address (one MAC address per port) and security shutdown feature. They will validate security implementation and explain the process to another student or the class (Instructor choice).

Scenario

You are the network administrator for a small- to medium-sized business. Corporate headquarters for your business has mandated that on all switches in all offices, security must be implemented. The memorandum delivered to you this morning states:

“By Monday, April 18, 20xx, the first three ports of all configurable switches located in all offices must be secured with MAC addresses — one address will be reserved for the printer, one address will be reserved for the laptop in the office, and one address will be reserved for the office server.

If a port’s security is breached, we ask you to shut it down until the reason for the breach can be certified.

Please implement this policy no later than the date stated in this memorandum. For questions, call 1.800.555.1212. Thank you. The Network Management Team”

Work with a partner in the class and create a Packet Tracer example to test this new security policy. Once you have created your file, test it with, at least, one device to ensure it is operational or validated.

Save your work and be prepared to share it with the entire class. (Instructor choice)

Reflection

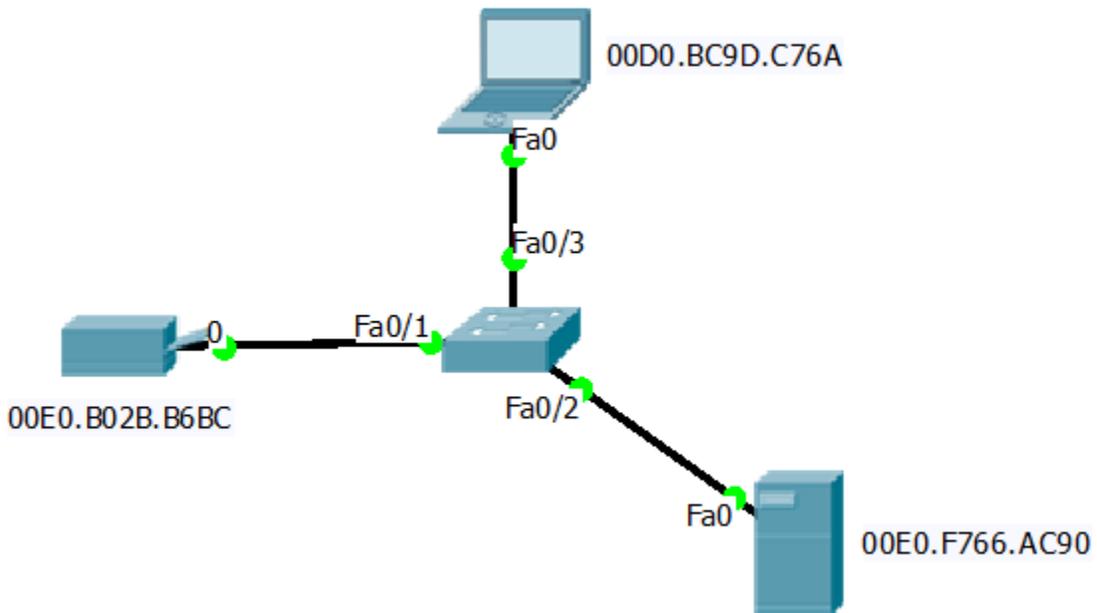
1. Why would one port on a switch be secured on a switch using these scenario parameters (and not all the ports on the same switch)?

Answers will vary – students may mention that securing every port on a switch would make it difficult for many users to connect to the switch, therefore limiting port use to certain pieces of equipment – laptop mobility might be compromised, as users would not be able to connect to the switch unless they knew which port they were allowed to use.

2. Why would a network administrator use a network simulator to create, configure, and validate a security plan, instead of using the small- to medium-sized business’ actual, physical equipment?

Using a network simulator can save time and quality of network data delivery by pre-testing and validating new configurations.

Original Physical Topology (for concept representation only)



After configuring port security for the Printer, Server, and Laptop – all devices are reporting to the switch on their correct ports.

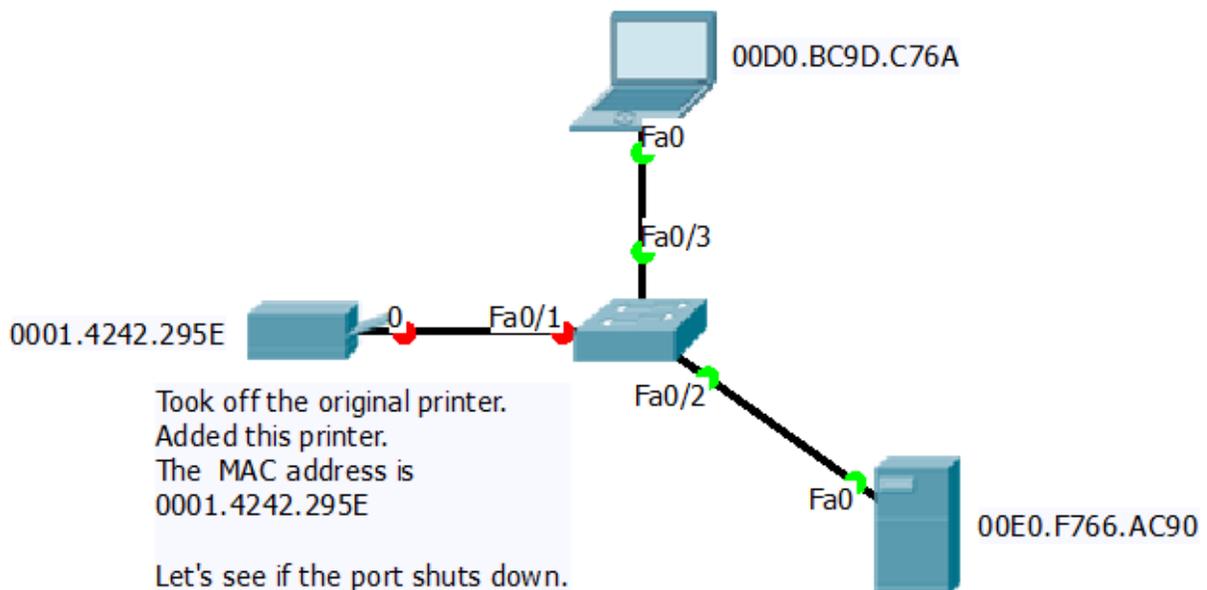
```
Switch# show port-security address
                Secure Mac Address Table
-----
Vlan  Mac Address  Type           Ports          Remaining Age
      (mins)
-----
1     00E0.B02B.B6BC  SecureSticky   FastEthernet0/1  -
1     00E0.F766.AC90  SecureSticky   FastEthernet0/2  -
1     00D0.BC9D.C76A  SecureSticky   FastEthernet0/3  -
-----
Total Addresses in System (excluding one mac per port)    : 0
Max Addresses limit in System (excluding one mac per port) : 1024
```

Output showing port security status for Fa0/1:

```
Switch# show port-security int fa0/1
Port Security           : Enabled
Port Status             : Secure-up
Violation Mode         : Shutdown
Aging Time              : 0 mins
Aging Type              : Absolute
SecureStatic Address Aging : Disabled
Maximum MAC Addresses   : 1
Total MAC Addresses     : 1
Configured MAC Addresses : 0
Sticky MAC Addresses    : 1
Last Source Address:Vlan : 00E0.B02B.B6BC:1
Security Violation Count : 0
```

Topology Change with Security Violation (for concept representation only)

After exchanging the original Printer with a new one, Fa0/1 shuts down on the switch.



Instructor Note: Identify elements of the model that map to IT-related content:

- Switches can be secured by assigning MAC addresses to any and all ports – manually or configuration-based.
- LAN switch ports can be shut down if security on the port is breached.
- Network administrators can implement best practice policies devised by management to ensure that networks are not compromised through security attacks.

Vacation Station (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Explain the purpose of VLANs in a switched network.

To prepare for learning VLAN concepts in a switched network for this chapter, students will envision how and why network VLAN-switching groups are created.

Scenario

You have purchased a three floor vacation home at the beach for rental purposes. The floor plan is identical on each floor. Each floor offers one digital television for renters to use.

According to the local Internet service provider, only three stations may be offered within a television package. It is your job to decide which television packages you offer your guests.

- Divide the class into groups of three students per group.
- Choose three different stations to make one subscription package for each floor of your rental home.
- Complete the PDF for this activity.

Share your completed group-reflection answers with the class.

Television Station Subscription Package – Floor 1		
Local News <input type="checkbox"/>	Sports <input type="checkbox"/>	Weather <input type="checkbox"/>
Home Improvement <input type="checkbox"/>	Movies <input type="checkbox"/>	History <input type="checkbox"/>
Television Station Subscription Package – Floor 2		
Local News <input type="checkbox"/>	Sports <input type="checkbox"/>	Weather <input type="checkbox"/>
Home Improvement <input type="checkbox"/>	Movies <input type="checkbox"/>	History <input type="checkbox"/>
Television Station Subscription Package – Floor 3		
Local News <input type="checkbox"/>	Sports <input type="checkbox"/>	Weather <input type="checkbox"/>
Home Improvement <input type="checkbox"/>	Movies <input type="checkbox"/>	History <input type="checkbox"/>

Reflection

1. What were some of the criteria you used to select the final three stations?
-

Vacation Station

Answers will vary, but some answers might include: local news is usually important to everyone, weather is important to beach vacationers, home improvement might be important to rental property use, watching sports and movies are popular vacation pastimes, and history provides vacationers with information about places they are currently visiting or plan to visit.

2. Why do you think this Internet service provider offers different television station options to subscribers? Why not offer all stations to all subscribers?

Limiting options to certain groups allows for ISPs to conserve televised bandwidth to groups with the options selected. It also allows them to charge additional prices for additional options.

3. Compare this scenario to data communications and networks for small- to medium-sized businesses. Why would it be a good idea to divide your small- to medium-sized business networks into logical and physical groups?

Answers will vary. Some answers might include: dividing networks into groups allows businesses to: improve network performance; regulate network management and security; use data, voice, network-controlled traffic options more effectively; and group data traffic based upon network-desired functions.

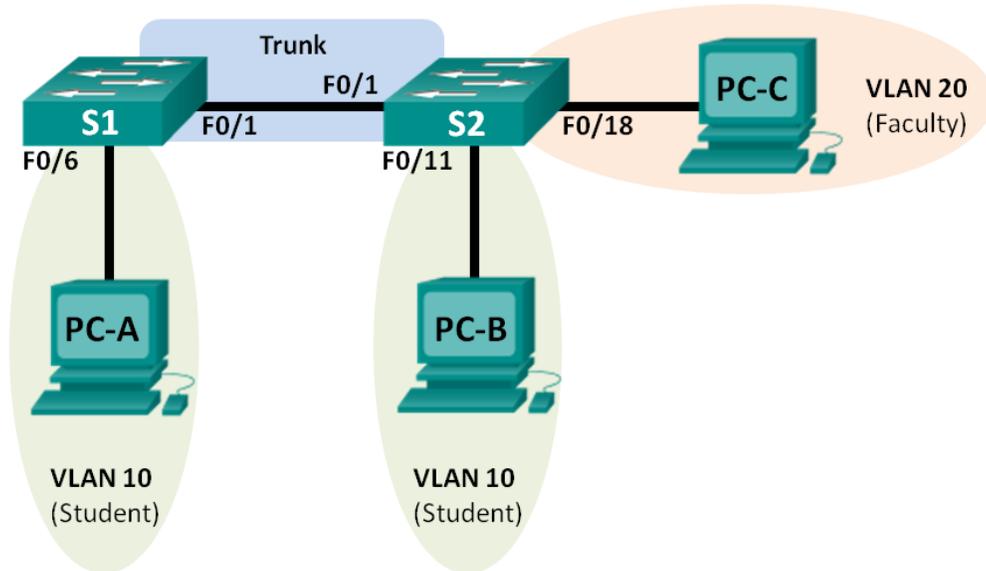
Identify elements of the model that map to IT-related content:

- In this scenario, the ISPs cable modem could function as a network switch.
- Floors 1-3 could be compared to network VLAN groups.
- The digital televisions could be compared to hosts within the VLAN groups.

Lab - Configuring VLANs and Trunking (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
S1	VLAN 1	192.168.1.11	255.255.255.0	N/A
S2	VLAN 1	192.168.1.12	255.255.255.0	N/A
PC-A	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC-B	NIC	192.168.10.4	255.255.255.0	192.168.10.1
PC-C	NIC	192.168.20.3	255.255.255.0	192.168.20.1

Objectives

- Part 1: Build the Network and Configure Basic Device Settings**
- Part 2: Create VLANs and Assign Switch Ports**
- Part 3: Maintain VLAN Port Assignments and the VLAN Database**
- Part 4: Configure an 802.1Q Trunk between the Switches**
- Part 5: Delete the VLAN Database**

Background / Scenario

Modern switches use virtual local-area networks (VLANs) to improve network performance by separating large Layer 2 broadcast domains into smaller ones. VLANs can also be used as a security measure by controlling which hosts can communicate. In general, VLANs make it easier to design a network to support the goals of an organization.

VLAN trunks are used to span VLANs across multiple devices. Trunks allow the traffic from multiple VLANs to travel over a single link, while keeping the VLAN identification and segmentation intact.

In this lab, you will create VLANs on both switches in the topology, assign VLANs to switch access ports, verify that VLANs are working as expected, and then create a VLAN trunk between the two switches to allow hosts in the same VLAN to communicate through the trunk, regardless of which switch the host is actually attached to.

Note: The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Note: Ensure that the switches have been erased and have no startup configurations. If you are unsure contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings on the PC hosts and switches.

Step 1: Cable the network as shown in the topology.

Attach the devices as shown in the topology diagram, and cable as necessary.

Step 2: Initialize and reload the switches as necessary.

Step 3: Configure basic settings for each switch.

- a. Disable DNS lookup.
- b. Configure device name as shown in the topology.
- c. Assign **class** as the privileged EXEC password.
- d. Assign **cisco** as the console and vty passwords and enable login for console and vty lines.
- e. Configure **logging synchronous** for the console line.
- f. Configure a MOTD banner to warn users that unauthorized access is prohibited.
- g. Configure the IP address listed in the Addressing Table for VLAN 1 on both switches.
- h. Administratively deactivate all unused ports on the switch.
- i. Copy the running configuration to the startup configuration.

Step 4: Configure PC hosts.

Refer to the Addressing Table for PC host address information.

Step 5: Test connectivity.

Verify that the PC hosts can ping one another.

Note: It may be necessary to disable the PCs firewall to ping between PCs.

- Can PC-A ping PC-B? _____ **Yes**
- Can PC-A ping PC-C? _____ **No**
- Can PC-A ping S1? _____ **No**
- Can PC-B ping PC-C? _____ **No**
- Can PC-B ping S2? _____ **No**
- Can PC-C ping S2? _____ **No**
- Can S1 ping S2? _____ **Yes**

If you answered no to any of the above questions, why were the pings unsuccessful?

Pings were unsuccessful when trying to ping a device on a different subnet. For those pings to be successful, a default gateway must exist to route traffic from one subnet to another.

Part 2: Create VLANs and Assign Switch Ports

In Part 2, you will create student, faculty, and management VLANs on both switches. You will then assign the VLANs to the appropriate interface. The **show vlan** command is used to verify your configuration settings.

Step 1: Create VLANs on the switches.

- a. Create the VLANs on S1.

```
S1(config)# vlan 10
S1(config-vlan)# name Student
S1(config-vlan)# vlan 20
S1(config-vlan)# name Faculty
S1(config-vlan)# vlan 99
S1(config-vlan)# name Management
S1(config-vlan)# end
```

- b. Create the same VLANs on S2.

- c. Issue the **show vlan** command to view the list of VLANs on S1.

```
S1# show vlan
```

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24 Gi0/1, Gi0/2

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```
10 Student active
20 Faculty active
99 Management active
1002 fddi-default act/unsup
1003 token-ring-default act/unsup
1004 fddinet-default act/unsup
1005 trnet-default act/unsup
```

VLAN	Type	SAID	MTU	Parent	RingNo	BridgeNo	Stp	BrdgMode	Trans1	Trans2
1	enet	100001	1500	-	-	-	-	-	0	0
10	enet	100010	1500	-	-	-	-	-	0	0
20	enet	100020	1500	-	-	-	-	-	0	0
99	enet	100099	1500	-	-	-	-	-	0	0

VLAN	Type	SAID	MTU	Parent	RingNo	BridgeNo	Stp	BrdgMode	Trans1	Trans2
1002	fddi	101002	1500	-	-	-	-	-	0	0
1003	tr	101003	1500	-	-	-	-	-	0	0
1004	fdnet	101004	1500	-	-	-	ieee	-	0	0
1005	trnet	101005	1500	-	-	-	ibm	-	0	0

Remote SPAN VLANs

Primary	Secondary	Type	Ports
---------	-----------	------	-------

What is the default VLAN? _____ VLAN 1

What ports are assigned to the default VLAN?

All switch ports are assigned to VLAN 1 by default.

Step 2: Assign VLANs to the correct switch interfaces.

- a. Assign VLANs to the interfaces on S1.

- 1) Assign PC-A to the Student VLAN.

```
S1(config)# interface f0/6
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 10
```

- 2) Move the switch IP address VLAN 99.

```
S1(config)# interface vlan 1
S1(config-if)# no ip address
S1(config-if)# interface vlan 99
S1(config-if)# ip address 192.168.1.11 255.255.255.0
S1(config-if)# end
```

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- b. Issue the **show vlan brief** command and verify that the VLANs are assigned to the correct interfaces.

```
S1# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/18, Fa0/19, Fa0/20, Fa0/21 Fa0/22, Fa0/23, Fa0/24, Gi0/1 Gi0/2
10 Student	active	Fa0/6
20 Faculty	active	
99 Management	active	
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

- c. Issue the **show ip interface brief** command.

```
S1# show ip interface brief
```

Interface	IP-Address	OK?	Method	Status	Protocol
Vlan1	unassigned	YES	unset	up	up
Vlan99	192.168.1.11	YES	manual	up	down
FastEthernet0/1	unassigned	YES	unset	up	up
FastEthernet0/2	unassigned	YES	unset	administratively down	down
FastEthernet0/3	unassigned	YES	unset	administratively down	down
FastEthernet0/4	unassigned	YES	unset	administratively down	down
FastEthernet0/5	unassigned	YES	unset	administratively down	down
FastEthernet0/6	unassigned	YES	unset	up	up
FastEthernet0/7	unassigned	YES	unset	administratively down	down

<output omitted>

What is the status of VLAN 99? Why?

The status of VLAN 99 is up/down, because it has not been assigned to an active port yet.

- d. Use the Topology to assign VLANs to the appropriate ports on S2.
e. Remove the IP address for VLAN 1 on S2.
f. Configure an IP address for VLAN 99 on S2 according to the Addressing Table.
g. Use the **show vlan brief** command to verify that the VLANs are assigned to the correct interfaces.

```
S2# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4

Fa0/5, Fa0/6, Fa0/7, Fa0/8
 Fa0/9, Fa0/10, Fa0/12, Fa0/13
 Fa0/14, Fa0/15, Fa0/16, Fa0/17
 Fa0/19, Fa0/20, Fa0/21, Fa0/22
 Fa0/23, Fa0/24, Gi0/1, Gi0/2

```

10 Student active Fa0/11
20 Faculty active Fa0/18
99 Management active
1002 fddi-default act/unsup
1003 token-ring-default act/unsup
1004 fddinet-default act/unsup
1005 trnet-default act/unsup
    
```

Is PC-A able to ping PC-B? Why?

No. Interface F0/1 is not assigned to VLAN 10, so VLAN 10 traffic will not be sent over it.

Is S1 able to ping S2? Why?

No. The IP addresses for the switches now reside in VLAN 99. VLAN 99 traffic will not be sent over interface F0/1.

Part 3: Maintain VLAN Port Assignments and the VLAN Database

In Part 3, you will change VLAN assignments to ports and remove VLANs from the VLAN database.

Step 1: Assign a VLAN to multiple interfaces.

- a. On S1, assign interfaces F0/11 – 24 to VLAN 10.

```

S1(config)# interface range f0/11-24
S1(config-if-range)# switchport mode access
S1(config-if-range)# switchport access vlan 10
S1(config-if-range)# end
    
```

- b. Issue the **show vlan brief** command to verify VLAN assignments.

S1# show vlan brief

```

VLAN Name                Status    Ports
-----
1    default                 active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                           Fa0/5, Fa0/7, Fa0/8, Fa0/9
                                           Fa0/10, Gi0/1, Gi0/2
10   Student                 active    Fa0/6, Fa0/11, Fa0/12, Fa0/13
                                           Fa0/14, Fa0/15, Fa0/16, Fa0/17
                                           Fa0/18, Fa0/19, Fa0/20, Fa0/21
                                           Fa0/22, Fa0/23, Fa0/24
20   Faculty                 active
99   Management              active
1002 fddi-default            act/unsup
1003 token-ring-default    act/unsup
    
```

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```
1004 fddinet-default      act/unsup
1005 trnet-default        act/unsup
```

- c. Reassign F0/11 and F0/21 to VLAN 20.

```
S1(config)# interface range f0/11, f0/21
S1(config-if-range)# switchport access vlan 20
S1(config-if-range)# end
```

- d. Verify that VLAN assignments are correct.

```
S1# show vlan brief
```

```
VLAN Name                Status    Ports
-----
1    default                active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                           Fa0/5, Fa0/7, Fa0/8, Fa0/9
                                           Fa0/10, Gi0/1, Gi0/2
10   Student                active    Fa0/6, Fa0/12, Fa0/13, Fa0/14
                                           Fa0/15, Fa0/16, Fa0/17, Fa0/18
                                           Fa0/19, Fa0/20, Fa0/22, Fa0/23
                                           Fa0/24
20   Faculty                active    Fa0/11, Fa0/21
99   Management             active
1002 fddi-default          act/unsup
1003 token-ring-default   act/unsup
1004 fddinet-default      act/unsup
1005 trnet-default        act/unsup
```

Step 2: Remove a VLAN assignment from an interface.

- a. Use the **no switchport access vlan** command to remove the VLAN 10 assignment to F0/24.

```
S1(config)# interface f0/24
S1(config-if)# no switchport access vlan
S1(config-if)# end
```

- b. Verify that the VLAN change was made.

Which VLAN is F0/24 now associated with?

VLAN 1, the default VLAN.

```
S1# show vlan brief
```

```
VLAN Name                Status    Ports
-----
1    default                active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                           Fa0/5, Fa0/7, Fa0/8, Fa0/9
                                           Fa0/10, Fa0/24, Gi0/1, Gi0/2
10   Student                active    Fa0/6, Fa0/12, Fa0/13, Fa0/14
                                           Fa0/15, Fa0/16, Fa0/17, Fa0/18
                                           Fa0/19, Fa0/20, Fa0/22, Fa0/23
20   Faculty                active    Fa0/11, Fa0/21
99   Management             active
```

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```
1002 fddi-default          act/unsup
1003 token-ring-default    act/unsup
1004 fddinet-default       act/unsup
1005 trnet-default         act/unsup
```

Step 3: Remove a VLAN ID from the VLAN database.

- a. Add VLAN 30 to interface F0/24 without issuing the VLAN command.

```
S1(config)# interface f0/24
S1(config-if)# switchport access vlan 30
% Access VLAN does not exist. Creating vlan 30
```

Note: Current switch technology no longer requires that the **vlan** command be issued to add a VLAN to the database. By assigning an unknown VLAN to a port, the VLAN adds to the VLAN database.

- b. Verify that the new VLAN is displayed in the VLAN table.

```
S1# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Gi0/1, Gi0/2
10 Student	active	Fa0/12, Fa0/13, Fa0/14, Fa0/15 Fa0/16, Fa0/17, Fa0/18, Fa0/19 Fa0/20, Fa0/22, Fa0/23
20 Faculty	active	Fa0/11, Fa0/21
30 VLAN0030	active	Fa0/24
99 Management	active	
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

What is the default name of VLAN 30?

VLAN0030

- c. Use the **no vlan 30** command to remove VLAN 30 from the VLAN database.

```
S1(config)# no vlan 30
S1(config)# end
```

- d. Issue the **show vlan brief** command. F0/24 was assigned to VLAN 30.

After deleting VLAN 30, what VLAN is port F0/24 assigned to? What happens to the traffic destined to the host attached to F0/24?

Port F0/24 is not assigned to any VLAN. This port will not transfer any traffic.

```
S1# show vlan brief
```

VLAN Name	Status	Ports
-----------	--------	-------

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```
-----  
1    default                active    Fa0/1, Fa0/2, Fa0/3, Fa0/4  
                                           Fa0/5, Fa0/6, Fa0/7, Fa0/8  
                                           Fa0/9, Fa0/10, Gi0/1, Gi0/2  
10   Student                active    Fa0/12, Fa0/13, Fa0/14, Fa0/15  
                                           Fa0/16, Fa0/17, Fa0/18, Fa0/19  
                                           Fa0/20, Fa0/22, Fa0/23  
20   Faculty                active    Fa0/11, Fa0/21  
99   Management            active  
1002 fddi-default          act/unsup  
1003 token-ring-default    act/unsup  
1004 fddinet-default       act/unsup  
1005 trnet-default         act/unsup
```

- e. Issue the **no switchport access vlan** command on interface F0/24.

```
S1(config)# interface f0/24  
S1(config-if)# no switchport access vlan  
S1(config-if)# end
```

- f. Issue the **show vlan brief** command to determine the VLAN assignment for F0/24. To which VLAN is F0/24 assigned?

VLAN 1

```
S1# show vlan brief
```

```
VLAN Name                Status    Ports  
-----  
1    default                active    Fa0/1, Fa0/2, Fa0/3, Fa0/4  
                                           Fa0/5, Fa0/7, Fa0/8, Fa0/9  
                                           Fa0/10, Fa0/24, Gi0/1, Gi0/2  
10   Student                active    Fa0/6, Fa0/12, Fa0/13, Fa0/14  
                                           Fa0/15, Fa0/16, Fa0/17, Fa0/18  
                                           Fa0/19, Fa0/20, Fa0/22, Fa0/23  
20   Faculty                active    Fa0/11, Fa0/21  
99   Management            active  
1002 fddi-default          act/unsup  
1003 token-ring-default    act/unsup  
1004 fddinet-default       act/unsup  
1005 trnet-default         act/unsup
```

Note: Before removing a VLAN from the database, it is recommended that you reassign all the ports assigned to that VLAN.

Why should you reassign a port to another VLAN before removing the VLAN from the VLAN database?

The interfaces assigned to a VLAN that is removed from the VLAN database are unavailable for use until they are reassigned to another VLAN. This can be a tricky thing to troubleshoot as trunked interfaces do not show up in the port list as well (Part 4 contains more information about trunked interfaces).

Part 4: Configure an 802.1Q Trunk Between the Switches

In Part 4, you will configure interface F0/1 to use the Dynamic Trunking Protocol (DTP) to allow it to negotiate the trunk mode. After this has been accomplished and verified, you will disable DTP on interface F0/1 and manually configure it as a trunk.

Step 1: Use DTP to initiate trunking on F0/1.

The default DTP mode of a 2960 switch port is dynamic auto. This allows the interface to convert the link to a trunk if the neighboring interface is set to trunk or dynamic desirable mode.

- a. Set F0/1 on S1 to negotiate trunk mode.

```
S1(config)# interface f0/1
S1(config-if)# switchport mode dynamic desirable
*Mar 1 05:07:28.746: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed
state to down
*Mar 1 05:07:29.744: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1,
changed state to down
S1(config-if)#
*Mar 1 05:07:32.772: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1,
changed state to up
S1(config-if)#
*Mar 1 05:08:01.789: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan99, changed
state to up
*Mar 1 05:08:01.797: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed
state to up
```

You should also receive link status messages on S2.

```
S2#
*Mar 1 05:07:29.794: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1,
changed state to down
S2#
*Mar 1 05:07:32.823: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1,
changed state to up
S2#
*Mar 1 05:08:01.839: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan99, changed
state to up
*Mar 1 05:08:01.850: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed
state to up
```

- b. Issue the **show vlan brief** command on S1 and S2. Interface F0/1 is no longer assigned to VLAN 1. Trunked interfaces are not listed in the VLAN table.

```
S1# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/24, Gi0/1, Gi0/2
10 Student	active	Fa0/6, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/22, Fa0/23
20 Faculty	active	Fa0/11, Fa0/21

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```
99 Management active
1002 fddi-default act/unsup
1003 token-ring-default act/unsup
1004 fddinet-default act/unsup
1005 trnet-default act/unsup
```

- c. Issue the **show interfaces trunk** command to view trunked interfaces. Notice that the mode on S1 is set to desirable, and the mode on S2 is set to auto.

S1# **show interfaces trunk**

```
Port      Mode           Encapsulation  Status      Native vlan
Fa0/1     desirable     802.1q         trunking    1
```

```
Port      Vlans allowed on trunk
Fa0/1     1-4094
```

```
Port      Vlans allowed and active in management domain
Fa0/1     1,10,20,99
```

```
Port      Vlans in spanning tree forwarding state and not pruned
Fa0/1     1,10,20,99
```

S2# **show interfaces trunk**

```
Port      Mode           Encapsulation  Status      Native vlan
Fa0/1     auto           802.1q         trunking    1
```

```
Port      Vlans allowed on trunk
Fa0/1     1-4094
```

```
Port      Vlans allowed and active in management domain
Fa0/1     1,10,20,99
```

```
Port      Vlans in spanning tree forwarding state and not pruned
Fa0/1     1,10,20,99
```

Note: By default, all VLANs are allowed on a trunk. The **switchport trunk** command allows you to control what VLANs have access to the trunk. For this lab, keep the default settings which allows all VLANs to traverse F0/1.

- d. Verify that VLAN traffic is traveling over trunk interface F0/1.

Can S1 ping S2? _____ **Yes**

Can PC-A ping PC-B? _____ **Yes**

Can PC-A ping PC-C? _____ **No**

Can PC-B ping PC-C? _____ **No**

Can PC-A ping S1? _____ **No**

Can PC-B ping S2? _____ **No**

Can PC-C ping S2? _____ **No**

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If you answered no to any of the above questions, explain below.

PC-C cannot ping PC-A or PC-B because PC-C is in a different VLAN. The switches are in different VLANs than the PCs; therefore, the pings were unsuccessful.

Step 2: Manually configure trunk interface F0/1.

The **switchport mode trunk** command is used to manually configure a port as a trunk. This command should be issued on both ends of the link.

- a. Change the switchport mode on interface F0/1 to force trunking. Make sure to do this on both switches.

```
S1(config)# interface f0/1
S1(config-if)# switchport mode trunk
```

```
S2(config)# interface f0/1
S2(config-if)# switchport mode trunk
```

- b. Issue the **show interfaces trunk** command to view the trunk mode. Notice that the mode changed from **desirable** to **on**.

```
S2# show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	99

Port	Vlans allowed on trunk
Fa0/1	1-4094

Port	Vlans allowed and active in management domain
Fa0/1	1,10,20,99

Port	Vlans in spanning tree forwarding state and not pruned
Fa0/1	1,10,20,99

Why might you want to manually configure an interface to trunk mode instead of using DTP?

Not all equipment uses DTP. Using the **switchport mode trunk** command ensures that the port will become a trunk no matter what type of equipment is connected to the other end of the link.

Part 5: Delete the VLAN Database

In Part 5, you will delete the VLAN Database from the switch. It is necessary to do this when initializing a switch back to its default settings.

Step 1: Determine if the VLAN database exists.

Issue the **show flash** command to determine if a **vlan.dat** file exists in flash.

```
S1# show flash
```

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Directory of flash:/

```
 2  -rwx      1285   Mar 1 1993 00:01:24 +00:00  config.text
 3  -rwx     43032   Mar 1 1993 00:01:24 +00:00  multiple-fs
 4  -rwx         5   Mar 1 1993 00:01:24 +00:00  private-config.text
 5  -rwx    11607161  Mar 1 1993 02:37:06 +00:00  c2960-lanbasek9-mz.150-2.SE.bin
 6  -rwx       736   Mar 1 1993 00:19:41 +00:00  vlan.dat
```

32514048 bytes total (20858880 bytes free)

Note: If there is a **vlan.dat** file located in flash, then the VLAN database does not contain its default settings.

Step 2: Delete the VLAN database.

- Issue the **delete vlan.dat** command to delete the **vlan.dat** file from flash and reset the VLAN database back to its default settings. You will be prompted twice to confirm that you want to delete the **vlan.dat** file. Press Enter both times.

```
S1# delete vlan.dat
Delete filename [vlan.dat]?
Delete flash:/vlan.dat? [confirm]
S1#
```

- Issue the **show flash** command to verify that the **vlan.dat** file has been deleted.

```
S1# show flash
```

Directory of flash:/

```
 2  -rwx      1285   Mar 1 1993 00:01:24 +00:00  config.text
 3  -rwx     43032   Mar 1 1993 00:01:24 +00:00  multiple-fs
 4  -rwx         5   Mar 1 1993 00:01:24 +00:00  private-config.text
 5  -rwx    11607161  Mar 1 1993 02:37:06 +00:00  c2960-lanbasek9-mz.150-2.SE.bin
```

32514048 bytes total (20859904 bytes free)

To initialize a switch back to its default settings, what other commands are needed?

To get a switch back to its default settings, the **erase startup-config** and **reload** commands need to be issued after the **delete vlan.dat** command.

Reflection

- What is needed to allow hosts on VLAN 10 to communicate to hosts on VLAN 20?

Answers will vary, but Layer 3 routing is needed to route traffic between VLANs.

- What are some primary benefits that an organization can receive through effective use of VLANs?

Lab - Configuring VLANs and Trunking

Answers will vary, but VLAN benefits include: better security, cost savings (efficient use of bandwidth and uplinks), higher performance (smaller broadcast domains), broadcast storm mitigation, improved IT staff efficiency, simpler project and application management.

Device Configs - Final

Switch S1

Building configuration...

Current configuration : 2571 bytes

```
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname S1  
!  
boot-start-marker  
boot-end-marker  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
system mtu routing 1500  
!  
no ip domain-lookup  
!  
spanning-tree mode pvst  
spanning-tree extend system-id  
!  
vlan internal allocation policy ascending  
!  
interface FastEthernet0/1  
  switchport mode trunk  
!  
interface FastEthernet0/2  
  shutdown  
!  
interface FastEthernet0/3  
  shutdown  
!  
interface FastEthernet0/4  
  shutdown
```

Lab - Configuring VLANs and Trunking

```
!  
interface FastEthernet0/5  
shutdown  
!  
interface FastEthernet0/6  
switchport access vlan 10  
switchport mode access  
!  
interface FastEthernet0/7  
shutdown  
!  
interface FastEthernet0/8  
shutdown  
!  
interface FastEthernet0/9  
shutdown  
!  
interface FastEthernet0/10  
shutdown  
!  
interface FastEthernet0/11  
switchport access vlan 20  
switchport mode access  
shutdown  
!  
interface FastEthernet0/12  
switchport access vlan 10  
switchport mode access  
shutdown  
!  
interface FastEthernet0/13  
switchport access vlan 10  
switchport mode access  
shutdown  
!  
interface FastEthernet0/14  
switchport access vlan 10  
switchport mode access  
shutdown  
!  
interface FastEthernet0/15  
switchport access vlan 10  
switchport mode access  
shutdown  
!  
interface FastEthernet0/16  
switchport access vlan 10  
switchport mode access  
shutdown
```

Lab - Configuring VLANs and Trunking

```
!  
interface FastEthernet0/17  
  switchport access vlan 10  
  switchport mode access  
  shutdown  
!  
interface FastEthernet0/18  
  switchport access vlan 10  
  switchport mode access  
  shutdown  
!  
interface FastEthernet0/19  
  switchport access vlan 10  
  switchport mode access  
  shutdown  
!  
interface FastEthernet0/20  
  switchport access vlan 10  
  switchport mode access  
  shutdown  
!  
interface FastEthernet0/21  
  switchport access vlan 20  
  switchport mode access  
  shutdown  
!  
interface FastEthernet0/22  
  switchport access vlan 10  
  switchport mode access  
  shutdown  
!  
interface FastEthernet0/23  
  switchport access vlan 10  
  switchport mode access  
  shutdown  
!  
interface FastEthernet0/24  
  switchport mode access  
  shutdown  
!  
interface GigabitEthernet0/1  
  shutdown  
!  
interface GigabitEthernet0/2  
  shutdown  
!  
interface Vlan1  
  no ip address  
!
```

Lab - Configuring VLANs and Trunking

```
interface Vlan99
 ip address 192.168.1.11 255.255.255.0
!
 ip http server
 ip http secure-server
!
!
 banner motd ^C
  Unauthorized Access is Prohibited!
^C
!
 line con 0
  password cisco
  logging synchronous
  login
 line vty 0 4
  password cisco
  login
 line vty 5 15
  password cisco
  login
!
end
```

Switch S2

Building configuration...

```
Current configuration : 1875 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGholQM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
```

Lab - Configuring VLANs and Trunking

```
!  
vlan internal allocation policy ascending  
!  
interface FastEthernet0/1  
  switchport mode trunk  
!  
interface FastEthernet0/2  
  shutdown  
!  
interface FastEthernet0/3  
  shutdown  
!  
interface FastEthernet0/4  
  shutdown  
!  
interface FastEthernet0/5  
  shutdown  
!  
interface FastEthernet0/6  
  shutdown  
!  
interface FastEthernet0/7  
  shutdown  
!  
interface FastEthernet0/8  
  shutdown  
!  
interface FastEthernet0/9  
  shutdown  
!  
interface FastEthernet0/10  
  shutdown  
!  
interface FastEthernet0/11  
  switchport access vlan 10  
  switchport mode access  
!  
interface FastEthernet0/12  
  shutdown  
!  
interface FastEthernet0/13  
  shutdown  
!  
interface FastEthernet0/14  
  shutdown  
!  
interface FastEthernet0/15  
  shutdown  
!
```

Lab - Configuring VLANs and Trunking

```
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
switchport access vlan 20
switchport mode access
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
!
interface GigabitEthernet0/1
shutdown
!
Interface GigabitEthernet0/2
shutdown
!
interface Vlan1
no ip address
!
interface Vlan99
ip address 192.168.1.12 255.255.255.0
!
ip http server
ip http secure-server
!
!
banner motd ^C
  Unauthorized Access is Prohibited!
^C
!
line con 0
```

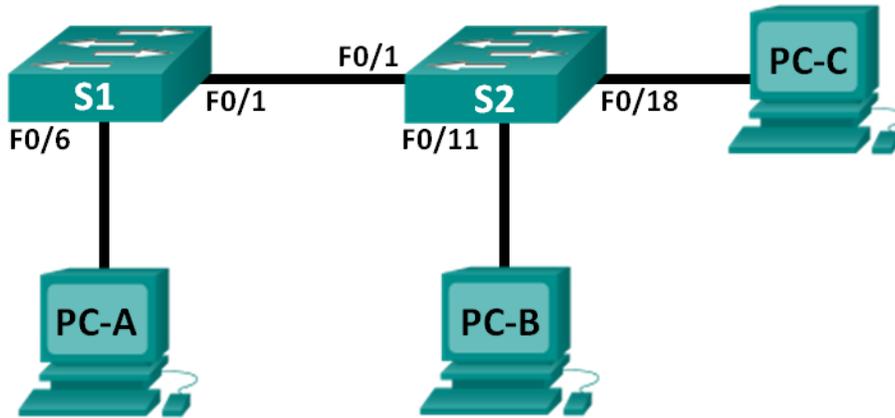
Lab - Configuring VLANs and Trunking

```
password cisco
logging synchronous
login
line vty 0 4
password cisco
login
line vty 5 15
password cisco
login
!
end
```

Lab - Troubleshooting VLAN Configurations (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
S1	VLAN 1	192.168.1.2	255.255.255.0	N/A
S2	VLAN 1	192.168.1.3	255.255.255.0	N/A
PC-A	NIC	192.168.10.2	255.255.255.0	192.168.10.1
PC-B	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC-C	NIC	192.168.20.3	255.255.255.0	192.168.20.1

Switch Port Assignment Specifications

Ports	Assignment	Network
F0/1	802.1Q Trunk	N/A
F0/6-12	VLAN 10 – Students	192.168.10.0/24
F0/13-18	VLAN 20 – Faculty	192.168.20.0/24
F0/19-24	VLAN 30 – Guest	192.168.30.0/24

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Troubleshoot VLAN 10

Part 3: Troubleshoot VLAN 20

Background / Scenario

VLANs provide logical segmentation within an internetwork and improve network performance by separating large broadcast domains into smaller ones. By separating hosts into different networks, VLANs can be used to control which hosts can communicate. In this lab, a school has decided to implement VLANs in order to separate traffic from different end users. The school is using 802.1Q trunking to facilitate VLAN communication between switches.

The S1 and S2 switches have been configured with VLAN and trunking information. Several errors in the configuration have resulted in connectivity issues. You have been asked to troubleshoot and correct the configuration errors and document your work.

Note: The switches used with this lab are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Note: Make sure that the switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure the switches with some basic settings, such as passwords and IP addresses. Preset VLAN-related configurations, which contain errors, are provided for you for the initial switch configurations. You will also configure the IP settings for the PCs in the topology.

Step 1: Cable the network as shown in the topology.

Step 2: Configure PC hosts.

Step 3: Initialize and reload the switches as necessary.

Step 4: Configure basic settings for each switch.

- a. Disable DNS lookup.
- b. Configure the IP address according to the Addressing Table.
- c. Assign **cisco** as the console and vty passwords and enable login for console and vty lines.
- d. Assign **class** as the privileged EXEC password.
- e. Configure **logging synchronous** to prevent console messages from interrupting command entry.

Step 5: Load switch configurations.

The configurations for the switches S1 and S2 are provided for you. There are errors within these configurations, and it is your job to determine the incorrect configurations and correct them.

Switch S1 Configuration:

Lab - Troubleshooting VLAN Configurations

```
hostname S1
vlan 10
  name Students
vlan 2
!vlan 20
name Faculty
vlan 30
  name Guest
interface range f0/1-24
  switchport mode access
  shutdown
!interface f0/1
! switchport mode trunk
! no shutdown
interface range f0/7-12
!interface range f0/6-12
  switchport access vlan 10
interface range f0/13-18
  switchport access vlan 2
! switchport access vlan 20
interface range f0/19-24
  switchport access vlan 30
end
```

Switch S2 Configuration:

```
hostname S2
vlan 10
  name Students
vlan 20
  name Faculty
vlan 30
  name Guest
interface f0/1
  switchport mode trunk
  switchport trunk allowed vlan 1,10,2,30
! switchport trunk allowed vlan 1,10,20,30
interface range f0/2-24
  switchport mode access
  shutdown
!interface range f0/6-12
! switchport access vlan 10
interface range f0/13-18
  switchport access vlan 20
interface range f0/19-24
  switchport access vlan 30
  shutdown
end
```

Step 6: Copy the running configuration to the startup configuration.

Part 2: Troubleshoot VLAN 10

In Part 2, you must examine VLAN 10 on S1 and S2 to determine if it is configured correctly. You will troubleshoot the scenario until connectivity is established.

Step 1: Troubleshoot VLAN 10 on S1.

- a. Can PC-A ping PC-B? _____ **No**
- b. After verifying that PC-A was configured correctly, examine the S1 switch to find possible configuration errors by viewing a summary of the VLAN information. Enter the **show vlan brief** command.

S1# **show vlan brief**

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Gi0/1, Gi0/2
2	Faculty	active	Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18
10	Students	active	Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12
30	Guest	active	Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

- c. Are there any problems with the VLAN configuration?

Yes. The port for PC-A is not assigned to the correct VLAN. The port for F0/1 is assigned to VLAN 1; therefore, it is not acting as a trunk port.

- d. Examine the switch for trunk configurations using the **show interfaces trunk** and the **show interfaces f0/1 switchport** commands.

S1# **show interfaces trunk**

S1# **show interfaces f0/1 switchport**

```
Name: Fa0/1
Switchport: Enabled
Administrative Mode: static access
Operational Mode: down
Administrative Trunking Encapsulation: dot1q
Negotiation of Trunking: Off
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
Administrative private-vlan host-association: none
```

Lab - Troubleshooting VLAN Configurations

```
Administrative private-vlan mapping: none
Administrative private-vlan trunk native VLAN: none
Administrative private-vlan trunk Native VLAN tagging: enabled
Administrative private-vlan trunk encapsulation: dot1q
Administrative private-vlan trunk normal VLANs: none
Administrative private-vlan trunk associations: none
Administrative private-vlan trunk mappings: none
Operational private-vlan: none
Trunking VLANs Enabled: ALL
Pruning VLANs Enabled: 2-1001
Capture Mode Disabled
Capture VLANs Allowed: ALL

Protected: false
Unknown unicast blocked: disabled
Unknown multicast blocked: disabled
Appliance trust: none
```

- e. Are there any problems with the trunking configuration?

Yes. No trunk ports exist and F0/1 is configured as an access port instead of a trunk port.

- f. Examine the running configuration of the switch to find possible configuration errors.
Are there any problems with the current configuration?

Yes. F0/1-5 are all configured as access ports and all ports on the switch are shutdown.

- g. Correct the errors found regarding F0/1 and VLAN 10 on S1. Record the commands used in the space below.

```
S1(config)# interface f0/1
S1(config-if)# no shutdown
S1(config-if)# switchport mode trunk
S1(config-if)# interface f0/6
S1(config-if)# no shutdown
S1(config-if)# switchport access vlan 10
```

- h. Verify the commands had the desired effects by issuing the appropriate **show** commands.

```
S1# show interfaces trunk
```

```
Port      Mode      Encapsulation  Status      Native vlan
Fa0/1     on        802.1q         trunking    1
```

```
Port      Vlans allowed on trunk
Fa0/1     1-4094
```

Lab - Troubleshooting VLAN Configurations

```
Port      Vlans allowed and active in management domain
Fa0/1     1-2,10,30
```

```
Port      Vlans in spanning tree forwarding state and not pruned
Fa0/1     1-2,10,30
```

```
S1# show vlan brief
```

```
VLAN Name                Status    Ports
-----
1    default                 active    Fa0/2, Fa0/3, Fa0/4, Fa0/5
                                           Gi0/1, Gi0/2
2    Faculty                 active    Fa0/13, Fa0/14, Fa0/15, Fa0/16
                                           Fa0/17, Fa0/18
10   Students                active    Fa0/6, Fa0/7, Fa0/8, Fa0/9
                                           Fa0/10, Fa0/11, Fa0/12
30   Guest                   active    Fa0/19, Fa0/20, Fa0/21, Fa0/22
                                           Fa0/23, Fa0/24
1002 fddi-default           act/unsup
1003 token-ring-default   act/unsup
1004 fddinet-default       act/unsup
1005 trnet-default         act/unsup
```

- i. Can PC-A ping PC-B? _____ **No**

Step 2: Troubleshoot VLAN 10 on S2.

- a. Using the previous commands, examine the S2 switch to find possible configuration errors. Are there any problems with the current configuration?

Yes. No ports were assigned access to VLAN 10 and ports F0/1 and F0/11 are shutdown.

```
S2# show vlan brief
```

```
VLAN Name                Status    Ports
-----
1    default                 active    Fa0/2, Fa0/3, Fa0/4, Fa0/5
                                           Fa0/6, Fa0/7, Fa0/8, Fa0/9
                                           Fa0/10, Fa0/11, Fa0/12, Gi0/1
                                           Gi0/2
10   Students                active
20   Faculty                 active    Fa0/13, Fa0/14, Fa0/15, Fa0/16
                                           Fa0/17, Fa0/18
30   Guest                   active    Fa0/19, Fa0/20, Fa0/21, Fa0/22
                                           Fa0/23, Fa0/24
1002 fddi-default           act/unsup
1003 token-ring-default   act/unsup
1004 fddinet-default       act/unsup
1005 trnet-default         act/unsup
```

Lab - Troubleshooting VLAN Configurations

- b. Correct the errors found regarding interfaces and VLAN 10 on S2. Record the commands below.

```
S2(config)# interface range f0/6-12
S2(config-if-range)# switchport access vlan 10
S2(config-if-range)# interface f0/11
S2(config-if)# no shutdown
```

- c. Can PC-A ping PC-B? _____ Yes

Part 3: Troubleshoot VLAN 20

In Part 3, you must examine VLAN 20 on S1 and S2 to determine if it is configured correctly. To verify functionality, you will reassign PC-A into VLAN 20, and then troubleshoot the scenario until connectivity is established.

Step 1: Assign PC-A to VLAN 20.

- a. On PC-A, change the IP address to 192.168.20.2/24 with a default gateway of 192.168.20.1.
- b. On S1, assign the port for PC-A to VLAN 20. Write the commands needed to complete the configuration.

```
S1(config)# interface f0/6
S1(config-if)# switchport access vlan 20
```

- c. Verify that the port for PC-A has been assigned to VLAN 20.

```
S1# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Gi0/1, Gi0/2
2 Faculty	active	Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18
10 Students	active	Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12
20 VLAN0020	active	Fa0/6
30 Guest	active	Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

Lab - Troubleshooting VLAN Configurations

d. Can PC-A ping PC-C? _____ **No**

Step 2: Troubleshoot VLAN 20 on S1.

- a. Using the previous commands, examine the S1 switch to find possible configuration errors.
Are there any problems with the current configuration?

Yes. VLAN 2 was created instead of VLAN 20 and ports have been assigned to VLAN 2 instead of VLAN 20.

- b. Correct the errors found regarding VLAN 20.

```
S1(config)# interface range f0/13-18
S1(config-if-range)# switchport access vlan 20
S1(config-if-range)# exit
S1(config)# no vlan 2
S1(config)# vlan 20
S1(config-vlan)# name Faculty
```

c. Can PC-A ping PC-C? _____ **No**

Step 3: Troubleshoot VLAN 20 on S2.

- a. Using the previous commands, examine the S2 switch to find possible configuration errors.
Are there any problems with the current configuration?

Yes. The trunked interface has been misconfigured to allow communication for VLAN 2 instead of VLAN 20 and port f0/18 is shutdown.

```
S2# show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	1

```
Port Vlans allowed on trunk
```

```
Fa0/1 1-2,10,30
```

```
Port Vlans allowed and active in management domain
```

```
Fa0/1 1,10,30
```

```
Port Vlans in spanning tree forwarding state and not pruned
```

```
Fa0/1 1,10,30
```

```
S2# show run interface f0/18
```

```
Building configuration...
```

```
Current configuration : 95 bytes
```

```
!
```

```
interface FastEthernet0/18
```

Lab - Troubleshooting VLAN Configurations

```
switchport access vlan 20
switchport mode access
shutdown
end
```

- b. Correct the errors found regarding VLAN 20. Record the commands used below.

```
S2(config)# interface f0/18
S2(config-if)# no shutdown
S2(config)# interface f0/1
S2(config-if)# switchport trunk allowed vlan remove 2
S2(config-if)# switchport trunk allowed vlan add 20
```

- c. Can PC-A ping PC-C? _____ Yes

Note: It may be necessary to disable the PC firewall to ping between PCs.

Reflection

1. Why is a correctly configured trunk port critical in a multi-VLAN environment?

An 802.1Q trunk port allows for transmission of multiple VLANs across one link. An incorrectly configured trunk port can prevent VLANs from communicating across switches.

2. Why would a network administrator limit traffic for specific VLANs on a trunk port?

To prevent unwanted VLAN traffic from traveling through that trunk port.

Device Configs

Instructor Note: The VLANs configured do not display in the running configuration but are stored in the vlan.dat file.

Switch S1

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Gi0/1, Gi0/2
10	Students	active	Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12
20	Faculty	active	Fa0/6, Fa0/13, Fa0/14, Fa0/15

Lab - Troubleshooting VLAN Configurations

```

Fa0/16, Fa0/17, Fa0/18
30  Guest                active  Fa0/19, Fa0/20, Fa0/21, Fa0/22
Fa0/23, Fa0/24
1002 fddi-default        act/unsup
1003 token-ring-default  act/unsup
1004 fddinet-default     act/unsup
1005 trnet-default       act/unsup
```

```
S1#show run
```

```
Building configuration...
```

```
Current configuration : 3966 bytes
```

```
!
version 15.0
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 5 $1$Hf8a$8iwF0hpldYGTxw1UsJuE5/
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
!
interface FastEthernet0/1
 switchport mode trunk
!
interface FastEthernet0/2
 switchport mode access
```

Lab - Troubleshooting VLAN Configurations

```
shutdown
!
interface FastEthernet0/3
  switchport mode access
  shutdown
!
interface FastEthernet0/4
  switchport mode access
  shutdown
!
interface FastEthernet0/5
  switchport mode access
  shutdown
!
interface FastEthernet0/6
  switchport access vlan 20
  switchport mode access
!
interface FastEthernet0/7
  switchport access vlan 10
  switchport mode access
  shutdown
!
interface FastEthernet0/8
  switchport access vlan 10
  switchport mode access
  shutdown
!
interface FastEthernet0/9
  switchport access vlan 10
  switchport mode access
  shutdown
!
interface FastEthernet0/10
  switchport access vlan 10
  switchport mode access
  shutdown
!
interface FastEthernet0/11
  switchport access vlan 10
  switchport mode access
  shutdown
!
interface FastEthernet0/12
  switchport access vlan 10
  switchport mode access
  shutdown
!
interface FastEthernet0/13
```

Lab - Troubleshooting VLAN Configurations

```
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/14
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/15
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/16
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/17
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/18
switchport access vlan 20
switchport mode access
shutdown
!
interface FastEthernet0/19
switchport access vlan 30
switchport mode access
shutdown
!
interface FastEthernet0/20
switchport access vlan 30
switchport mode access
shutdown
!
interface FastEthernet0/21
switchport access vlan 30
switchport mode access
shutdown
!
interface FastEthernet0/22
switchport access vlan 30
switchport mode access
shutdown
!
```

Lab - Troubleshooting VLAN Configurations

```
interface FastEthernet0/23
  switchport access vlan 30
  switchport mode access
  shutdown
!
interface FastEthernet0/24
  switchport access vlan 30
  switchport mode access
  shutdown
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
  ip address 192.168.1.2 255.255.255.0
  no ip route-cache
!
ip http server
ip http secure-server
logging esm config
!
line con 0
  password cisco
  logging synchronous
  login
line vty 0 4
  password cisco
  login
line vty 5 15
  password cisco
  login
!
end
```

Switch S2

```
S2# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Gi0/1, Gi0/2
10 Students	active	Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12
20 Faculty	active	Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18
30 Guest	active	Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24
1002 fddi-default	act/unsup	

Lab - Troubleshooting VLAN Configurations

```
1003 token-ring-default          act/unsup
1004 fddinet-default             act/unsup
1005 trnet-default                act/unsup
S2# show run
Building configuration...
Current configuration : 3966 bytes
!
! Last configuration change at 00:07:17 UTC Mon Mar 1 1993
!
version 15.0
no service pad
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 5 $1$T7f6$AYijj smnLmWzgIAET.DDj/
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
!
interface FastEthernet0/1
  switchport trunk allowed vlan 1,10,20,30
  switchport mode trunk
!
interface FastEthernet0/2
  switchport mode access
  shutdown
!
interface FastEthernet0/3
```

Lab - Troubleshooting VLAN Configurations

```
switchport mode access
shutdown
!
interface FastEthernet0/4
switchport mode access
shutdown
!
interface FastEthernet0/5
switchport mode access
shutdown
!
interface FastEthernet0/6
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/7
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/8
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/9
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/10
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/11
switchport access vlan 10
switchport mode access
!
interface FastEthernet0/12
switchport access vlan 10
switchport mode access
shutdown
!
interface FastEthernet0/13
switchport access vlan 20
switchport mode access
shutdown
```

Lab - Troubleshooting VLAN Configurations

```
!  
interface FastEthernet0/14  
  switchport access vlan 20  
  switchport mode access  
  shutdown
```

```
!  
interface FastEthernet0/15  
  switchport access vlan 20  
  switchport mode access  
  shutdown
```

```
!  
interface FastEthernet0/16  
  switchport access vlan 20  
  switchport mode access  
  shutdown
```

```
!  
interface FastEthernet0/17  
  switchport access vlan 20  
  switchport mode access  
  shutdown
```

```
!  
interface FastEthernet0/18  
  switchport access vlan 20  
  switchport mode access
```

```
!  
interface FastEthernet0/19  
  switchport access vlan 30  
  switchport mode access  
  shutdown
```

```
!  
interface FastEthernet0/20  
  switchport access vlan 30  
  switchport mode access  
  shutdown
```

```
!  
interface FastEthernet0/21  
  switchport access vlan 30  
  switchport mode access  
  shutdown
```

```
!  
interface FastEthernet0/22  
  switchport access vlan 30  
  switchport mode access  
  shutdown
```

```
!  
interface FastEthernet0/23  
  switchport access vlan 30  
  switchport mode access
```

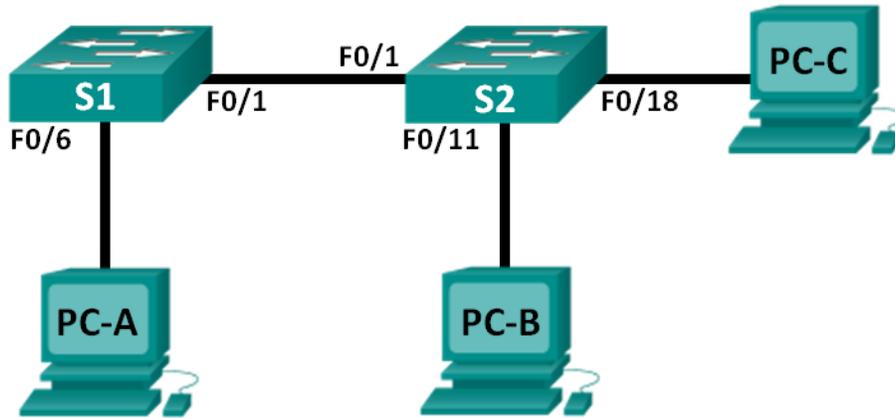
Lab - Troubleshooting VLAN Configurations

```
shutdown
!
interface FastEthernet0/24
  switchport access vlan 30
  switchport mode access
shutdown
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
  ip address 192.168.1.3 255.255.255.0
  no ip route-cache
!
ip http server
ip http secure-server
logging esm config
!
line con 0
  password cisco
  logging synchronous
  login
line vty 0 4
  password cisco
  login
line vty 5 15
  password cisco
  login
!
end
```

Lab – Implementing VLAN Security (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
S1	VLAN 99	172.17.99.11	255.255.255.0	172.17.99.1
S2	VLAN 99	172.17.99.12	255.255.255.0	172.17.99.1
PC-A	NIC	172.17.99.3	255.255.255.0	172.17.99.1
PC-B	NIC	172.17.10.3	255.255.255.0	172.17.10.1
PC-C	NIC	172.17.99.4	255.255.255.0	172.17.99.1

VLAN Assignments

VLAN	Name
10	Data
99	Management&Native
999	BlackHole

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Implement VLAN Security on the Switches

Background / Scenario

Best practice dictates configuring some basic security settings for both access and trunk ports on switches. This will help guard against VLAN attacks and possible sniffing of network traffic within the network.

Lab – Implementing VLAN Security

In this lab, you will configure the network devices in the topology with some basic settings, verify connectivity and then apply more stringent security measures on the switches. You will examine how Cisco switches behave by using various **show** commands. You will then apply security measures.

Note: The switches used with this lab are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Note: Make sure that the switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will configure basic settings on the switches and PCs. Refer to the Addressing Table for device names and address information.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the switches.

Step 3: Configure IP addresses on PC-A, PC-B, and PC-C.

Refer to the Addressing Table for PC address information.

Step 4: Configure basic settings for each switch.

- a. Disable DNS lookup.
- b. Configure the device names as shown in the topology.
- c. Assign **class** as the privileged EXEC mode password.
- d. Assign **cisco** as the console and VTY password and enable login for console and vty lines.
- e. Configure synchronous logging for console and vty lines.

Step 5: Configure VLANs on each switch.

- a. Create and name VLANs according to the VLAN Assignments table.
- b. Configure the IP address listed in the Addressing Table for VLAN 99 on both switches.
- c. Configure F0/6 on S1 as an access port and assign it to VLAN 99.
- d. Configure F0/11 on S2 as an access port and assign it to VLAN 10.
- e. Configure F0/18 on S2 as an access port and assign it to VLAN 99.
- f. Issue **show vlan brief** command to verify VLAN and port assignments.

```
S1# show vlan brief
```

Lab – Implementing VLAN Security

```
VLAN Name                Status    Ports
-----
1    default                active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                           Fa0/5, Fa0/7, Fa0/8, Fa0/9
                                           Fa0/10, Fa0/11, Fa0/12, Fa0/13
                                           Fa0/14, Fa0/15, Fa0/16, Fa0/17
                                           Fa0/18, Fa0/19, Fa0/20, Fa0/21
                                           Fa0/22, Fa0/23, Fa0/24, Gi0/1
                                           Gi0/2
10   Data                    active
99   Management&Native       active    Fa0/6
999  BlackHole                active
1002 fddi-default             act/unsup
1003 token-ring-default     act/unsup
1004 fddinet-default         act/unsup
1005 trnet-default          act/unsup
```

S2# **show vlan brief**

```
VLAN Name                Status    Ports
-----
1    default                active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                           Fa0/5, Fa0/6, Fa0/7, Fa0/8
                                           Fa0/9, Fa0/10, Fa0/12, Fa0/13
                                           Fa0/14, Fa0/15, Fa0/16, Fa0/17
                                           Fa0/19, Fa0/20, Fa0/21, Fa0/22
                                           Fa0/23, Fa0/24, Gi0/1, Gi0/2
10   Data                    active    Fa0/11
99   Management&Native       active    Fa0/18
999  BlackHole                active
1002 fddi-default             act/unsup
1003 token-ring-default     act/unsup
1004 fddinet-default         act/unsup
1005 trnet-default          act/unsup
```

To which VLAN would an unassigned port, such as F0/8 on S2, belong?

All ports by default are assigned to VLAN 1.

Step 6: Configure basic switch security.

- Configure a MOTD banner to warn users that unauthorized access is prohibited.
- Encrypt all passwords.
- Shut down all unused physical ports.
- Disable the basic web service running.

```
S1(config)# no ip http server
```

```
S2(config)# no ip http server
```

Lab – Implementing VLAN Security

- e. Copy the running configuration to startup configuration.

Step 7: Verify connectivity between devices and VLAN information.

- a. From a command prompt on PC-A, ping the management address of S1. Were the pings successful? Why?

Yes, the pings were successful. PC-A is in the same VLAN as the management address on the switch.

- b. From S1, ping the management address of S2. Were the pings successful? Why?

No, the pings were not successful. The management addresses on S1 and S2 are in the same VLAN but interface F0/1 on both switches is not configured as a trunk port. Port F0/1 still belongs to VLAN 1 and not VLAN 99.

- c. From a command prompt on PC-B, ping the management addresses on S1 and S2 and the IP address of PC-A and PC-C. Were your pings successful? Why?

The pings to S1, S2, PC-A, and PC-C from PC-B were all unsuccessful. PC-B is on VLAN 10, and S1, S2, PC-A, and PC-C are on VLAN 99. There is no Layer 3 device to route between networks.

- d. From a command prompt on PC-C, ping the management addresses on S1 and S2. Were you successful? Why?

Partial success. PC-C is in the same VLAN as S1 and S2. PC-C is able to ping the management address of S2 but still cannot ping S1 because a trunk link has not been established yet between S1 and S2.

Note: It may be necessary to disable the PC firewall to ping between PCs.

Part 2: Implement VLAN Security on the Switches

Step 1: Configure trunk ports on S1 and S2.

- a. Configure port F0/1 on S1 as a trunk port.
S1(config)# **interface f0/1**
S1(config-if)# **switchport mode trunk**
- b. Configure port F0/1 on S2 as a trunk port.
S2(config)# **interface f0/1**
S2(config-if)# **switchport mode trunk**
- c. Verify trunking on S1 and S2. Issue the **show interface trunk** command on both switches.
S1# **show interface trunk**

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	1

Lab – Implementing VLAN Security

```
Port          Vlans allowed on trunk
Fa0/1         1-4094
```

```
Port          Vlans allowed and active in management domain
Fa0/1         1,10,99,999
```

```
Port          Vlans in spanning tree forwarding state and not pruned
Fa0/1         1,10,99,999
```

Step 2: Change the native VLAN for the trunk ports on S1 and S2.

Changing the native VLAN for trunk ports from VLAN 1 to another VLAN is a good practice for security.

- a. What is the current native VLAN for the S1 and S2 F0/1 interfaces?

VLAN 1 is the native VLAN for both switches.

- b. Configure the native VLAN on the S1 F0/1 trunk interface to Management&Native VLAN 99.

```
S1# config t
S1(config)# interface f0/1
S1(config-if)# switchport trunk native vlan 99
```

- c. Wait a few seconds. You should start receiving error messages on the console session of S1. What does the %CDP-4-NATIVE_VLAN_MISMATCH: message mean?

This is a Cisco Discovery Protocol (CDP) message indicating that the S1 and S2 native VLANs do not match. S2 still has the native VLAN set to VLAN 1. S1 has set the native VLAN to 99.

- d. Configure the native VLAN on the S2 F0/1 trunk interface to VLAN 99.

```
S2(config)# interface f0/1
S2(config-if)# switchport trunk native vlan 99
```

- e. Verify that the native VLAN is now 99 on both switches. S1 output is shown below.

```
S1# show interface trunk
```

```
Port          Mode          Encapsulation  Status        Native vlan
Fa0/1         on            802.1q         trunking     99
```

```
Port          Vlans allowed on trunk
Fa0/1         1-4094
```

```
Port          Vlans allowed and active in management domain
Fa0/1         1,10,99,999
```

```
Port          Vlans in spanning tree forwarding state and not pruned
Fa0/1         10,999
```

Step 3: Verify that traffic can successfully cross the trunk link.

- a. From a command prompt on PC-A, ping the management address of S1. Were the pings successful? Why?

Yes, the pings were successful. PC-A is in the same VLAN as the management address on the switch.

- b. From the console session on S1, ping the management address of S2. Were the pings successful? Why?

Yes, the pings were successful. Trunking has been successfully established, and both switches are in VLAN 99.

- c. From a command prompt on PC-B, ping the management addresses on S1 and S2 and the IP address of PC-A and PC-C. Were your pings successful? Why?

The pings to S1, S2, PC-A, and PC-C from PC-B were all unsuccessful. PC-B is on VLAN 10 and S1, S2, PC-A, and PC-C are on VLAN 99. There is no Layer 3 device to route between networks.

- d. From a command prompt on PC-C, ping the management addresses on S1 and S2 and the IP address of PC-A. Were you successful? Why?

The pings were all successful. PC-C is in the same VLAN as S1 and S2 and PC-A.

Step 4: Prevent the use of DTP on S1 and S2.

Cisco uses a proprietary protocol known as the Dynamic Trunking Protocol (DTP) on its switches. Some ports automatically negotiate to trunking. A good practice is to turn off negotiation. You can see this default behavior by issuing the following command:

```
S1# show interface f0/1 switchport
Name: Fa0/1
Switchport: Enabled
Administrative Mode: trunk
Operational Mode: trunk
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: dot1q
Negotiation of Trunking: On
<Output Omitted>
```

- a. Turn off negotiation on S1.

```
S1(config)# interface f0/1
S1(config-if)# switchport nonegotiate
```

- b. Turn off negotiation on S2.

```
S2(config)# interface f0/1
S2(config-if)# switchport nonegotiate
```

- c. Verify that negotiation is off by issuing the **show interface f0/1 switchport** command on S1 and S2.

```
S1# show interface f0/1 switchport
Name: Fa0/1
```

```
Switchport: Enabled
Administrative Mode: trunk
Operational Mode: trunk
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: dot1q
Negotiation of Trunking: Off
<Output Omitted>
```

Step 5: Secure access ports on S1 and S2.

Even though you shut down unused ports on the switches, if a device is connected to one of those ports and the interface is enabled, trunking could occur. In addition, all ports by default are in VLAN 1. A good practice is to put all unused ports in a “black hole” VLAN. In this step, you will disable trunking on all unused ports. You will also assign unused ports to VLAN 999. For the purposes of this lab, only ports 2 through 5 will be configured on both switches.

- Issue the **show interface f0/2 switchport** command on S1. Notice the administrative mode and state for trunking negotiation.

```
S1# show interface f0/2 switchport
Name: Fa0/2
Switchport: Enabled
Administrative Mode: dynamic auto
Operational Mode: down
Administrative Trunking Encapsulation: dot1q
Negotiation of Trunking: On
<Output Omitted>
```

- Disable trunking on S1 access ports.

```
S1(config)# interface range f0/2 - 5
S1(config-if-range)# switchport mode access
S1(config-if-range)# switchport access vlan 999
```

- Disable trunking on S2 access ports.

```
S2(config)# interface range f0/2 - 5
S2(config-if-range)# switchport mode access
S2(config-if-range)# switchport access vlan 999
```

- Verify that port F0/2 is set to access on S1.

```
S1# show interface f0/2 switchport
Name: Fa0/2
Switchport: Enabled
Administrative Mode: static access
Operational Mode: down
Administrative Trunking Encapsulation: dot1q
Negotiation of Trunking: Off
Access Mode VLAN: 999 (BlackHole)
Trunking Native Mode VLAN: 1 (default)
Administrative Native VLAN tagging: enabled
Voice VLAN: none
<Output Omitted>
```

- Verify that VLAN port assignments on both switches are correct. S1 is shown below as an example.

Lab – Implementing VLAN Security

```
S1# show vlan brief
```

```
VLAN Name                Status    Ports
-----
1    default                active   Fa0/7, Fa0/8, Fa0/9, Fa0/10
                                   Fa0/11, Fa0/12, Fa0/13, Fa0/14
                                   Fa0/15, Fa0/16, Fa0/17, Fa0/18
                                   Fa0/19, Fa0/20, Fa0/21, Fa0/22
                                   Fa0/23, Fa0/24, Gi0/1, Gi0/2
10   Data                    active
99   Management&Native      active   Fa0/6
999  BlackHole               active   Fa0/2, Fa0/3, Fa0/4, Fa0/5
1002 fddi-default           act/unsup
1003 token-ring-default   act/unsup
1004 fddinet-default       act/unsup
1005 trnet-default        act/unsup
Restrict VLANs allowed on trunk ports.
```

By default, all VLANs are allowed to be carried on trunk ports. For security reasons, it is a good practice to only allow specific desired VLANs to cross trunk links on your network.

- f. Restrict the trunk port F0/1 on S1 to only allow VLANs 10 and 99.

```
S1(config)# interface f0/1
S1(config-if)# switchport trunk allowed vlan 10,99
```

- g. Restrict the trunk port F0/1 on S2 to only allow VLANs 10 and 99.

```
S2(config)# interface f0/1
S2(config-if)# switchport trunk allowed vlan 10,99
```

- h. Verify the allowed VLANs. Issue a **show interface trunk** command in privileged EXEC mode on both S1 and S2.

```
S1# show interface trunk
```

```
Port      Mode          Encapsulation  Status        Native vlan
Fa0/1     on            802.1q         trunking      99

Port      Vlans allowed on trunk
Fa0/1     10,99

Port      Vlans allowed and active in management domain
Fa0/1     10,99

Port      Vlans in spanning tree forwarding state and not pruned
Fa0/1     10,99
```

What is the result?

Only VLANs 10 and 99 are allowed on the trunk link between S1 and S2.

Reflection

What, if any, are the security problems with the default configuration of a Cisco switch?

The fact that all ports are assigned to VLAN 1 by default is one possible security issue. Another is that on many Cisco switches, trunking is set to auto-negotiate, so trunk links may be turned on without your knowledge, if a rogue switch is connected. Another possible answer is that both console and VTY passwords are displayed in plain text by default. In addition, the HTTP server is enabled by default.

Device Configs

Switch S1

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10	Data	active	
99	Management&Native	active	Fa0/6
999	BlackHole	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

```
S1#sh run
```

```
Building configuration...
```

```
Current configuration : 3821 bytes
```

```
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
service password-encryption  
!  
hostname S1  
!  
boot-start-marker  
boot-end-marker  
!
```

Lab – Implementing VLAN Security

```
enable secret 4 06YFDUHH61wAE/kLkDq9BGholQM5EnRtoyr8cHAUg.2
!  
no aaa new-model  
system mtu routing 1500  
!  
no ip domain-lookup  
!  
spanning-tree mode pvst  
spanning-tree extend system-id  
!  
vlan internal allocation policy ascending  
!  
interface FastEthernet0/1  
  switchport trunk native vlan 99  
  switchport trunk allowed vlan 10,99  
  switchport mode trunk  
  switchport nonegotiate  
!  
interface FastEthernet0/2  
  switchport access vlan 999  
  switchport mode access  
  shutdown  
!  
interface FastEthernet0/3  
  switchport access vlan 999  
  switchport mode access  
  shutdown  
!  
interface FastEthernet0/4  
  switchport access vlan 999  
  switchport mode access  
  shutdown  
!  
interface FastEthernet0/5  
  switchport access vlan 999  
  switchport mode access  
  shutdown  
!  
interface FastEthernet0/6  
  switchport access vlan 99  
  switchport mode access  
!  
interface FastEthernet0/7  
  shutdown  
!  
interface FastEthernet0/8  
  shutdown  
!  
interface FastEthernet0/9
```

Lab – Implementing VLAN Security

```
shutdown
!  
interface FastEthernet0/10  
shutdown  
!  
interface FastEthernet0/11  
shutdown  
!  
interface FastEthernet0/12  
shutdown  
!  
interface FastEthernet0/13  
shutdown  
!  
interface FastEthernet0/14  
shutdown  
!  
interface FastEthernet0/15  
shutdown  
!  
interface FastEthernet0/16  
shutdown  
!  
interface FastEthernet0/17  
shutdown  
!  
interface FastEthernet0/18  
shutdown  
!  
interface FastEthernet0/19  
shutdown  
!  
interface FastEthernet0/20  
shutdown  
!  
interface FastEthernet0/21  
shutdown  
!  
interface FastEthernet0/22  
shutdown  
!  
interface FastEthernet0/23  
shutdown  
!  
interface FastEthernet0/24  
shutdown  
!  
interface GigabitEthernet0/1  
shutdown
```

Lab – Implementing VLAN Security

```
!  
interface GigabitEthernet0/2  
shutdown  
!  
interface Vlan1  
no ip address  
shutdown  
!  
interface Vlan99  
ip address 172.17.99.11 255.255.255.0  
!  
no ip http server  
ip http secure-server  
!  
banner motd ^CWarning. Unauthorized access is prohibited.^C  
!  
line con 0  
password 7 070C285F4D06  
logging synchronous  
login  
line vty 0 4  
password 7 070C285F4D06  
logging synchronous  
login  
line vty 5 15  
password 7 070C285F4D06  
logging synchronous  
login  
!  
end
```

Switch S2

```
S2#show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/19 Fa0/20, Fa0/21, Fa0/22, Fa0/23 Fa0/24, Gi0/1, Gi0/2
10 Data	active	Fa0/11
99 Management&Native	active	Fa0/18
999 BlackHole	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

Lab – Implementing VLAN Security

```
S2#sh run
Building configuration...

Current configuration : 3852 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGholQM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 switchport trunk native vlan 99
 switchport trunk allowed vlan 10,99
 switchport mode trunk
 switchport nonegotiate
!
interface FastEthernet0/2
 switchport access vlan 999
 switchport mode access
 shutdown
!
interface FastEthernet0/3
 switchport access vlan 999
 switchport mode access
 shutdown
!
interface FastEthernet0/4
 switchport access vlan 999
 switchport mode access
 shutdown
!
```

Lab – Implementing VLAN Security

```
interface FastEthernet0/5
  switchport access vlan 999
  switchport mode access
  shutdown
!
interface FastEthernet0/6
  shutdown

interface FastEthernet0/6
  shutdown
!
interface FastEthernet0/7
  shutdown
!
interface FastEthernet0/8
  shutdown
!
interface FastEthernet0/9
  shutdown
!
interface FastEthernet0/10
  shutdown
!
interface FastEthernet0/11
  switchport access vlan 10
  switchport mode access
!
interface FastEthernet0/12
  shutdown
!
interface FastEthernet0/13
  shutdown
!
interface FastEthernet0/14
  shutdown
!
interface FastEthernet0/15
  shutdown
!
interface FastEthernet0/16
  shutdown
!
interface FastEthernet0/17
  shutdown
!
interface FastEthernet0/18
  switchport access vlan 99
  switchport mode access
!
```

Lab – Implementing VLAN Security

```
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
!
interface GigabitEthernet0/1
shutdown
!
interface GigabitEthernet0/2
shutdown
!
interface Vlan1
no ip address
!
interface Vlan99
ip address 172.17.99.12 255.255.255.0
!
no ip http server
ip http secure-server
!
banner motd ^CWarning. Unauthorized access is prohibited.^C
!
line con 0
password 7 00071A150754
logging synchronous
login
line vty 0 4
password 7 00071A150754
logging synchronous
login
line vty 5 15
password 7 070C285F4D06
logging synchronous
login
!
end
```

VLAN Plan (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Implement VLANs to segment a small- to medium-sized network.

This class activity focuses students' thoughts on how VLANs are designed. Groups of two or three students should be created to complete this class activity.

Scenario

You are designing a VLAN switched network for your small- to medium- sized business.

Your business owns space on two floors of a high-rise building. The following elements need VLAN consideration and access for planning purposes:

- Management
- Finance
- Sales
- Human Resources
- Network administrator
- General visitors to your business location

You have two Cisco 3560-24PS switches.

Use a word processing software program to design your VLAN-switched network scheme.

Section 1 of your design should include the regular names of your departments, suggested VLAN names and numbers, and which switch ports would be assigned to each VLAN.

Section 2 of your design should list how security would be planned for this switched network.

Once your VLAN plan is finished, complete the reflection questions from this activity.

Save your work. Be able to explain and discuss your VLAN design with another group or with the class.

Required Resources

Word processing program

Reflection

1. What criteria did you use for assigning ports to the VLANs?

Number of users, types of end-devices and how many MAC addresses would need to be assigned to each port of the VLAN, if any.

2. How could these users access your network if the switches were not physically available to general users via direct connection?

An additional network device could be incorporated into the network or perhaps a wireless access point or ISR router with access to the general VLAN switchports. If this is a new building, wired connections could be established allowing separate, direct access to network ports built into office walls or conference tables.

3. Could you reduce the number of switch ports assigned for general users if you used another device to connect them to the VLAN network switch? What would be affected?

Bandwidth would be shared if users shared a port.

Modeling Activity Graphic Representation (designs will vary)

Instructor Notes: This is a representative example that could be “built” as a result of this activity:

Tables are used in this design - students may elect to show their switched network design in graphic format with notes indicating port assignments, department/inter-VLAN associations and security considerations.

In this example, both switches would use the same switchport assignments and VLAN information to facilitate network administration tasks. Switches would be connected via a configured trunk line using one of the Gigabit ports. The remaining Gigabit ports would be reserved for connectivity to intermediary devices, additional trunk lines or servers.

Section 1: VLAN Names and Numbers – VLAN Switchport Assignments

Department	Assigned VLAN Name and Number	Switchport Numbers
Network Administration	Native90	Gi0/1 and Gi0/2
Management	Management10	Fa0/1-0/2
Finance	Finance20	Fa0/3-Fa0/6
Sales	Sales30	Fa0/7-Fa0/10
Human Resources	HR40	Fa0/13-Fa0/16
General	General50	Fa0/17-Fa0/22
(not assigned)	Leave in VLAN1	(Fa0/23 and Fa0/24 will be shut down and reserved for future VLAN consideration)

Section 2: Security Design:

- Ports Fa0/1 and Fa0/2 would be configured with two specific MAC addresses – if a non-specified MAC address from an end-device accesses these two ports, the ports will shut down.
- Fa0/3-Fa0/16 would be assigned specific MAC addresses. The assigned addresses will be based on the addresses recorded from the end-devices located in each department. The ports will shut down if security is breached.
- Ports Fa0/17-Fa0/22 would be open ports for general use within the small- to medium-size business.
- Ports Fa23 and Fa24 would be shut down by the network administrator and saved for future VLAN assignment.

Identify elements of the model that map to IT-related content:

- VLANs
- VLAN trunking
- VLAN domains
- VLAN assignment
- VLAN security

Stormy Traffic (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Explain the purpose of the Spanning Tree Protocol (STP) in a switched LAN environment with redundant switch links.

Instructor Notes:

- Spanning Tree Protocol (STP) and its variations are the focus of this chapter. This modeling activity is designed to help students realize that a switched network can be shaped using STP or its variations.
- This activity can be completed individually, in small groups, or as a class.

Scenario

It is your first day on the job as a network administrator for a small- to medium-sized business. The previous network administrator left suddenly after a network upgrade took place for the business.

During the upgrade, a new switch was added. Since the upgrade, many employees complain that they are having trouble accessing the Internet and servers on your network. In fact, most of them cannot access the network at all. Your corporate manager asks you to immediately research what could be causing these connectivity problems and delays.

So you take a look at the equipment operating on your network at your main distribution facility in the building. You notice that the network topology seems to be visually correct and that cables have been connected correctly, routers and switches are powered on and operational, and switches are connected together to provide backup or redundancy.

However, one thing you do notice is that all of your switches' status lights are constantly blinking at a very fast pace to the point that they almost appear solid. You think you have found the problem with the connectivity issues your employees are experiencing.

Use the Internet to research STP. As you research, take notes and describe:

- Broadcast storm
- Switching loops
- The purpose of STP
- Variations of STP

Complete the reflection questions that accompany the PDF file for this activity. Save your work and be prepared to share your answers with the class.

Resources

- Internet access to the World Wide Web

Reflection

1. What is a definition of a broadcast storm? How does a broadcast storm develop?

A broadcast storm develops when switches forward traffic out of all ports while looking for a destination for the traffic. It develops when switches continuously forward traffic between themselves without time to block interfaces on the switches to create one good path to the destination.

2. What is a definition of a switching loop? What causes a switching loop?

Stormy Traffic

A switching loop forms when redundancy is present on switches and the paths formed create a circle of delivery. Packets travel endlessly along the redundant paths, particularly with multicast and broadcast traffic. This causes a myriad of traffic on the network, causing hosts to have problems accessing the network.

3. How can you mitigate broadcast storms and switching loops caused by introducing redundant switches to your network?

Implement STP or one of its variations. Create VLANs to limit broadcast domains. Check physical connections to make sure that cabling is correct so that switches are not perpetuating broadcasts and routing loops within your network.

4. What is the IEEE standard for STP and some other STP variations, as mentioned in the hyperlinks provided?

802.1D (STP), 802.1W (RSTP), and 802.1I (MST)

5. In answer to this scenario, what would be your first step (after visually checking your network) to correcting the described network problem?

Three answers would be appropriate for this question.

- A network protocol analyzer could be used to check and map network traffic, thus identifying what kind of network problem is present.
- Removing the new switch and its cables to isolate the problem might be a troubleshooting step.
- Checking each switch to make sure that STP is operational is another possible troubleshooting step.

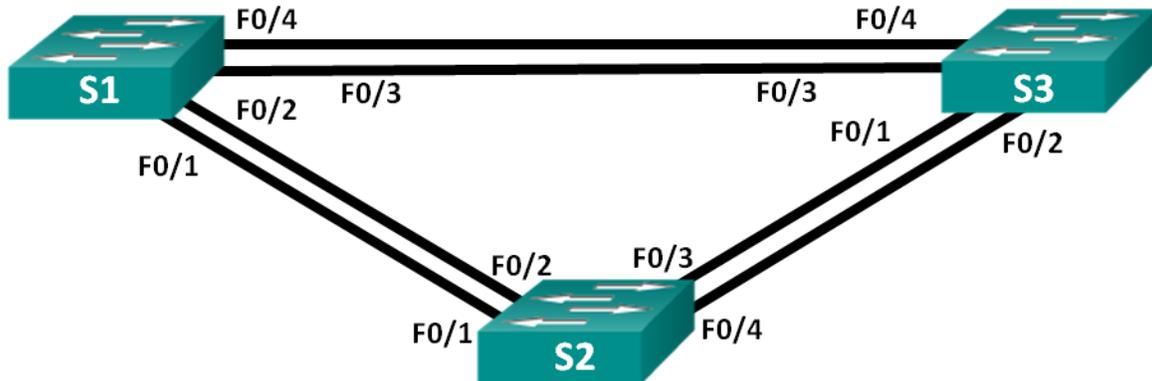
Identify elements of the model that map to IT-related content:

- Spanning Tree Protocol (STP)
- Broadcast storms
- Switching loops
- IEEE STP standards (802.1D, 802.1S, 802.1I)

Lab – Building a Switched Network with Redundant Links (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask
S1	VLAN 1	192.168.1.1	255.255.255.0
S2	VLAN 1	192.168.1.2	255.255.255.0
S3	VLAN 1	192.168.1.3	255.255.255.0

Objectives

- Part 1: Build the Network and Configure Basic Device Settings
- Part 2: Determine the Root Bridge
- Part 3: Observe STP Port Selection Based on Port Cost
- Part 4: Observe STP Port Selection Based on Port Priority

Background / Scenario

Redundancy increases the availability of devices in the network topology by protecting the network from a single point of failure. Redundancy in a switched network is accomplished through the use of multiple switches or multiple links between switches. When physical redundancy is introduced into a network design, loops and duplicate frames can occur.

The Spanning Tree Protocol (STP) was developed as a Layer 2 loop-avoidance mechanism for redundant links in a switched network. STP ensures that there is only one logical path between all destinations on the network by intentionally blocking redundant paths that could cause a loop.

In this lab, you will use the **show spanning-tree** command to observe the STP election process of the root bridge. You will also observe the port selection process based on cost and priority.

Lab – Building a Switched Network with Redundant Links

Note: The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Note: Make sure that the switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings on the switches.

Step 1: Cable the network as shown in the topology.

Attach the devices as shown in the topology diagram, and cable as necessary.

Step 2: Initialize and reload the switches as necessary.

Step 3: Configure basic settings for each switch.

- Disable DNS lookup.
- Configure the device name as shown in the topology.
- Assign **class** as the encrypted privileged EXEC mode password.
- Assign **cisco** as the console and vty passwords and enable login for console and vty lines.
- Configure logging synchronous for the console line.
- Configure a message of the day (MOTD) banner to warn users that unauthorized access is prohibited.
- Configure the IP address listed in the Addressing Table for VLAN 1 on all switches.
- Copy the running configuration to the startup configuration.

Step 4: Test connectivity.

Verify that the switches can ping one another.

Can S1 ping S2? _____ Yes

Can S1 ping S3? _____ Yes

Can S2 ping S3? _____ Yes

Troubleshoot until you are able to answer yes to all questions.

Part 2: Determine the Root Bridge

Every spanning-tree instance (switched LAN or broadcast domain) has a switch designated as the root bridge. The root bridge serves as a reference point for all spanning-tree calculations to determine which redundant paths to block.

Lab – Building a Switched Network with Redundant Links

An election process determines which switch becomes the root bridge. The switch with the lowest bridge identifier (BID) becomes the root bridge. The BID is made up of a bridge priority value, an extended system ID, and the MAC address of the switch. The priority value can range from 0 to 65,535, in increments of 4,096, with a default value of 32,768.

Step 1: Deactivate all ports on the switches.

```
S1(config)# interface range f0/1-24, g0/1-2
S1(config-if-range)# shutdown
S1(config-if-range)# end
```

```
S2(config)# interface range f0/1-24, g0/1-2
S2(config-if-range)# shutdown
S2(config-if-range)# end
```

```
S3(config)# interface range f0/1-24, g0/1-2
S3(config-if-range)# shutdown
S3(config-if-range)# end
```

Step 2: Configure connected ports as trunks.

```
S1(config)# interface range f0/1-4
S1(config-if-range)# switchport mode trunk
S1(config-if-range)# end
```

```
S2(config)# interface range f0/1-4
S2(config-if-range)# switchport mode trunk
S2(config-if-range)# end
```

```
S3(config)# interface range f0/1-4
S3(config-if-range)# switchport mode trunk
S3(config-if-range)# end
```

Step 3: Activate ports F0/2 and F0/4 on all switches.

```
S1(config)# interface range f0/2, f0/4
S1(config-if-range)# no shutdown
S1(config-if-range)# end
```

```
S2(config)# interface range f0/2, f0/4
S2(config-if-range)# no shutdown
S2(config-if-range)# end
```

```
S3(config)# interface range f0/2, f0/4
S3(config-if-range)# no shutdown
S3(config-if-range)# end
```

Step 4: Display spanning tree information.

Issue the **show spanning-tree** command on all three switches. The Bridge ID Priority is calculated by adding the priority value and the extended system ID. The extended system ID is always the VLAN number. In the example below, all three switches have equal Bridge ID Priority values (32769 = 32768 + 1, where default priority = 32768, VLAN number = 1); therefore, the switch with the lowest MAC address becomes the root bridge (S2 in the example).

S1# **show spanning-tree**

VLAN0001

Spanning tree enabled protocol ieee

Root ID Priority 32769
Address 0cd9.96d2.4000
Cost 19
Port 2 (FastEthernet0/2)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 0cd9.96e8.8a00
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec

Interface	Role	Sts	Cost	Prio.Nbr	Type
Fa0/2	Root	FWD	19	128.2	P2p
Fa0/4	Altn	BLK	19	128.4	P2p

S2# **show spanning-tree**

VLAN0001

Spanning tree enabled protocol ieee

Root ID Priority 32769
Address 0cd9.96d2.4000
This bridge is the root
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 0cd9.96d2.4000
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec

Interface	Role	Sts	Cost	Prio.Nbr	Type
Fa0/2	Desg	FWD	19	128.2	P2p
Fa0/4	Desg	FWD	19	128.4	P2p

S3# **show spanning-tree**

VLAN0001

Lab – Building a Switched Network with Redundant Links

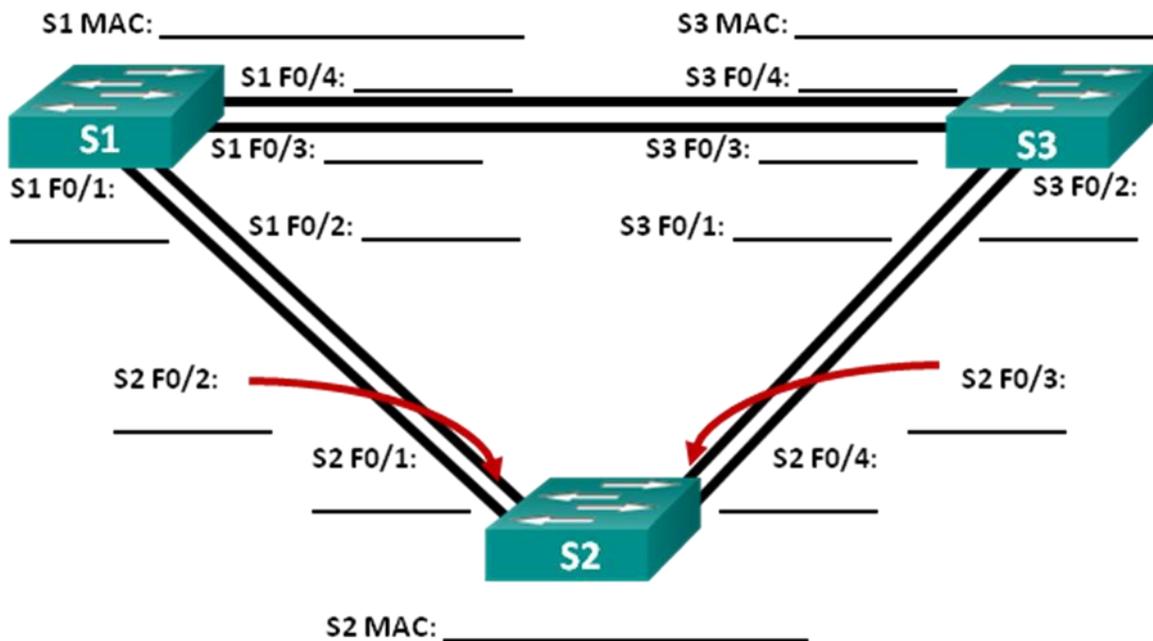
```
Spanning tree enabled protocol ieee
Root ID    Priority    32769
           Address    0cd9.96d2.4000
           Cost      19
           Port      2 (FastEthernet0/2)
           Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Bridge ID Priority    32769 (priority 32768 sys-id-ext 1)
           Address    0cd9.96e8.7400
           Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
           Aging Time 300 sec
```

Interface	Role	Sts	Cost	Prio.Nbr	Type
Fa0/2	Root	FWD	19	128.2	P2p
Fa0/4	Desg	FWD	19	128.4	P2p

Note: The default STP mode on the 2960 switch is Per VLAN Spanning Tree (PVST).

In the diagram below, record the Role and Status (Sts) of the active ports on each switch in the Topology.



Based on the output from your switches, answer the following questions.

Which switch is the root bridge? _____ Answers will vary, the above output shows S2 as the root bridge.

Why did spanning tree select this switch as the root bridge?

The root bridge was chosen because it had the lowest bridge ID (Priority value + extended system ID (VLAN) + MAC address of switch).

Lab – Building a Switched Network with Redundant Links

Which ports are the root ports on the switches? _____ Answers will vary, the above output shows S1 – F0/2, and S3 – F0/2.

Which ports are the designated ports on the switches? _____ Answers will vary, the above output shows S2 – F0/2 and F0/4, S3 – F0/4

What port is showing as an alternate port and is currently being blocked? _____ Answers will vary, the above output shows S1 – F0/4.

Why did spanning tree select this port as the non-designated (blocked) port?

The spanning tree algorithm (STA) uses the root bridge as the reference point and then determines which ports to block based on path cost. If path costs are equal it then compares BIDs. Lower numbers are preferred. In the output above, the link between S1 and S3 has the highest cost to the root bridge. The path cost through both switches is the same, so STA selected the path through the switch with the lower BID, and blocked the port (F0/4) on the switch with the higher BID (S1).

Part 3: Observe STP Port Selection Based on Port Cost

The spanning tree algorithm (STA) uses the root bridge as the reference point and then determines which ports to block, based on path cost. The port with the lower path cost is preferred. If port costs are equal, then spanning tree compares BIDs. If the BIDs are equal, then the port priorities are used to break the tie. Lower values are always preferred. In Part 3, you will change the port cost to control which port is blocked by spanning tree.

Step 1: Locate the switch with the blocked port.

With the current configuration, only one switch should have a port that is blocked by STP. Issue the **show spanning-tree** command on both non-root switches. In the example below, spanning tree is blocking port F0/4 on the switch with the highest BID (S1).

```
S1# show spanning-tree
```

```
VLAN0001
```

```
Spanning tree enabled protocol ieee
```

```
Root ID    Priority    32769
          Address    0cd9.96d2.4000
          Cost        19
          Port        2 (FastEthernet0/2)
          Hello Time  2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
          Address    0cd9.96e8.8a00
          Hello Time  2 sec Max Age 20 sec Forward Delay 15 sec
          Aging Time  300 sec
```

Interface	Role	Sts	Cost	Prio.Nbr	Type
-----	-----	-----	-----	-----	-----
Fa0/2	Root	FWD	19	128.2	P2p
Fa0/4	Altn	BLK	19	128.4	P2p

S3# **show spanning-tree**

```
VLAN0001
Spanning tree enabled protocol ieee
Root ID    Priority    32769
          Address    0cd9.96d2.4000
          Cost      19
          Port      2 (FastEthernet0/2)
          Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec

Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
          Address    0cd9.96e8.7400
          Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec
          Aging Time 15 sec

Interface          Role Sts Cost      Prio.Nbr Type
-----
Fa0/2              Root FWD 19        128.2   P2p
Fa0/4              Desg FWD 19        128.4   P2p
```

Note: Root bridge and port selection may differ in your topology.

Step 2: Change port cost.

In addition to the blocked port, the only other active port on this switch is the port designated as the root port. Lower the cost of this root port to 18 by issuing the **spanning-tree cost 18** interface configuration mode command.

```
S1(config)# interface f0/2
S1(config-if)# spanning-tree cost 18
```

Step 3: Observe spanning tree changes.

Re-issue the **show spanning-tree** command on both non-root switches. Observe that the previously blocked port (S1 - F0/4) is now a designated port and spanning tree is now blocking a port on the other non-root switch (S3 - F0/4).

S1# **show spanning-tree**

```
VLAN0001
Spanning tree enabled protocol ieee
Root ID    Priority    32769
          Address    0cd9.96d2.4000
          Cost      18
          Port      2 (FastEthernet0/2)
          Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec

Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
          Address    0cd9.96e8.8a00
          Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec
          Aging Time 300 sec
```

Lab – Building a Switched Network with Redundant Links

Interface	Role	Sts	Cost	Prio.Nbr	Type
-----	-----	-----	-----	-----	-----
Fa0/2	Root	FWD	18	128.2	P2p
Fa0/4	Desg	FWD	19	128.4	P2p

S3# **show spanning-tree**

VLAN0001

Spanning tree enabled protocol ieee

Root ID Priority 32769
 Address 0cd9.96d2.4000
 Cost 19
 Port 2 (FastEthernet0/2)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
 Address 0cd9.96e8.7400
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec

Interface	Role	Sts	Cost	Prio.Nbr	Type
-----	-----	-----	-----	-----	-----
Fa0/2	Root	FWD	19	128.2	P2p
Fa0/4	Altn	BLK	19	128.4	P2p

Why did spanning tree change the previously blocked port to a designated port, and block the port that was a designated port on the other switch?

STP looks at path cost first. The port with the lower path cost will always be preferred over a port with a higher path cost.

Step 4: Remove port cost changes.

- Issue the **no spanning-tree cost 18** interface configuration mode command to remove the cost statement that you created earlier.

```
S1(config)# interface f0/2
S1(config-if)# no spanning-tree cost 18
```

- Re-issue the **show spanning-tree** command to verify that STP has reset the port on the non-root switches back to the original port settings. It takes approximately 30 seconds for STP to complete the port transition process.

Part 4: Observe STP Port Selection Based on Port Priority

If port costs are equal, then spanning tree compares BIDs. If the BIDs are equal, then the port priorities are used to break the tie. The default port priority value is 128. STP aggregates the port priority with the port number to break ties. Lower values are always preferred. In Part 4, you will activate redundant paths to each switch to observe how STP selects a port using the port priority.

- Activate ports F0/1 and F0/3 on all switches.

```
S1(config)# interface range f0/1, f0/3
```

Lab – Building a Switched Network with Redundant Links

```
S1(config-if-range)# no shutdown
S1(config-if-range)# end
```

```
S2(config)# interface range f0/1, f0/3
S2(config-if-range)# no shutdown
S2(config-if-range)# end
```

```
S3(config)# interface range f0/1, f0/3
S3(config-if-range)# no shutdown
S3(config-if-range)# end
```

- b. Wait 30 seconds for STP to complete the port transition process, and then issue the **show spanning-tree** command on the non-root switches. Observe that the root port has moved to the lower numbered port linked to the root switch, and blocked the previous root port.

```
S1# show spanning-tree
```

```
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32769
             Address     0cd9.96d2.4000
             Cost        19
             Port        1 (FastEthernet0/1)
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
             Address     0cd9.96e8.8a00
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  15 sec

Interface                Role Sts Cost      Prio.Nbr Type
-----
Fa0/1                    Root FWD 19        128.1   P2p
Fa0/2                    Altn BLK 19        128.2   P2p
Fa0/3                    Altn BLK 19        128.3   P2p
Fa0/4                    Altn BLK 19        128.4   P2p
```

```
S3# show spanning-tree
```

```
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32769
             Address     0cd9.96d2.4000
             Cost        19
             Port        1 (FastEthernet0/1)
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
             Address     0cd9.96e8.7400
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
```

Lab – Building a Switched Network with Redundant Links

Aging Time 15 sec

Interface	Role	Sts	Cost	Prio.Nbr	Type
Fa0/1	Root	FWD	19	128.1	P2p
Fa0/2	Altn	BLK	19	128.2	P2p
Fa0/3	Desg	FWD	19	128.3	P2p
Fa0/4	Desg	FWD	19	128.4	P2p

What port did STP select as the root port on each non-root switch? _____

Answers will vary, but in the example above S1 – F0/1, and S3 – F0/1.

Why did STP select these ports as the root port on these switches?

The default port value of the ports is 128; therefore, STP used the port number to break the tie. It selected the lower port number as the root port, and blocked the higher-numbered port with the redundant path to the root bridge.

Reflection

1. After a root bridge has been selected, what is the first value STP uses to determine port selection?

Path cost. It selects the path with the lower accumulated cost.

2. If the first value is equal on the two ports, what is the next value that STP uses to determine port selection?

BID by selecting the lower value.

3. If both values are equal on the two ports, what is the next value that STP uses to determine port selection?

An aggregation of the port priority and the port number, the lower value is preferred.

Device Configs - Final

Switch S1

```
S1# show run
Building configuration...

Current configuration : 1829 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
```

Lab – Building a Switched Network with Redundant Links

```
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
  switchport mode trunk
!
interface FastEthernet0/2
  switchport mode trunk
!
interface FastEthernet0/3
  switchport mode trunk
!
interface FastEthernet0/4
  switchport mode trunk
!
interface FastEthernet0/5
  shutdown
!
interface FastEthernet0/6
  shutdown
!
interface FastEthernet0/7
  shutdown
!
interface FastEthernet0/8
  shutdown
!
interface FastEthernet0/9
  shutdown
!
interface FastEthernet0/10
  shutdown
!
interface FastEthernet0/11
  shutdown
!
interface FastEthernet0/12
```

Lab – Building a Switched Network with Redundant Links

```
shutdown
!  
interface FastEthernet0/13
shutdown
!  
interface FastEthernet0/14
shutdown
!  
interface FastEthernet0/15
shutdown
!  
interface FastEthernet0/16
shutdown
!  
interface FastEthernet0/17
shutdown
!  
interface FastEthernet0/18
shutdown
!  
interface FastEthernet0/19
shutdown
!  
interface FastEthernet0/20
shutdown
!  
interface FastEthernet0/21
shutdown
!  
interface FastEthernet0/22
shutdown
!  
interface FastEthernet0/23
shutdown
!  
interface FastEthernet0/24
shutdown
!  
interface GigabitEthernet0/1
shutdown
!  
interface GigabitEthernet0/2
shutdown
!  
interface Vlan1
ip address 192.168.1.1 255.255.255.0
!  
ip http server
ip http secure-server
```

Lab – Building a Switched Network with Redundant Links

```
!  
!  
banner motd ^C Unauthorized Access is Prohibited! ^C  
!  
line con 0  
password cisco  
logging synchronous  
login  
line vty 0 4  
password cisco  
login  
line vty 5 15  
password cisco  
login  
!  
end
```

Switch S2

```
S2# show run  
Building configuration...  
  
Current configuration : 1827 bytes  
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname S2  
!  
boot-start-marker  
boot-end-marker  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
system mtu routing 1500  
!  
no ip domain-lookup  
!  
spanning-tree mode pvst  
spanning-tree extend system-id  
!  
vlan internal allocation policy ascending  
!  
interface FastEthernet0/1  
switchport mode trunk  
!
```

Lab – Building a Switched Network with Redundant Links

```
interface FastEthernet0/2
  switchport mode trunk
!
interface FastEthernet0/3
  switchport mode trunk
!
interface FastEthernet0/4
  switchport mode trunk
!
interface FastEthernet0/5
  shutdown
!
interface FastEthernet0/6
  shutdown
!
interface FastEthernet0/7
  shutdown
!
interface FastEthernet0/8
  shutdown
!
interface FastEthernet0/9
  shutdown
!
interface FastEthernet0/10
  shutdown
!
interface FastEthernet0/11
  shutdown
!
interface FastEthernet0/12
  shutdown
!
interface FastEthernet0/13
  shutdown
!
interface FastEthernet0/14
  shutdown
!
interface FastEthernet0/15
  shutdown
!
interface FastEthernet0/16
  shutdown
!
interface FastEthernet0/17
  shutdown
!
interface FastEthernet0/18
```

Lab – Building a Switched Network with Redundant Links

```
shutdown
!  
interface FastEthernet0/19
shutdown
!  
interface FastEthernet0/20
shutdown
!  
interface FastEthernet0/21
shutdown
!  
interface FastEthernet0/22
shutdown
!  
interface FastEthernet0/23
shutdown
!  
interface FastEthernet0/24
shutdown
!  
interface GigabitEthernet0/1
shutdown
!  
interface GigabitEthernet0/2
shutdown
!  
interface Vlan1
ip address 192.168.1.2 255.255.255.0
!  
ip http server
ip http secure-server
!  
banner motd ^C Unauthorized Access is Prohibited! ^C
!  
line con 0
password cisco
logging synchronous
login
line vty 0 4
password cisco
login
line vty 5 15
password cisco
login
!  
end
```

Switch S3

```
S3# show run
```

Lab – Building a Switched Network with Redundant Links

Building configuration...

Current configuration : 1829 bytes

```
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname S3  
!  
boot-start-marker  
boot-end-marker  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
system mtu routing 1500  
!  
!  
no ip domain-lookup  
!  
spanning-tree mode pvst  
spanning-tree extend system-id  
!  
vlan internal allocation policy ascending  
!  
interface FastEthernet0/1  
  switchport mode trunk  
!  
interface FastEthernet0/2  
  switchport mode trunk  
!  
interface FastEthernet0/3  
  switchport mode trunk  
!  
interface FastEthernet0/4  
  switchport mode trunk  
!  
interface FastEthernet0/5  
  shutdown  
!  
interface FastEthernet0/6  
  shutdown  
!  
interface FastEthernet0/7  
  shutdown  
!
```

Lab – Building a Switched Network with Redundant Links

```
interface FastEthernet0/8
shutdown
!
interface FastEthernet0/9
shutdown
!
interface FastEthernet0/10
shutdown
!
interface FastEthernet0/11
shutdown
!
interface FastEthernet0/12
shutdown
!
interface FastEthernet0/13
shutdown
!
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
shutdown
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
```

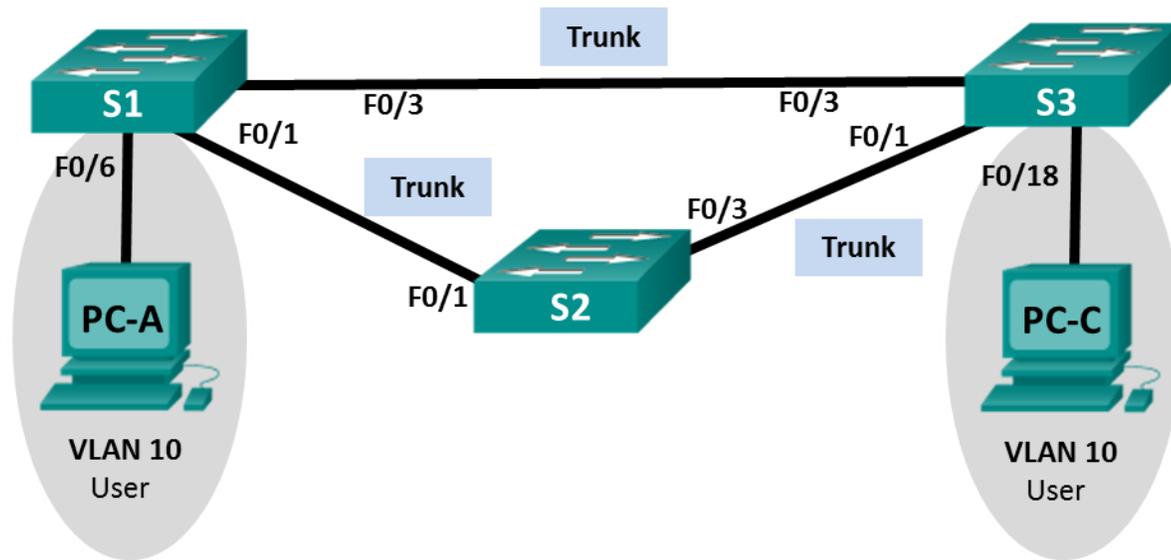
Lab – Building a Switched Network with Redundant Links

```
shutdown
!  
interface GigabitEthernet0/1  
shutdown  
!  
interface GigabitEthernet0/2  
shutdown  
!  
interface Vlan1  
ip address 192.168.1.3 255.255.255.0  
!  
ip http server  
ip http secure-server  
!  
banner motd ^C Unauthorized Access is Prohibited! ^C  
!  
line con 0  
password cisco  
logging synchronous  
login  
line vty 0 4  
password cisco  
login  
line vty 5 15  
password cisco  
login  
!  
end
```

Lab – Configuring Rapid PVST+, PortFast, and BPDU Guard (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask
S1	VLAN 99	192.168.1.11	255.255.255.0
S2	VLAN 99	192.168.1.12	255.255.255.0
S3	VLAN 99	192.168.1.13	255.255.255.0
PC-A	NIC	192.168.0.2	255.255.255.0
PC-C	NIC	192.168.0.3	255.255.255.0

VLAN Assignments

VLAN	Name
10	User
99	Management

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure VLANs, Native VLAN, and Trunks

Part 3: Configure the Root Bridge and Examine PVST+ Convergence

Part 4: Configure Rapid PVST+, PortFast, BPDU Guard, and Examine Convergence

Background / Scenario

The Per-VLAN Spanning Tree (PVST) protocol is Cisco proprietary. Cisco switches default to PVST. Rapid PVST+ (IEEE 802.1w) is an enhanced version of PVST+ and allows for faster spanning-tree calculations and convergence in response to Layer 2 topology changes. Rapid PVST+ defines three port states: discarding, learning, and forwarding, and provides multiple enhancements to optimize network performance.

In this lab, you will configure the primary and secondary root bridge, examine PVST+ convergence, configure Rapid PVST+ and compare its convergence to PVST+. In addition, you will configure edge ports to transition immediately to a forwarding state using PortFast and prevent the edge ports from forwarding BDPUs using BPDU guard.

Note: This lab provides minimal assistance with the actual commands necessary for configuration. However, the required commands are provided in Appendix A. Test your knowledge by trying to configure the devices without referring to the appendix.

Note: The switches used with CCNA hands-on labs are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Note: Make sure that the switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings, such as the interface IP addresses, device access, and passwords.

Step 1: Cable the network as shown in the topology.

Step 2: Configure PC hosts.

Step 3: Initialize and reload the switches as necessary.

Step 4: Configure basic settings for each switch.

- a. Disable DNS lookup.
- b. Configure the device name as shown in the Topology.
- c. Assign **cisco** as the console and vty passwords and enable login.
- d. Assign **class** as the encrypted privileged EXEC mode password.
- e. Configure **logging synchronous** to prevent console messages from interrupting command entry.
- f. Shut down all switch ports.

- g. Copy the running configuration to startup configuration.

Part 2: Configure VLANs, Native VLAN, and Trunks

In Part 2, you will create VLANs, assign switch ports to VLANs, configure trunk ports, and change the native VLAN for all switches.

Note: The required commands for Part 2 are provided in Appendix A. Test your knowledge by trying to configure the VLANs, native VLAN, and trunks without referring to the appendix.

Step 1: Create VLANs.

Use the appropriate commands to create VLANs 10 and 99 on all of the switches. Name VLAN 10 as **User** and VLAN 99 as **Management**.

```
S1(config)# vlan 10
S1(config-vlan)# name User
S1(config-vlan)# vlan 99
S1(config-vlan)# name Management
```

```
S2(config)# vlan 10
S2(config-vlan)# name User
S2(config-vlan)# vlan 99
S2(config-vlan)# name Management
```

```
S3(config)# vlan 10
S3(config-vlan)# name User
S3(config-vlan)# vlan 99
S3(config-vlan)# name Management
```

Step 2: Enable user ports in access mode and assign VLANs.

For S1 F0/6 and S3 F0/18, enable the ports, configure them as access ports, and assign them to VLAN 10.

```
S1(config)# interface f0/6
S1(config-if)# no shutdown
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 10
```

```
S3(config)# interface f0/18
S3(config-if)# no shutdown
S3(config-if)# switchport mode access
S3(config-if)# switchport access vlan 10
```

Step 3: Configure trunk ports and assign to native VLAN 99.

For ports F0/1 and F0/3 on all switches, enable the ports, configure them as trunk ports, and assign them to native VLAN 99.

```
S1(config)# interface range f0/1,f0/3
S1(config-if)# no shutdown
S1(config-if)# switchport mode trunk
```

```
S1(config-if)# switchport trunk native vlan 99
```

```
S2(config)# interface range f0/1,f0/3
```

```
S2(config-if)# no shutdown
```

```
S2(config-if)# switchport mode trunk
```

```
S2(config-if)# switchport trunk native vlan 99
```

```
S3(config)# interface range f0/1,f0/3
```

```
S3(config-if)# no shutdown
```

```
S3(config-if)# switchport mode trunk
```

```
S3(config-if)# switchport trunk native vlan 99
```

Step 4: Configure the management interface on all switches.

Using the Addressing Table, configure the management interface on all switches with the appropriate IP address.

```
S1(config)# interface vlan 99
```

```
S1(config-if)# ip address 192.168.1.11 255.255.255.0
```

```
S2(config)# interface vlan 99
```

```
S2(config-if)# ip address 192.168.1.12 255.255.255.0
```

```
S3(config)# interface vlan 99
```

```
S3(config-if)# ip address 192.168.1.13 255.255.255.0
```

Step 5: Verify configurations and connectivity.

Use the **show vlan brief** command on all switches to verify that all VLANs are registered in the VLAN table and that the correct ports are assigned.

```
S1# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/2, Fa0/4, Fa0/5, Fa0/7 Fa0/8, Fa0/9, Fa0/10, Fa0/11 Fa0/12, Fa0/13, Fa0/14, Fa0/15 Fa0/16, Fa0/17, Fa0/18, Fa0/19 Fa0/20, Fa0/21, Fa0/22, Fa0/23 Fa0/24, Gi0/1, Gi0/2
10 User	active	Fa0/6
99 Management	active	
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

```
S2# show vlan brief
```

Lab – Configuring Rapid PVST+, PortFast, and BPDU Guard

```
VLAN Name                Status    Ports
-----
1    default                active   Fa0/2, Fa0/4, Fa0/5, Fa0/6
                                         Fa0/7, Fa0/8, Fa0/9, Fa0/10
                                         Fa0/11, Fa0/12, Fa0/13, Fa0/14
                                         Fa0/15, Fa0/16, Fa0/17, Fa0/18
                                         Fa0/19, Fa0/20, Fa0/21, Fa0/22
                                         Fa0/23, Fa0/24, Gi0/1, Gi0/2

10   User                    active
99   Management              active
1002 fddi-default            act/unsup
1003 token-ring-default    act/unsup
1004 fddinet-default        act/unsup
1005 trnet-default          act/unsup
```

S3# **show vlan brief**

```
VLAN Name                Status    Ports
-----
1    default                active   Fa0/2, Fa0/4, Fa0/5, Fa0/6
                                         Fa0/7, Fa0/8, Fa0/9, Fa0/10
                                         Fa0/11, Fa0/12, Fa0/13, Fa0/14
                                         Fa0/15, Fa0/16, Fa0/17, Fa0/19
                                         Fa0/20, Fa0/21, Fa0/22, Fa0/23
                                         Fa0/24, Gi0/1, Gi0/2

10   User                    active   Fa0/18
99   Management              active
1002 fddi-default            act/unsup
1003 token-ring-default    act/unsup
1004 fddinet-default        act/unsup
1005 trnet-default          act/unsup
```

Use the **show interfaces trunk** command on all switches to verify trunk interfaces.

S1# **show interfaces trunk**

```
Port      Mode      Encapsulation  Status      Native vlan
Fa0/1     on        802.1q         trunking    99
Fa0/3     on        802.1q         trunking    99
```

```
Port      Vlans allowed on trunk
Fa0/1     1-4094
Fa0/3     1-4094
```

```
Port      Vlans allowed and active in management domain
Fa0/1     1,10,99
Fa0/3     1,10,99
```

```
Port      Vlans in spanning tree forwarding state and not pruned
```

Lab – Configuring Rapid PVST+, PortFast, and BPDU Guard

```
Fa0/1    none
Fa0/3    1,10,99
```

```
S2# show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	99
Fa0/3	on	802.1q	trunking	99

Port	Vlans allowed on trunk
Fa0/1	1-4094
Fa0/3	1-4094

Port	Vlans allowed and active in management domain
Fa0/1	1,10,99
Fa0/3	1,10,99

Port	Vlans in spanning tree forwarding state and not pruned
Fa0/1	1,10,99
Fa0/3	1,10,99

```
S3# show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	99
Fa0/3	on	802.1q	trunking	99

Port	Vlans allowed on trunk
Fa0/1	1-4094
Fa0/3	1-4094

Port	Vlans allowed and active in management domain
Fa0/1	1,10,99
Fa0/3	1,10,99

Port	Vlans in spanning tree forwarding state and not pruned
Fa0/1	1,10,99
Fa0/3	1,10,99

Use the **show running-config** command on all switches to verify all other configurations.

```
S1# show running-config
```

```
Building configuration...
```

```
Current configuration : 1857 bytes
```

```
!
```

```
version 15.0
```

```
no service pad
```

```
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
  switchport trunk native vlan 99
  switchport mode trunk
!
interface FastEthernet0/2
  shutdown
!
interface FastEthernet0/3
  switchport trunk native vlan 99
  switchport mode trunk
!
interface FastEthernet0/4
  shutdown
!
interface FastEthernet0/5
  shutdown
!
interface FastEthernet0/6
  switchport access vlan 10
  switchport mode access
!
interface FastEthernet0/7
  shutdown
!
```

```
interface FastEthernet0/8
  shutdown
!
interface FastEthernet0/9
  shutdown
!
interface FastEthernet0/10
  shutdown
!
interface FastEthernet0/11
  shutdown
!
interface FastEthernet0/12
  shutdown
!
interface FastEthernet0/13
  shutdown
!
interface FastEthernet0/14
  shutdown
!
interface FastEthernet0/15
  shutdown
!
interface FastEthernet0/16
  shutdown
!
interface FastEthernet0/17
  shutdown
!
interface FastEthernet0/18
  shutdown
!
interface FastEthernet0/19
  shutdown
!
interface FastEthernet0/20
  shutdown
!
interface FastEthernet0/21
  shutdown
!
interface FastEthernet0/22
  shutdown
!
```

```
interface FastEthernet0/23
  shutdown
!
interface FastEthernet0/24
  shutdown
!
interface GigabitEthernet0/1
  shutdown
!
interface GigabitEthernet0/2
  shutdown
!
interface Vlan1
  no ip address
!
interface Vlan99
  ip address 192.168.1.11 255.255.255.0
!
ip http server
ip http secure-server
!
line con 0
  password cisco
  logging synchronous
  login
line vty 0 4
  password cisco
  login
line vty 5 15
  password cisco
  login
!
end
```

What is the default setting for spanning-tree mode on Cisco switches?

The default spanning-tree mode is PVST+.

Verify connectivity between PC-A and PC-C. Was your ping successful? _____ Yes.

If your ping was unsuccessful, troubleshoot the configurations until the issue is resolved.

Note: It may be necessary to disable the PC firewall to successfully ping between PCs.

Part 3: Configure the Root Bridge and Examine PVST+ Convergence

In Part 3, you will determine the default root in the network, assign the primary and secondary root, and use the **debug** command to examine convergence of PVST+.

Lab – Configuring Rapid PVST+, PortFast, and BPDU Guard

Note: The required commands for Part 3 are provided in Appendix A. Test your knowledge by trying to configure the root bridge without referring to the appendix.

Step 1: Determine the current root bridge.

Which command allows a user to determine the spanning-tree status of a Cisco Catalyst switch for all VLANs? Write the command in the space provided.

show spanning-tree

Use the command on all three switches to determine the answers to the following questions:

Note: There are three instances of the spanning tree on each switch. The default STP configuration on Cisco switches is PVST+, which creates a separate spanning tree instance for each VLAN (VLAN 1 and any user-configured VLANs).

What is the bridge priority of switch S1 for VLAN 1? _____ 32769

What is the bridge priority of switch S2 for VLAN 1? _____ 32769

What is the bridge priority of switch S3 for VLAN 1? _____ 32769

Which switch is the root bridge? _____ Answers will vary. In this configuration, it is switch S3.

Why was this switch elected as the root bridge?

By default, spanning tree elects the root bridge based on lowest MAC address.

```
S1# show spanning-tree
```

```
VLAN0001
```

```
Spanning tree enabled protocol ieee
```

```
Root ID    Priority    32769
Address    0cd9.96d2.5100
Cost       19
Port       3 (FastEthernet0/3)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
Address    0cd9.96e2.3d80
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec
```

```
Interface          Role Sts Cost          Prio.Nbr Type
-----
Fa0/1              Desg FWD 19           128.1   P2p
Fa0/3              Root FWD 19           128.3   P2p
```

```
VLAN0010
```

```
Spanning tree enabled protocol ieee
```

```
Root ID    Priority    32778
Address    0cd9.96d2.5100
Cost       19
Port       3 (FastEthernet0/3)
```

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```

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32778 (priority 32768 sys-id-ext 10)
Address 0cd9.96e2.3d80
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec

Interface Role Sts Cost Prio.Nbr Type
-----
Fa0/1 Desg FWD 19 128.1 P2p
Fa0/3 Root FWD 19 128.3 P2p
Fa0/6 Desg FWD 19 128.6 P2p

VLAN0099
Spanning tree enabled protocol ieee
Root ID Priority 32867
Address 0cd9.96d2.5100
Cost 19
Port 3 (FastEthernet0/3)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32867 (priority 32768 sys-id-ext 99)
Address 0cd9.96e2.3d80
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec

Interface Role Sts Cost Prio.Nbr Type
-----
Fa0/1 Desg FWD 19 128.1 P2p
Fa0/3 Root FWD 19 128.3 P2p

S2# show spanning-tree

VLAN0001
Spanning tree enabled protocol ieee
Root ID Priority 32769
Address 0cd9.96d2.5100
Cost 19
Port 3 (FastEthernet0/3)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 0cd9.96e8.6f80
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec

Interface Role Sts Cost Prio.Nbr Type
-----
Fa0/1 Altn BLK 19 128.1 P2p
```

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```
Fa0/3          Root FWD 19      128.3    P2p
```

VLAN0010

```
Spanning tree enabled protocol ieee
```

```
Root ID      Priority    32778
Address      0cd9.96d2.5100
Cost         19
Port         3 (FastEthernet0/3)
Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Bridge ID    Priority    32778 (priority 32768 sys-id-ext 10)
Address      0cd9.96e8.6f80
Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time   300 sec
```

Interface	Role	Sts	Cost	Prio.Nbr	Type
Fa0/1	Altn	BLK	19	128.1	P2p
Fa0/3	Root	FWD	19	128.3	P2p

VLAN0099

```
Spanning tree enabled protocol ieee
```

```
Root ID      Priority    32867
Address      0cd9.96d2.5100
Cost         19
Port         3 (FastEthernet0/3)
Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Bridge ID    Priority    32867 (priority 32768 sys-id-ext 99)
Address      0cd9.96e8.6f80
Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time   300 sec
```

Interface	Role	Sts	Cost	Prio.Nbr	Type
Fa0/1	Altn	BLK	19	128.1	P2p
Fa0/3	Root	FWD	19	128.3	P2p

```
S3# show spanning-tree
```

VLAN0001

```
Spanning tree enabled protocol ieee
```

```
Root ID      Priority    32769
Address      0cd9.96d2.5100
This bridge is the root
Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Bridge ID    Priority    32769 (priority 32768 sys-id-ext 1)
Address      0cd9.96d2.5100
```

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```
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec
```

Interface	Role	Sts	Cost	Prio.Nbr	Type
-----	-----	---	-----	-----	-----
Fa0/1	Desg	FWD	19	128.1	P2p
Fa0/3	Desg	FWD	19	128.3	P2p

VLAN0010

```
Spanning tree enabled protocol ieee
```

```
Root ID Priority 32778
Address 0cd9.96d2.5100
```

```
This bridge is the root
```

```
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Bridge ID Priority 32778 (priority 32768 sys-id-ext 10)
```

```
Address 0cd9.96d2.5100
```

```
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Aging Time 300 sec
```

Interface	Role	Sts	Cost	Prio.Nbr	Type
-----	-----	---	-----	-----	-----
Fa0/1	Desg	FWD	19	128.1	P2p
Fa0/3	Desg	FWD	19	128.3	P2p
Fa0/18	Desg	FWD	19	128.18	P2p

VLAN0099

```
Spanning tree enabled protocol ieee
```

```
Root ID Priority 32867
Address 0cd9.96d2.5100
```

```
This bridge is the root
```

```
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Bridge ID Priority 32867 (priority 32768 sys-id-ext 99)
```

```
Address 0cd9.96d2.5100
```

```
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Aging Time 300 sec
```

Interface	Role	Sts	Cost	Prio.Nbr	Type
-----	-----	---	-----	-----	-----
Fa0/1	Desg	FWD	19	128.1	P2p
Fa0/3	Desg	FWD	19	128.3	P2p

Step 2: Configure a primary and secondary root bridge for all existing VLANs.

Having a root bridge (switch) elected by MAC address may lead to a suboptimal configuration. In this lab, you will configure switch S2 as the root bridge and S1 as the secondary root bridge.

- Configure switch S2 to be the primary root bridge for all existing VLANs. Write the command in the space provided.

```
S2(config)# spanning-tree vlan 1,10,99 root primary
```

- b. Configure switch S1 to be the secondary root bridge for all existing VLANs. Write the command in the space provided.

```
S1(config)# spanning-tree vlan 1,10,99 root secondary
```

Use the **show spanning-tree** command to answer the following questions:

What is the bridge priority of S1 for VLAN 1? _____ **28673**

What is the bridge priority of S2 for VLAN 1? _____ **24577**

Which interface in the network is in a blocking state? _____

Interface F0/3 on switch S3

```
S1# show spanning-tree vlan 1
```

```
VLAN0001
```

```
Spanning tree enabled protocol ieee
```

```
Root ID      Priority      24577
Address      0cd9.96d2.4000
Cost         19
Port         1 (FastEthernet0/1)
Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
```

```
Bridge ID    Priority      28673 (priority 28672 sys-id-ext 1)
Address      0cd9.96e8.8a00
Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
Aging Time   15 sec
```

Interface	Role	Sts	Cost	Prio.Nbr	Type
Fa0/1	Root	FWD	19	128.1	P2p
Fa0/3	Desg	FWD	19	128.3	P2p

```
S2# show spanning-tree vlan 1
```

```
VLAN0001
```

```
Spanning tree enabled protocol ieee
```

```
Root ID      Priority      24577
Address      0cd9.96d2.4000
This bridge is the root
Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
```

```
Bridge ID    Priority      24577 (priority 24576 sys-id-ext 1)
Address      0cd9.96d2.4000
Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
Aging Time   15 sec
```

Interface	Role	Sts	Cost	Prio.Nbr	Type
-----------	------	-----	------	----------	------

```
-----  
Fa0/1          Desg FWD 19          128.1    P2p  
Fa0/3          Desg FWD 19          128.3    P2p
```

S3# **show spanning-tree vlan 1**

VLAN0001

Spanning tree enabled protocol ieee

```
Root ID      Priority    24577  
            Address    0cd9.96d2.4000  
            Cost        19  
            Port        1 (FastEthernet0/1)  
            Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
```

```
Bridge ID    Priority    32769 (priority 32768 sys-id-ext 1)  
            Address    0cd9.96e8.7400  
            Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec  
            Aging Time  300 sec
```

```
Interface          Role Sts Cost          Prio.Nbr Type  
-----  
Fa0/1              Root FWD 19          128.1    P2p  
Fa0/3              Altn BLK 19          128.3    P2p
```

Step 3: Change the Layer 2 topology and examine convergence.

To examine PVST+ convergence, you will create a Layer 2 topology change while using the **debug** command to monitor spanning-tree events.

- Enter the **debug spanning-tree events** command in privileged EXEC mode on switch S3.

```
S3# debug spanning-tree events
```

Spanning Tree event debugging is on

- Create a topology change by disabling interface F0/1 on S3.

```
S3(config)# interface f0/1
```

```
S3(config-if)# shutdown
```

```
*Mar 1 00:58:56.225: STP: VLAN0001 new root port Fa0/3, cost 38
```

```
*Mar 1 00:58:56.225: STP: VLAN0001 Fa0/3 -> listening
```

```
*Mar 1 00:58:56.225: STP[1]: Generating TC trap for port FastEthernet0/1
```

```
*Mar 1 00:58:56.225: STP: VLAN0010 new root port Fa0/3, cost 38
```

```
*Mar 1 00:58:56.225: STP: VLAN0010 Fa0/3 -> listening
```

```
*Mar 1 00:58:56.225: STP[10]: Generating TC trap for port FastEthernet0/1
```

```
*Mar 1 00:58:56.225: STP: VLAN0099 new root port Fa0/3, cost 38
```

```
*Mar 1 00:58:56.225: STP: VLAN0099 Fa0/3 -> listening
```

```
*Mar 1 00:58:56.225: STP[99]: Generating TC trap for port FastEthernet0/1
```

```
*Mar 1 00:58:56.242: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed state to down
```

```
*Mar 1 00:58:56.242: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan99, changed state to down
```

```
*Mar 1 00:58:58.214: %LINK-5-CHANGED: Interface FastEthernet0/1, changed state to administratively down
```

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```
*Mar 1 00:58:58.230: STP: VLAN0001 sent Topology Change Notice on Fa0/3
*Mar 1 00:58:58.230: STP: VLAN0010 sent Topology Change Notice on Fa0/3
*Mar 1 00:58:58.230: STP: VLAN0099 sent Topology Change Notice on Fa0/3
*Mar 1 00:58:59.220: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1,
changed state to down
*Mar 1 00:59:11.233: STP: VLAN0001 Fa0/3 -> learning
*Mar 1 00:59:11.233: STP: VLAN0010 Fa0/3 -> learning
*Mar 1 00:59:11.233: STP: VLAN0099 Fa0/3 -> learning
*Mar 1 00:59:26.240: STP[1]: Generating TC trap for port FastEthernet0/3
*Mar 1 00:59:26.240: STP: VLAN0001 Fa0/3 -> forwarding
*Mar 1 00:59:26.240: STP[10]: Generating TC trap for port FastEthernet0/3
*Mar 1 00:59:26.240: STP: VLAN0010 sent Topology Change Notice on Fa0/3
*Mar 1 00:59:26.240: STP: VLAN0010 Fa0/3 -> forwarding
*Mar 1 00:59:26.240: STP[99]: Generating TC trap for port FastEthernet0/3
*Mar 1 00:59:26.240: STP: VLAN0099 Fa0/3 -> forwarding
*Mar 1 00:59:26.248: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed
state to up
*Mar 1 00:59:26.248: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan99, changed
state to up
```

Note: Before proceeding, use the **debug** output to verify that all VLANs on F0/3 have reached a forwarding state then use the command **no debug spanning-tree events** to stop the **debug** output.

Through which port states do each VLAN on F0/3 proceed during network convergence?

Listening, learning, and forwarding

Using the time stamp from the first and last STP debug message, calculate the time (to the nearest second) that it took for the network to converge. **Hint:** The debug timestamp format is date hh.mm.ss:msec.

Answers may vary slightly but convergence time should be approximately 30 seconds.

Part 4: Configure Rapid PVST+, PortFast, BPDU Guard, and Examine Convergence

In Part 4, you will configure Rapid PVST+ on all switches. You will configure PortFast and BPDU guard on all access ports, and then use the **debug** command to examine Rapid PVST+ convergence.

Note: The required commands for Part 4 are provided in Appendix A. Test your knowledge by trying to configure the Rapid PVST+, PortFast, and BPDU guard without referring to the appendix.

Step 1: Configure Rapid PVST+.

- Configure S1 for Rapid PVST+. Write the command in the space provided.

```
S1(config)# spanning-tree mode rapid-pvst
```

- Configure S2 and S3 for Rapid PVST+.

```
S2(config)# spanning-tree mode rapid-pvst
```

```
S3(config)# spanning-tree mode rapid-pvst
```

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- c. Verify configurations with the **show running-config | include spanning-tree mode** command.

```
S1# show running-config | include spanning-tree mode
spanning-tree mode rapid-pvst
```

```
S2# show running-config | include spanning-tree mode
spanning-tree mode rapid-pvst
```

```
S3# show running-config | include spanning-tree mode
spanning-tree mode rapid-pvst
```

Step 2: Configure PortFast and BPDU Guard on access ports.

PortFast is a feature of spanning tree that transitions a port immediately to a forwarding state as soon as it is turned on. This is useful in connecting hosts so that they can start communicating on the VLAN instantly, rather than waiting on spanning tree. To prevent ports that are configured with PortFast from forwarding BPDUs, which could change the spanning tree topology, BPDU guard can be enabled. At the receipt of a BPDU, BPDU guard disables a port configured with PortFast.

- a. Configure interface F0/6 on S1 with PortFast. Write the command in the space provided.

```
S1(config)# interface f0/6
S1(config-if)# spanning-tree portfast
```

- b. Configure interface F0/6 on S1 with BPDU guard. Write the command in the space provided.

```
S1(config)# interface f0/6
S1(config-if)# spanning-tree bpduguard enable
```

- c. Globally configure all non-trunking ports on switch S3 with PortFast. Write the command in the space provided.

```
S3(config)# spanning-tree portfast default
```

- d. Globally configure all non-trunking PortFast ports on switch S3 with BPDU guard. Write the command in the space provided.

```
S3(config)# spanning-tree portfast bpduguard default
```

Step 3: Examine Rapid PVST+ convergence.

- a. Enter the **debug spanning-tree events** command in privileged EXEC mode on switch S3.

- b. Create a topology change by enabling interface F0/1 on switch S3.

```
S3(config)# interface f0/1
S3(config-if)# no shutdown
*Mar  1 01:28:34.946: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Mar  1 01:28:37.588: RSTP(1): initializing port Fa0/1
*Mar  1 01:28:37.588: RSTP(1): Fa0/1 is now designated
*Mar  1 01:28:37.588: RSTP(10): initializing port Fa0/1
*Mar  1 01:28:37.588: RSTP(10): Fa0/1 is now designated
```

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```
*Mar 1 01:28:37.588: RSTP(99): initializing port Fa0/1
*Mar 1 01:28:37.588: RSTP(99): Fa0/1 is now designated
*Mar 1 01:28:37.597: RSTP(1): transmitting a proposal on Fa0/1
*Mar 1 01:28:37.597: RSTP(10): transmitting a proposal on Fa0/1
*Mar 1 01:28:37.597: RSTP(99): transmitting a proposal on Fa0/1
*Mar 1 01:28:37.597: RSTP(1): updt roles, received superior bpdu on Fa0/1
*Mar 1 01:28:37.597: RSTP(1): Fa0/1 is now root port
*Mar 1 01:28:37.597: RSTP(1): Fa0/3 blocked by re-root
*Mar 1 01:28:37.597: RSTP(1): synced Fa0/1
*Mar 1 01:28:37.597: RSTP(1): Fa0/3 is now alternate
*Mar 1 01:28:37.597: RSTP(10): updt roles, received superior bpdu on Fa0/1
*Mar 1 01:28:37.597: RSTP(10): Fa0/1 is now root port
*Mar 1 01:28:37.597: RSTP(10): Fa0/3 blocked by re-root
*Mar 1 01:28:37.597: RSTP(10): synced Fa0/1
*Mar 1 01:28:37.597: RSTP(10): Fa0/3 is now alternate
*Mar 1 01:28:37.597: RSTP(99): updt roles, received superior bpdu on Fa0/1
*Mar 1 01:28:37.605: RSTP(99): Fa0/1 is now root port
*Mar 1 01:28:37.605: RSTP(99): Fa0/3 blocked by re-root
*Mar 1 01:28:37.605: RSTP(99): synced Fa0/1
*Mar 1 01:28:37.605: RSTP(99): Fa0/3 is now alternate
*Mar 1 01:28:37.605: STP[1]: Generating TC trap for port FastEthernet0/1
*Mar 1 01:28:37.605: STP[10]: Generating TC trap for port FastEthernet0/1
*Mar 1 01:28:37.605: STP[99]: Generating TC trap for port FastEthernet0/1
*Mar 1 01:28:37.622: RSTP(1): transmitting an agreement on Fa0/1 as a response to a proposal
*Mar 1 01:28:37.622: RSTP(10): transmitting an agreement on Fa0/1 as a response to a proposal
*Mar 1 01:28:37.622: RSTP(99): transmitting an agreement on Fa0/1 as a response to a proposal
*Mar 1 01:28:38.595: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1,
changed state to up
```

Using the time stamp from the first and last RSTP debug message, calculate the time that it took for the network to converge.

Answers may vary slightly but convergence time should be under a second.

Reflection

1. What is the main benefit of using Rapid PVST+?

Rapid PVST+ decreases the time of Layer 2 convergence significantly over PVST+.

2. How does configuring a port with PortFast allow for faster convergence?

PortFast allows for an access port to immediately transition into a forwarding state which decreases Layer 2 convergence time.

3. What protection does BPDU guard provide?
-

BPDU guard protects the STP domain by disabling access ports that receive a BPDU. BPDUs can be used in a denial of service attack that changes a domain's root bridge and forces an STP recalculation.

Appendix A – Switch Configuration Commands

Switch S1

```
S1(config)# vlan 10
S1(config-vlan)# name User
S1(config-vlan)# vlan 99
S1(config-vlan)# name Management
S1(config-vlan)# exit
S1(config)# interface f0/6
S1(config-if)# no shutdown
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 10
S1(config-if)# interface f0/1
S1(config-if)# no shutdown
S1(config-if)# switchport mode trunk
S1(config-if)# switchport trunk native vlan 99
S1(config-if)# interface f0/3
S1(config-if)# no shutdown
S1(config-if)# switchport mode trunk
S1(config-if)# switchport trunk native vlan 99
S1(config-if)# interface vlan 99
S1(config-if)# ip address 192.168.1.11 255.255.255.0
S1(config-if)# exit
S1(config)# spanning-tree vlan 1,10,99 root secondary
S1(config)# spanning-tree mode rapid-pvst
S1(config)# interface f0/6
S1(config-if)# spanning-tree portfast
S1(config-if)# spanning-tree bpduguard enable
```

Switch S2

```
S2(config)# vlan 10
S2(config-vlan)# name User
S2(config-vlan)# vlan 99
S2(config-vlan)# name Management
S2(config-vlan)# exit
S2(config)# interface f0/1
S2(config-if)# no shutdown
S2(config-if)# switchport mode trunk
S2(config-if)# switchport trunk native vlan 99
S2(config-if)# interface f0/3
S2(config-if)# no shutdown
S2(config-if)# switchport mode trunk
```

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```
S2(config-if)# switchport trunk native vlan 99
S2(config-if)# interface vlan 99
S2(config-if)# ip address 192.168.1.12 255.255.255.0
S2(config-if)# exit
S2(config)# spanning-tree vlan 1,10,99 root primary
S2(config)# spanning-tree mode rapid-pvst
```

Switch S3

```
S3(config)# vlan 10
S3(config-vlan)# name User
S3(config-vlan)# vlan 99
S3(config-vlan)# name Management
S3(config-vlan)# exit
S3(config)# interface f0/18
S3(config-if)# no shutdown
S3(config-if)# switchport mode access
S3(config-if)# switchport access vlan 10
S3(config-if)# spanning-tree portfast
S3(config-if)# spanning-tree bpduguard enable
S3(config-if)# interface f0/1
S3(config-if)# no shutdown
S3(config-if)# switchport mode trunk
S3(config-if)# switchport trunk native vlan 99
S3(config-if)# interface f0/3
S3(config-if)# no shutdown
S3(config-if)# switchport mode trunk
S3(config-if)# switchport trunk native vlan 99
S3(config-if)# interface vlan 99
S3(config-if)# ip address 192.168.1.13 255.255.255.0
S3(config-if)# exit
S3(config)# spanning-tree mode rapid-pvst
```

Device Configs – Final

Switch S1

```
S1#show run
Building configuration...

Current configuration : 1963 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
```

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```
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode rapid-pvst
spanning-tree extend system-id
spanning-tree vlan 1,10,99 priority 28672
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
  switchport trunk native vlan 99
  switchport mode trunk
!
interface FastEthernet0/2
  shutdown
!
interface FastEthernet0/3
  switchport trunk native vlan 99
  switchport mode trunk
!
interface FastEthernet0/4
  shutdown
!
interface FastEthernet0/5
  shutdown
!
interface FastEthernet0/6
  switchport access vlan 10
  switchport mode access
  spanning-tree portfast
  spanning-tree bpduguard enable
!
interface FastEthernet0/7
  shutdown
!
interface FastEthernet0/8
  shutdown
!
interface FastEthernet0/9
  shutdown
!
interface FastEthernet0/10
  shutdown
!
interface FastEthernet0/11
  shutdown
!
interface FastEthernet0/12
  shutdown
!
```

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```
interface FastEthernet0/13
shutdown
!
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
shutdown
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
!
interface GigabitEthernet0/1
shutdown
!
interface GigabitEthernet0/2
shutdown
!
interface Vlan1
no ip address
!
interface Vlan99
ip address 192.168.1.11 255.255.255.0
!
ip http server
ip http secure-server
!
line con 0
password cisco
logging synchronous
login
line vty 0 4
password cisco
```

Lab – Configuring Rapid PVST+, PortFast, and BPDU Guard

```
login
line vty 5 15
password cisco
login
!
end
```

Switch S2

```
S2#show run
Building configuration...

Current configuration : 1864 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode rapid-pvst
spanning-tree extend system-id
spanning-tree vlan 1,10,99 priority 24576
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
switchport trunk native vlan 99
switchport mode trunk
!
interface FastEthernet0/2
shutdown
!
interface FastEthernet0/3
switchport trunk native vlan 99
switchport mode trunk
!
interface FastEthernet0/4
shutdown
```

Lab – Configuring Rapid PVST+, PortFast, and BPDU Guard

```
!  
interface FastEthernet0/5  
shutdown  
!  
interface FastEthernet0/6  
shutdown  
!  
interface FastEthernet0/7  
shutdown  
!  
interface FastEthernet0/8  
shutdown  
!  
interface FastEthernet0/9  
shutdown  
!  
interface FastEthernet0/10  
shutdown  
!  
interface FastEthernet0/11  
shutdown  
!  
interface FastEthernet0/12  
shutdown  
!  
interface FastEthernet0/13  
shutdown  
!  
interface FastEthernet0/14  
shutdown  
!  
interface FastEthernet0/15  
shutdown  
!  
interface FastEthernet0/16  
shutdown  
!  
interface FastEthernet0/17  
shutdown  
!  
interface FastEthernet0/18  
shutdown  
!  
interface FastEthernet0/19  
shutdown  
!  
interface FastEthernet0/20  
shutdown  
!
```

Lab – Configuring Rapid PVST+, PortFast, and BPDU Guard

```
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
!
interface GigabitEthernet0/1
shutdown
!
interface GigabitEthernet0/2
shutdown
!
interface Vlan1
no ip address
!
interface Vlan99
ip address 192.168.1.12 255.255.255.0
!
ip http server
ip http secure-server
!
!
line con 0
password cisco
logging synchronous
login
line vty 0 4
password cisco
login
line vty 5 15
password cisco
login
!
end
```

Switch S3

```
S3#show run
Building configuration...

Current configuration : 1935 bytes
!
version 15.0
no service pad
```

Lab – Configuring Rapid PVST+, PortFast, and BPDU Guard

```
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S3
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode rapid-pvst
spanning-tree portfast default
spanning-tree portfast bpduguard default
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 switchport trunk native vlan 99
 switchport mode trunk
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 switchport trunk native vlan 99
 switchport mode trunk
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
 shutdown
!
interface FastEthernet0/6
 shutdown
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
```

Lab – Configuring Rapid PVST+, PortFast, and BPDU Guard

```
interface FastEthernet0/9
shutdown
!
interface FastEthernet0/10
shutdown
!
interface FastEthernet0/11
shutdown
!
interface FastEthernet0/12
shutdown
!
interface FastEthernet0/13
shutdown
!
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
switchport access vlan 10
switchport mode access
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
!
```

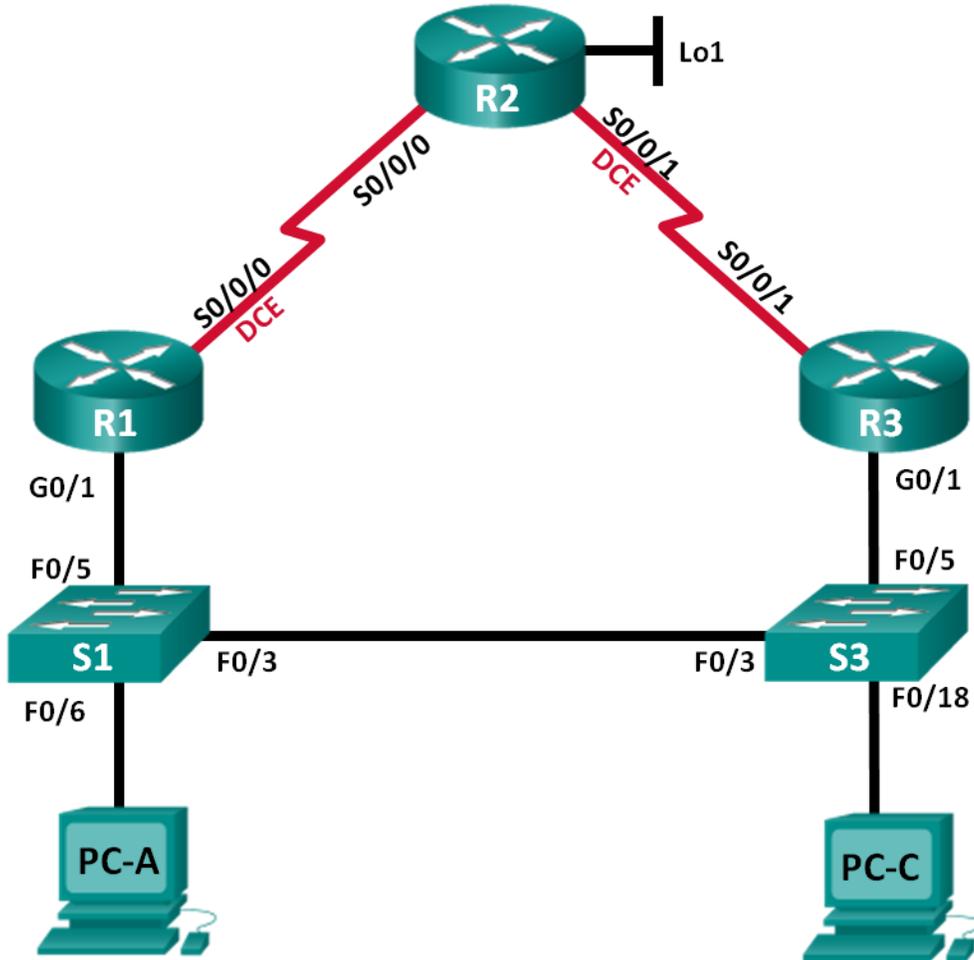
Lab – Configuring Rapid PVST+, PortFast, and BPDU Guard

```
interface GigabitEthernet0/1
 shutdown
!
interface GigabitEthernet0/2
 shutdown
!
interface Vlan1
 no ip address
!
interface Vlan99
 ip address 192.168.1.13 255.255.255.0
!
ip http server
ip http secure-server
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

Lab – Configuring HSRP and GLBP (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/1	192.168.1.1	255.255.255.0	N/A
	S0/0/0 (DCE)	10.1.1.1	255.255.255.252	N/A
R2	S0/0/0	10.1.1.2	255.255.255.252	N/A
	S0/0/1 (DCE)	10.2.2.2	255.255.255.252	N/A
	Lo1	209.165.200.225	255.255.255.224	N/A
R3	G0/1	192.168.1.3	255.255.255.0	N/A
	S0/0/1	10.2.2.1	255.255.255.252	N/A
S1	VLAN 1	192.168.1.11	255.255.255.0	192.168.1.1
S3	VLAN 1	192.168.1.13	255.255.255.0	192.168.1.3
PC-A	NIC	192.168.1.31	255.255.255.0	192.168.1.1
PC-C	NIC	192.168.1.33	255.255.255.0	192.168.1.3

Objectives

Part 1: Build the Network and Verify Connectivity

Part 2: Configure First Hop Redundancy using HSRP

Part 3: Configure First Hop Redundancy using GLBP

Background / Scenario

Spanning tree provides loop-free redundancy between switches within your LAN. However, it does not provide redundant default gateways for end-user devices within your network if one of your routers fails. First Hop Redundancy Protocols (FHRPs) provide redundant default gateways for end devices with no end-user configuration necessary.

In this lab, you will configure two FHRPs. In Part 2, you will configure Cisco's Hot Standby Routing Protocol (HSRP), and in Part 3 you will configure Cisco's Gateway Load Balancing Protocol (GLBP).

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)

- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Verify Connectivity

In Part 1, you will set up the network topology and configure basic settings, such as the interface IP addresses, static routing, device access, and passwords.

Step 1: Cable the network as shown in the topology.

Attach the devices as shown in the topology diagram, and cable as necessary.

Step 2: Configure PC hosts.

Step 3: Initialize and reload the routers and switches as necessary.

Step 4: Configure basic settings for each router.

- Disable DNS lookup.
- Configure the device name as shown in the topology.
- Configure IP addresses for the routers as listed in the Addressing Table.
- Set clock rate to **128000** for all DCE serial interfaces.
- Assign **class** as the encrypted privileged EXEC mode password.
- Assign **cisco** for the console and vty password and enable login.
- Configure **logging synchronous** to prevent console messages from interrupting command entry.
- Copy the running configuration to the startup configuration.

Step 5: Configure basic settings for each switch.

- Disable DNS lookup.
- Configure the device name as shown in the topology.
- Assign **class** as the encrypted privileged EXEC mode password.
- Configure IP addresses for the switches as listed in the Addressing Table.
- Configure the default gateway on each switch.
- Assign **cisco** for the console and vty password and enable login.
- Configure **logging synchronous** to prevent console messages from interrupting command entry.
- Copy the running configuration to the startup configuration.

Step 6: Verify connectivity between PC-A and PC-C.

Ping from PC-A to PC-C. Were the ping results successful? _____ **Yes**

If the pings are not successful, troubleshoot the basic device configurations before continuing.

Note: It may be necessary to disable the PC firewall to successfully ping between PCs.

Step 7: Configure routing.

- a. Configure EIGRP on the routers and use AS of 1. Add all the networks, except 209.165.200.224/27 into the EIGRP process.
- b. Configure a default route on R2 using Lo1 as the exit interface to 209.165.200.224/27 network and redistribute this route into the EIGRP process.

Step 8: Verify connectivity.

- a. From PC-A, you should be able to ping every interface on R1, R2, R3, and PC-C. Were all pings successful? _____ **Yes**
- b. From PC-C, you should be able to ping every interface on R1, R2, R3, and PC-A. Were all pings successful? _____ **Yes**

Part 2: Configure First Hop Redundancy Using HSRP

Even though the topology has been designed with some redundancy (two routers and two switches on the same LAN network), both PC-A and PC-C are configured with only one gateway address. PC-A is using R1 and PC-C is using R3. If either of these routers or the interfaces on the routers went down, the PC could lose its connection to the Internet.

In Part 2, you will test how the network behaves both before and after configuring HSRP. To do this, you will determine the path that packets take to the loopback address on R2.

Step 1: Determine the path for Internet traffic for PC-A and PC-C.

- a. From a command prompt on PC-A, issue a **tracert** command to the 209.165.200.225 loopback address of R2.

```
C:\ tracert 209.165.200.225
Tracing route to 209.165.200.225 over a maximum of 30 hops
```

1	1 ms	1 ms	1 ms	192.168.1.1
2	13 ms	13 ms	13 ms	209.165.200.225

Trace complete.

What path did the packets take from PC-A to 209.165.200.225? _____
PC-A to R1 to R2

- b. From a command prompt on PC-C, issue a **tracert** command to the 209.165.200.225 loopback address of R2.

What path did the packets take from PC-C to 209.165.200.225? _____
PC-C to R3 to R2

Step 2: Start a ping session on PC-A, and break the connection between S1 and R1.

- a. From a command prompt on PC-A, issue a **ping -t** command to the **209.165.200.225** address on R2. Make sure you leave the command prompt window open.

Note: The pings continue until you press **Ctrl+C**, or until you close the command prompt window.

```
C:\ ping -t 209.165.200.225
Pinging 209.165.200.225 with 32 bytes of data:
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
```

Lab – Configuring HSRP and GLBP

```
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
<output omitted>
```

- b. As the ping continues, disconnect the Ethernet cable from F0/5 on S1. You can also shut down the S1 F0/5 interface, which creates the same result.

What happened to the ping traffic?

After the cable was disconnected from F0/5 on S1 (or the interface was shut down), pings failed. Sample output is below.

```
Request timed out.
Request timed out.
Request timed out.
Request timed out.
<output omitted>
```

- c. Repeat Steps 2a and 2b on PC-C and S3. Disconnect cable from F0/5 on S3.

What were your results?

The results were the same as on PC-A. After the Ethernet cable was disconnected from F0/5 on S3, the pings failed.

- d. Reconnect the Ethernet cables to F0/5 or enable the F0/5 interface on both S1 and S3, respectively. Re-issue pings to 209.165.200.225 from both PC-A and PC-C to make sure connectivity is re-established.

Step 3: Configure HSRP on R1 and R3.

In this step, you will configure HSRP and change the default gateway address on PC-A, PC-C, S1, and S2 to the virtual IP address for HSRP. R1 becomes the active router via configuration of the HSRP priority command.

- a. Configure HSRP on R1.

```
R1(config)# interface g0/1
R1(config-if)# standby 1 ip 192.168.1.254
R1(config-if)# standby 1 priority 150
R1(config-if)# standby 1 preempt
```

- b. Configure HSRP on R3.

```
R3(config)# interface g0/1
R3(config-if)# standby 1 ip 192.168.1.254
```

- c. Verify HSRP by issuing the **show standby** command on R1 and R3.

Lab – Configuring HSRP and GLBP

R1# **show standby**

```
GigabitEthernet0/1 - Group 1
  State is Active
    1 state change, last state change 00:02:11
  Virtual IP address is 192.168.1.254
  Active virtual MAC address is 0000.0c07.ac01
    Local virtual MAC address is 0000.0c07.ac01 (v1 default)
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 0.784 secs
  Preemption enabled
  Active router is local
  Standby router is 192.168.1.3, priority 100 (expires in 9.568 sec)
  Priority 150 (configured 150)
  Group name is "hsrp-Gi0/1-1" (default)
```

R3# **show standby**

```
GigabitEthernet0/1 - Group 1
  State is Standby
    4 state changes, last state change 00:02:20
  Virtual IP address is 192.168.1.254
  Active virtual MAC address is 0000.0c07.ac01
    Local virtual MAC address is 0000.0c07.ac01 (v1 default)
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 2.128 secs
  Preemption disabled
  Active router is 192.168.1.1, priority 150 (expires in 10.592 sec)
  Standby router is local
  Priority 100 (default 100)
  Group name is "hsrp-Gi0/1-1" (default)
```

Using the output shown above, answer the following questions:

Which router is the active router? _____ **R1**

What is the MAC address for the virtual IP address? _____ **0000.0c07.ac01**

What is the IP address and priority of the standby router?

IP address is 192.168.1.3 and the priority is 100 (the default which is less than that of R1, the active router, with a priority of 150).

- d. Use the **show standby brief** command on R1 and R3 to view an HSRP status summary. Sample output is shown below.

R1# **show standby brief**

```
          P indicates configured to preempt.
          |
Interface  Grp  Pri P State   Active           Standby           Virtual IP
Gi0/1      1    150 P Active  local            192.168.1.3      192.168.1.254
```

R3# **show standby brief**

Lab – Configuring HSRP and GLBP

P indicates configured to preempt.

Interface	Grp	Pri	P	State	Active	Standby	Virtual IP
Gi0/1	1	100		Standby	192.168.1.1	local	192.168.1.254

- e. Change the default gateway address for PC-A, PC-C, S1, and S3. Which address should you use?

192.168.1.254

Verify the new settings. Issue a ping from both PC-A and PC-C to the loopback address of R2. Are the pings successful? _____ **Yes**

Step 4: Start a ping session on PC-A and break the connection between the switch that is connected to the Active HSRP router (R1).

- From a command prompt on PC-A, issue a **ping -t** command to the 209.165.200.225 address on R2. Ensure that you leave the command prompt window open.
- As the ping continues, disconnect the Ethernet cable from F0/5 on S1 or shut down the F0/5 interface. What happened to the ping traffic?

A few packets may be dropped while the Standby router takes over. Sample output is shown below:

```
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Request timed out.
Request timed out.
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
<output Omitted>
```

Step 5: Verify HSRP settings on R1 and R3.

- Issue the **show standby brief** command on R1 and R3.

Which router is the active router? _____ **R3 is now the active router.**

- Reconnect the cable between the switch and the router or enable interface F0/5.
- Disable the HSRP configuration commands on R1 and R3.

```
R1(config)# interface g0/1
R1(config-if)# no standby 1
```

```
R3(config)# interface g0/1
R3(config-if)# no standby 1
```

Part 3: Configure First Hop Redundancy Using GLBP

By default, HSRP does NOT do load balancing. The active router always handles all of the traffic, while the standby router sits unused, unless there is a link failure. This is not an efficient use of resources. GLBP provides nonstop path redundancy for IP by sharing protocol and MAC addresses between redundant gateways. GLBP also allows a group of routers to share the load of the default gateway on a LAN.

Lab – Configuring HSRP and GLBP

Configuring GLBP is very similar to HSRP. Load balancing can be done in a variety of ways using GLBP. In this lab, you will use the round-robin method.

Step 1: Configure GLBP on R1 and R3.

- a. Configure GLBP on R1.

```
R1(config)# interface g0/1
R1(config-if)# glbp 1 ip 192.168.1.254
R1(config-if)# glbp 1 preempt
R1(config-if)# glbp 1 priority 150
R1(config-if)# glbp 1 load-balancing round-robin
```

- b. Configure GLBP on R3.

```
R3(config)# interface g0/1
R3(config-if)# glbp 1 ip 192.168.1.254
R3(config-if)# glbp 1 load-balancing round-robin
```

Step 2: Verify GLBP on R1 and R3.

- a. Issue the **show glbp brief** command on R1 and R3.

```
R1# show glbp brief
```

Interface	Grp	Fwd	Pri	State	Address	Active router	Standby router
Gi0/1	1	-	150	Active	192.168.1.254	local	192.168.1.3
Gi0/1	1	1	-	Active	0007.b400.0101	local	-
Gi0/1	1	2	-	Listen	0007.b400.0102	192.168.1.3	-

```
R3# show glbp brief
```

Interface	Grp	Fwd	Pri	State	Address	Active router	Standby router
Gi0/1	1	-	100	Standby	192.168.1.254	192.168.1.1	local
Gi0/1	1	1	-	Listen	0007.b400.0101	192.168.1.1	-
Gi0/1	1	2	-	Active	0007.b400.0102	local	-

Step 3: Generate traffic from PC-A and PC-C to the R2 loopback interface.

- a. From a command prompt on PC-A, ping the 209.165.200.225 address of R2.

```
C:\> ping 209.165.200.225
```

- b. Issue an **arp -a** command on PC-A. Which MAC address is used for the 192.168.1.254 address?

Answers will vary due to timing, but the MAC address will be either R1 or R3 GLBP G0/1 interface MAC.

- c. Generate more traffic to the loopback interface of R2. Issue another **arp -a** command. Did the MAC address change for the default gateway address of 192.168.1.254?

Yes. The MAC address changed from R1 to R3 and back. Note: You may need to have students generate traffic multiple times to see the change.

As you can see, both R1 and R3 play a role in forwarding traffic to the loopback interface of R2. Neither router remains idle.

Step 4: Start a ping session on PC-A, and break the connection between the switch that is connected to R1.

- a. From a command prompt on PC-A, issue a **ping -t** command to the 209.165.200.225 address on R2. Make sure you leave the command prompt window open.
- b. As the ping continues, disconnect the Ethernet cable from F0/5 on S1 or shut down the F0/5 interface. What happened to the ping traffic?

A few packets are dropped while transitioning to the Standby router. Sample output is shown below.

```
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Request timed out.
Reply from 209.165.200.225: bytes=32 time=18ms TTL=252
Reply from 209.165.200.225: bytes=32 time=18ms TTL=252
```

Reflection

1. Why would there be a need for redundancy in a LAN?

In today's networks, down time can be a critical issue affecting sales, productivity, and general connectivity (IP Telephony phones for example).

2. If you had a choice, which protocol would you implement in your network, HSRP or GLBP? Explain your choice.

Answers will vary. HSRP is easier to configure. There are more options with GLBP which can make it complex to configure.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router R1 (After Part 3 of this lab)

```
R1# show run
Building configuration...

Current configuration : 1375 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
```

Lab – Configuring HSRP and GLBP

```
!  
interface Embedded-Service-Engine0/0  
  no ip address  
  shutdown  
!  
interface GigabitEthernet0/0  
  no ip address  
  shutdown  
  duplex auto  
  speed auto  
!  
interface GigabitEthernet0/1  
  ip address 192.168.1.1 255.255.255.0  
  glbp 1 ip 192.168.1.254  
  glbp 1 priority 150  
  glbp 1 preempt  
  duplex auto  
  speed auto  
!  
interface Serial0/0/0  
  ip address 10.1.1.1 255.255.255.252  
  clock rate 128000  
!  
interface Serial0/0/1  
  no ip address  
  shutdown  
!  
!  
router eigrp 1  
  network 10.1.1.0 0.0.0.3  
  network 192.168.1.0  
!  
ip forward-protocol nd  
!  
no ip http server  
no ip http secure-server  
!  
!  
!  
control-plane  
!  
line con 0  
  password cisco  
  logging synchronous  
  login  
line aux 0  
line 2  
  no activation-character  
  no exec
```

Lab – Configuring HSRP and GLBP

```
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R2

```
R2# show run
Building configuration...

Current configuration : 1412 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R2
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
interface Loopback1
 ip address 209.165.200.225 255.255.255.224
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
```

Lab – Configuring HSRP and GLBP

```
duplex auto
speed auto
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
ip address 10.1.1.2 255.255.255.252
!
interface Serial0/0/1
ip address 10.2.2.2 255.255.255.252
clock rate 128000
!
!
router eigrp 1
network 10.1.1.0 0.0.0.3
network 10.2.2.0 0.0.0.3
redistribute static
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 0.0.0.0 0.0.0.0 Loopback1
!
!
control-plane
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
```

Lab – Configuring HSRP and GLBP

```
!  
scheduler allocate 20000 1000  
!  
end
```

Router R3 (After Part 3 of this Lab)

```
R3# show run  
Building configuration...  
  
Current configuration : 1319 bytes  
!  
version 15.2  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname R3  
!  
boot-start-marker  
boot-end-marker  
!  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGholQM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
!  
no ip domain lookup  
ip cef  
no ipv6 cef  
multilink bundle-name authenticated  
!  
interface Embedded-Service-Engine0/0  
no ip address  
shutdown  
!  
interface GigabitEthernet0/0  
no ip address  
shutdown  
duplex auto  
speed auto  
!  
interface GigabitEthernet0/1  
ip address 192.168.1.3 255.255.255.0  
glbp 1 ip 192.168.1.254  
duplex auto  
speed auto  
!  
interface Serial0/0/0  
no ip address
```

Lab – Configuring HSRP and GLBP

```
shutdown
clock rate 2000000
!
interface Serial0/0/1
ip address 10.2.2.1 255.255.255.252
!
!
router eigrp 1
network 10.2.2.0 0.0.0.3
network 192.168.1.0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
control-plane
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1

```
S1# show run
Building configuration...

Current configuration : 3114 bytes
!
version 15.0
no service pad
```

Lab – Configuring HSRP and GLBP

```
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
crypto pki trustpoint TP-self-signed-2530377856
  enrollment selfsigned
  subject-name cn=IOS-Self-Signed-Certificate-2530377856
  revocation-check none
  rsakeypair TP-self-signed-2530377856
!
!
!lspanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
interface FastEthernet0/1
!
interface FastEthernet0/2
!
interface FastEthernet0/3
!
interface FastEthernet0/4
!
interface FastEthernet0/5
!
interface FastEthernet0/6
!
interface FastEthernet0/7
!
interface FastEthernet0/8
!
interface FastEthernet0/9
!
interface FastEthernet0/10
```

Lab – Configuring HSRP and GLBP

```
!  
interface FastEthernet0/11  
!  
interface FastEthernet0/12  
!  
interface FastEthernet0/13  
!  
interface FastEthernet0/14  
!  
interface FastEthernet0/15  
!  
interface FastEthernet0/16  
!  
interface FastEthernet0/17  
!  
interface FastEthernet0/18  
!  
interface FastEthernet0/19  
!  
interface FastEthernet0/20  
!  
interface FastEthernet0/21  
!  
interface FastEthernet0/22  
!  
interface FastEthernet0/23  
!  
interface FastEthernet0/24  
!  
interface GigabitEthernet0/1  
!  
interface GigabitEthernet0/2  
!  
interface Vlan1  
 ip address 192.168.1.11 255.255.255.0  
!  
 ip default-gateway 192.168.1.254  
 ip http server  
 ip http secure-server  
!  
 line con 0  
   password cisco  
   logging synchronous  
   login  
 line vty 0 4  
   password cisco  
   login  
 line vty 5 15  
   password cisco
```

Lab – Configuring HSRP and GLBP

```
login
!  
end
```

Switch S3

```
S3# show run
Building configuration...

Current configuration : 2974 bytes
!  
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!  
hostname S3
!  
boot-start-marker
boot-end-marker
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!  
no aaa new-model
system mtu routing 1500
!  
!  
no ip domain-lookup
!  
!  
crypto pki trustpoint TP-self-signed-2530358400
  enrollment selfsigned
  subject-name cn=IOS-Self-Signed-Certificate-2530358400
  revocation-check none
  rsa-key-pair TP-self-signed-2530358400
!  
!  
!  
spanning-tree mode pvst
spanning-tree extend system-id
!  
vlan internal allocation policy ascending
!  
interface FastEthernet0/1
!  
interface FastEthernet0/2
!  
interface FastEthernet0/3
!  
!
```

Lab – Configuring HSRP and GLBP

```
interface FastEthernet0/4
!
interface FastEthernet0/5
!
interface FastEthernet0/6
!
interface FastEthernet0/7
!
interface FastEthernet0/8
!
interface FastEthernet0/9
!
interface FastEthernet0/10
!
interface FastEthernet0/11
!
interface FastEthernet0/12
!
interface FastEthernet0/13
!
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
!
interface FastEthernet0/17
!
interface FastEthernet0/18
!
interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
 ip address 192.168.1.13 255.255.255.0
!
```

Lab – Configuring HSRP and GLBP

```
ip default-gateway 192.168.1.254
ip http server
ip http secure-server
!
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

Documentation Tree (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Identify common STP configuration issues.

Instructor Note: This activity may be completed individually or in small groups.

Scenario

The employees in your building are having difficulty accessing a web server on the network. You look for the network documentation that the previous network engineer used before he transitioned to a new job; however, you cannot find any network documentation whatsoever.

Therefore, you decide create your own network recordkeeping system. You decide to start at the access layer of your network hierarchy. This is where redundant switches are located, as well as the company servers, printers, and local hosts.

You create a matrix to record your documentation and include access layer switches on the list. You also decide to document switch names, ports in use, cabling connections, and root ports, designated ports, and alternate ports.

For more detailed instructions on how to design your model, use the student PDF that accompanies this activity.

Resources

- Packet Tracer software
- Word processing software

Directions

Step 1: Create the topology diagram with three redundant switches.

Step 2: Connect host devices to the switches.

Step 3: Create the switch documentation matrix.

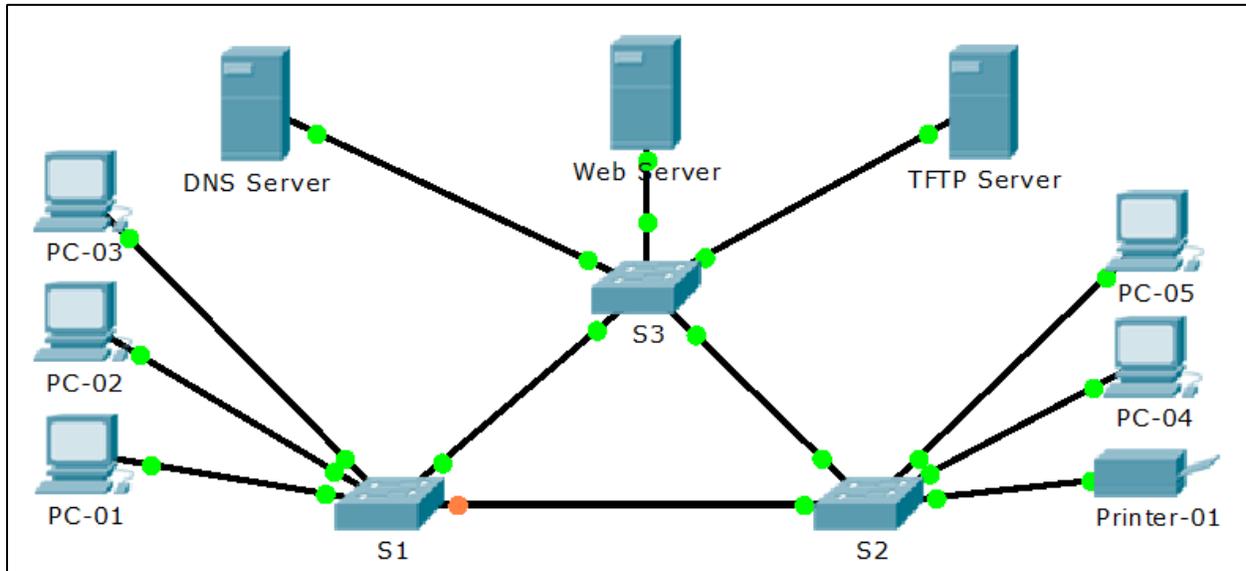
- a. Name and switch location
- b. General switch description
- c. Model, IOS version, and image name
- d. Switch serial number
- e. MAC address
- f. Ports currently in use
- g. Cable connections
- h. Root ports
- i. Designated ports, status, and cost
- j. Alternate ports, status, and cost

Step 4: Use show commands to locate Layer 2 switch information.

- a. show version
- b. show cdp neighbors detail
- c. show spanning-tree

Instructor – Example Activity Answer

Topology Diagram Example



Documentation Form Example (S1 only)

Switch Name and Location	S1 – Main Distribution Facility
General Switch Description	Access Layer Switch – grants network access for PCs 01-03
Switch Model, IOS Version, and Image Name	WS-C2960-24TT 12.2 C2960-LANBASE-M
Switch Serial Number	FOC1033Z1EY
Switch MAC Address	0050.0F5C.A2D1
Ports in Use	Fa0/2 Fa0/3 Fa0/1 Gi1/1 Gi1/2
Cable Connections	Fa0/2 connected to PC-02 Fa0/3 connected to PC-03 Fa0/1 connected to PC-01

Documentation Tree

	Gi1/1 connected to S2 Gi1/1 Gi1/2 connected to S3 Gi1/2
Root Port	Gi1/2
Designated Port(s), Status, and Cost	Fa0/1, Forwarding, Cost 19 Fa0/3, Forwarding, Cost 19 Fa0/2, Forwarding, Cost 19
Alternate Port(s), Status, and Cost	(non-designated port) Gi1/1, Blocking, Cost 4

S1# **show version**

Cisco IOS Software, C2960 Software (C2960-LANBASE-M), Version 12.2(25)FX, RELEASE SOFTWARE (fc1)

Copyright (c) 1986-2005 by Cisco Systems, Inc.

Compiled Wed 12-Oct-05 22:05 by pt_team

ROM: C2960 Boot Loader (C2960-HBOOT-M) Version 12.2(25r)FX, RELEASE SOFTWARE (fc4)

System returned to ROM by power-on

Cisco WS-C2960-24TT (RC32300) processor (revision C0) with 21039K bytes of memory.

24 FastEthernet/IEEE 802.3 interface(s)

2 Gigabit Ethernet/IEEE 802.3 interface(s)

63488K bytes of flash-simulated non-volatile configuration memory.

```
Base ethernet MAC Address       : 0050.0F5C.A2D1
Motherboard assembly number     : 73-9832-06
Power supply part number        : 341-0097-02
Motherboard serial number       : FOC103248MJ
Power supply serial number      : DCA102133JA
Model revision number           : B0
Motherboard revision number     : C0
Model number                    : WS-C2960-24TT
System serial number            : FOC1033Z1EY
Top Assembly Part Number        : 800-26671-02
Top Assembly Revision Number    : B0
Version ID                      : V02
CLEI Code Number                : COM3K00BRA
Hardware Board Revision Number  : 0x01
```

```
Switch  Ports  Model                SW Version          SW Image
-----  -
*    1    26    WS-C2960-24TT      12.2                C2960-LANBASE-M
```

Configuration register is 0xF

S1#

```
S1# show cdp neighbors detail
```

```
Device ID: S2  
Entry address(es):  
Platform: cisco 2960, Capabilities: Switch  
Interface: GigabitEthernet1/1, Port ID (outgoing port): GigabitEthernet1/1  
Holdtime: 151
```

```
Version :  
Cisco IOS Software, C2960 Software (C2960-LANBASE-M), Version 12.2(25)FX, RELEASE  
SOFTWARE (fcl)  
Copyright (c) 1986-2005 by Cisco Systems, Inc.  
Compiled Wed 12-Oct-05 22:05 by pt_team
```

```
advertisement version: 2  
Duplex: full  
-----
```

```
Device ID: S3  
Entry address(es):  
Platform: cisco 2960, Capabilities: Switch  
Interface: GigabitEthernet1/2, Port ID (outgoing port): GigabitEthernet1/2  
Holdtime: 151
```

```
Version :  
Cisco IOS Software, C2960 Software (C2960-LANBASE-M), Version 12.2(25)FX, RELEASE  
SOFTWARE (fcl)  
Copyright (c) 1986-2005 by Cisco Systems, Inc.  
Compiled Wed 12-Oct-05 22:05 by pt_team
```

```
advertisement version: 2  
Duplex: full
```

```
S1#
```

```
S1# show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32769
            Address    0001.635E.CE64
            Cost      4
            Port      26(GigabitEthernet1/2)
            Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
            Address    0050.0F5C.A2D1
            Hello Time 2 sec  Max Age 20 sec  Forward Delay 15 sec
            Aging Time 20

Interface      Role Sts Cost      Prio.Nbr Type
-----
Fa0/1          Desg FWD 19        128.1   P2p
Fa0/3          Desg FWD 19        128.3   P2p
Fa0/2          Desg FWD 19        128.2   P2p
Gi1/1          Altn BLK 4         128.25  P2p
Gi1/2          Root FWD 4         128.26  P2p

S1#
```

Identify elements of the model that map to IT-related content:

- Designated ports
- Root ports
- Alternate ports
- STP switch commands output
- LAN, Access-Layer documentation

Imagine This (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Explain the operation of link aggregation in a switched LAN environment.

Instructor Notes: This activity is introductory in nature and designed to help students envision how switches can be physically connected to use EtherChannel.

Students can work individually or in very small groups to research the EtherChannel concept and present their findings briefly to the class.

Scenario

It is the end of the work day. In your small- to medium-sized business, you are trying to explain to the network engineers about EtherChannel and how it looks when it is physically set up. The network engineers have difficulties envisioning how two switches could possibly be connected via several links that collectively act as one channel or connection. Your company is definitely considering implementing an EtherChannel network.

Therefore, you end the meeting with an assignment for the engineers. To prepare for the next day's meeting, they are to perform some research and bring to the meeting one graphic representation of an EtherChannel network connection. They are tasked with explaining how an EtherChannel network operates to the other engineers.

When researching EtherChannel, a good question to search for is "What does EtherChannel look like?" Prepare a few slides to demonstrate your research that will be presented to the network engineering group. These slides should provide a solid grasp of how EtherChannels are physically created within a network topology. Your goal is to ensure that everyone leaving the next meeting will have a good idea as to why they would consider moving to a network topology using EtherChannel as an option.

Required Resources

- Internet connectivity for research
- Software program for presentation model

Step 1: Use the Internet to research graphics depicting EtherChannel.

Step 2: Prepare a three-slide presentation to share with the class.

- a. The first slide should show a very short, concise definition of a switch-to-switch EtherChannel.
- b. The second slide should show a graphic of how a switch-to-switch EtherChannel physical topology would look if used in a small- to medium-sized business.
- c. The third slide should list three advantages of using EtherChannel.

Instructor Activity Example Resource

Slide 1: Definition

[EtherChannel](#) - EtherChannel provides incremental trunk speeds between Fast Ethernet, Gigabit Ethernet, and 10 Gigabit Ethernet. EtherChannel combines multiple Fast Ethernet up to 800 Mbps, Gigabit Ethernet up to 8 Gbps, and 10 Gigabit Ethernet up to 80 Gbps.

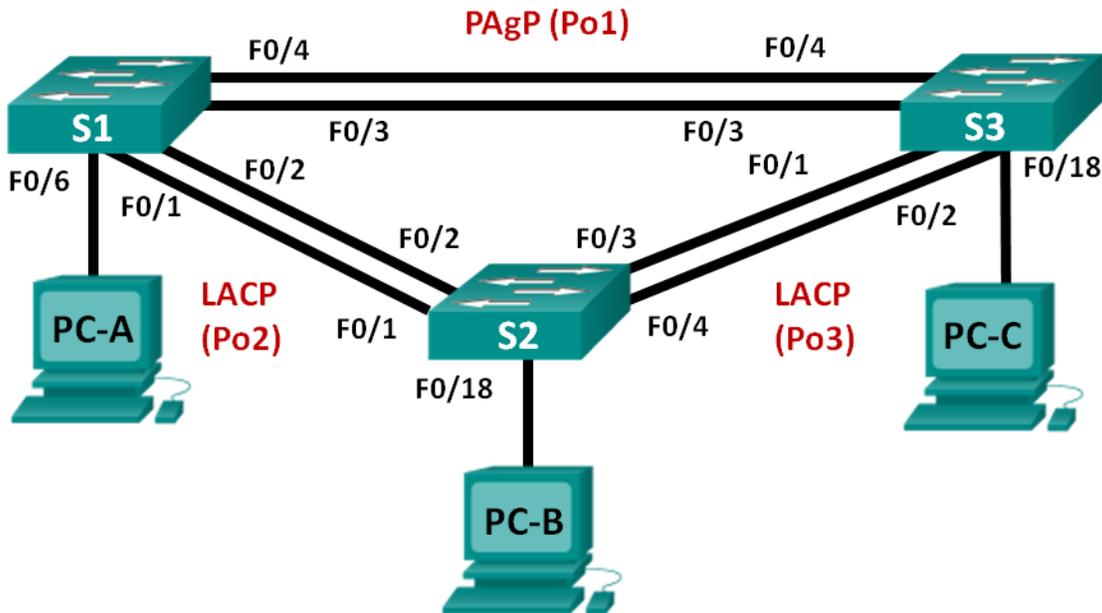
Slide 2: EtherChannel Physical Graphic Example

EtherChannel Physical Image

Lab – Configuring EtherChannel (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask
S1	VLAN 99	192.168.99.11	255.255.255.0
S2	VLAN 99	192.168.99.12	255.255.255.0
S3	VLAN 99	192.168.99.13	255.255.255.0
PC-A	NIC	192.168.10.1	255.255.255.0
PC-B	NIC	192.168.10.2	255.255.255.0
PC-C	NIC	192.168.10.3	255.255.255.0

Objectives

Part 1: Configure Basic Switch Settings

Part 2: Configure PAgP

Part 3: Configure LACP

Background / Scenario

Link aggregation allows the creation of logical links that are comprised of two or more physical links. This provides increased throughput beyond using only one physical link. Link aggregation also provides redundancy if one of the links fails.

Lab – Configuring EtherChannel

In this lab, you will configure EtherChannel, a form of link aggregation used in switched networks. You will configure EtherChannel using Port Aggregation Protocol (PAgP) and Link Aggregation Control Protocol (LACP).

Note: PAgP is a Cisco-proprietary protocol that you can only run on Cisco switches and on switches that are licensed vendors to support PAgP. LACP is a link aggregation protocol that is defined by IEEE 802.3ad, and it is not associated with any specific vendor.

LACP allows Cisco switches to manage Ethernet channels between switches that conform to the 802.3ad protocol. You can configure up to 16 ports to form a channel. Eight of the ports are in active mode and the other eight are in standby mode. When any of the active ports fail, a standby port becomes active. Standby mode works only for LACP, not for PAgP.

Note: The switches used with CCNA hands-on labs are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Note: Make sure that the switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 3 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Configure Basic Switch Settings

In Part 1, you will set up the network topology and configure basic settings, such as the interface IP addresses, device access, and passwords.

Step 1: Cable the network as shown in the topology.

Attach the devices as shown in the topology diagram, and cable as necessary.

Step 2: Initialize and reload the switches.

Step 3: Configure basic settings for each switch.

- a. Disable DNS lookup.
- b. Configure the device name as displayed in the topology.
- c. Encrypt plain text passwords.
- d. Create a MOTD banner warning users that unauthorized access is prohibited.
- e. Assign **class** as the encrypted privileged EXEC mode password.
- f. Assign **cisco** as the console and vty password and enable login.
- g. Configure logging synchronous to prevent console message from interrupting command entry.
- h. Shut down all switchports except the ports connected to PCs.
- i. Configure VLAN 99 and name it **Management**.
- j. Configure VLAN 10 and name it **Staff**.

Lab – Configuring EtherChannel

- k. Configure the switch ports with attached hosts as access ports in VLAN 10.
- l. Assign the IP addresses according to the Addressing Table.
- m. Copy the running configuration to startup configuration.

Step 4: Configure the PCs.

Assign IP addresses to the PCs according to the Addressing Table.

Part 2: Configure PAgP

PAgP is a Cisco proprietary protocol for link aggregation. In Part 2, a link between S1 and S3 will be configured using PAgP.

Step 1: Configure PAgP on S1 and S3.

For a link between S1 and S3, configure the ports on S1 with PAgP desirable mode and the ports on S3 with PAgP auto mode. Enable the ports after PAgP modes have been configured.

```
S1(config)# interface range f0/3-4
S1(config-if-range)# channel-group 1 mode desirable
Creating a port-channel interface Port-channel 1

S1(config-if-range)# no shutdown

S3(config)# interface range f0/3-4
S3(config-if-range)# channel-group 1 mode auto
Creating a port-channel interface Port-channel 1

S3(config-if-range)# no shutdown
*Mar 1 00:09:12.792: %LINK-3-UPDOWN: Interface FastEthernet0/3, changed state to up
*Mar 1 00:09:12.792: %LINK-3-UPDOWN: Interface FastEthernet0/4, changed state to up
S3(config-if-range)#
*Mar 1 00:09:15.384: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/3,
changed state to up
*Mar 1 00:09:16.265: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/4,
changed state to up
S3(config-if-range)#
*Mar 1 00:09:16.357: %LINK-3-UPDOWN: Interface Port-channell1, changed state to up
*Mar 1 00:09:17.364: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-channell1,
changed state to up
*Mar 1 00:09:44.383: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed
state to up
```

Step 2: Examine the configuration on the ports.

Currently the F0/3, F0/4, and Po1 (Port-channel1) interfaces on both S1 and S3 are in access operational mode with the administrative mode in dynamic auto. Verify the configuration using the **show run interface interface-id** and **show interfaces interface-id switchport** commands, respectively. The example configuration outputs for F0/3 on S1 are as follows:

```
S1# show run interface f0/3
Building configuration...
```

Lab – Configuring EtherChannel

```
Current configuration : 103 bytes
```

```
!
```

```
interface FastEthernet0/3  
  channel-group 1 mode desirable
```

```
S1# show interfaces f0/3 switchport
```

```
Name: Fa0/3
```

```
Switchport: Enabled
```

```
Administrative Mode: dynamic auto
```

```
Operational Mode: static access (member of bundle Po1)
```

```
Administrative Trunking Encapsulation: dot1q
```

```
Operational Trunking Encapsulation: native
```

```
Negotiation of Trunking: On
```

```
Access Mode VLAN: 1 (default)
```

```
Trunking Native Mode VLAN: 1 (default)
```

```
Administrative Native VLAN tagging: enabled
```

```
Voice VLAN: none
```

```
Administrative private-vlan host-association: none
```

```
Administrative private-vlan mapping: none
```

```
Administrative private-vlan trunk native VLAN: none
```

```
Administrative private-vlan trunk Native VLAN tagging: enabled
```

```
Administrative private-vlan trunk encapsulation: dot1q
```

```
Administrative private-vlan trunk normal VLANs: none
```

```
Administrative private-vlan trunk associations: none
```

```
Administrative private-vlan trunk mappings: none
```

```
Operational private-vlan: none
```

```
Trunking VLANs Enabled: ALL
```

```
Pruning VLANs Enabled: 2-1001
```

```
Capture Mode Disabled
```

```
Capture VLANs Allowed: ALL
```

```
Protected: false
```

```
Unknown unicast blocked: disabled
```

```
Unknown multicast blocked: disabled
```

```
Appliance trust: none
```

Step 3: Verify that the ports have been aggregated.

```
S1# show etherchannel summary
```

```
Flags: D - down          P - bundled in port-channel  
       I - stand-alone  s - suspended  
       H - Hot-standby (LACP only)  
       R - Layer3       S - Layer2  
       U - in use       f - failed to allocate aggregator  
  
       M - not in use, minimum links not met  
       u - unsuitable for bundling  
       w - waiting to be aggregated  
       d - default port
```

Lab – Configuring EtherChannel

```
Number of channel-groups in use: 1
Number of aggregators:          1
```

```
Group  Port-channel  Protocol  Ports
-----+-----+-----+-----
1      Po1 (SU)         PAgP     Fa0/3 (P) Fa0/4 (P)
```

S3# **show etherchannel summary**

```
Flags:  D - down          P - bundled in port-channel
        I - stand-alone  s - suspended
        H - Hot-standby (LACP only)
        R - Layer3       S - Layer2
        U - in use       f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port
```

```
Number of channel-groups in use: 1
Number of aggregators:          1
```

```
Group  Port-channel  Protocol  Ports
-----+-----+-----+-----
1      Po1 (SU)         PAgP     Fa0/3 (P) Fa0/4 (P)
```

What do the flags, SU and P, indicate in the Ethernet summary?

The flag P indicates that the ports are bundled in a port-channel. The flag S indicates that the port-channel is a Layer 2 EtherChannel. The U flag indicates that the EtherChannel is in use.

Step 4: Configure trunk ports.

After the ports have been aggregated, commands applied at the port channel interface affect all the links that were bundled together. Manually configure the Po1 ports on S1 and S3 as trunk ports and assign them to native VLAN 99.

```
S1(config)# interface port-channel 1
S1(config-if)# switchport mode trunk
S1(config-if)# switchport trunk native vlan 99
```

```
S3(config)# interface port-channel 1
S3(config-if)# switchport mode trunk
S3(config-if)# switchport trunk native vlan 99
```

Step 5: Verify that the ports are configured as trunk ports.

- a. Issue the **show run interface *interface-id*** commands on S1 and S3. What commands are listed for F0/3 and F0/4 on both switches? Compare the results to the running configuration for the Po1 interface? Record your observation.

```
switchport trunk native vlan 99
switchport mode trunk
```

The commands related to trunk configuration are the same. When the trunk commands were applied to the EtherChannel, the commands also affected the individual links in the bundle.

```
S1# show run interface po1
Building configuration...

Current configuration : 92 bytes
!
interface Port-channel1
  switchport trunk native vlan 99
  switchport mode trunk
end
```

```
S1# show run interface f0/3
Building configuration...

Current configuration : 126 bytes
!
interface FastEthernet0/3
  switchport trunk native vlan 99
  switchport mode trunk
  channel-group 1 mode desirable
end
```

- b. Issue the **show interfaces trunk** and **show spanning-tree** commands on S1 and S3. What trunk port is listed? What is the native VLAN? What is concluding result from the output?

The trunk port listed is Po1. The native VLAN is 99. After the links are bundled, only the aggregated interface is listed in some **show** commands.

From the **show spanning-tree** output, what is port cost and port priority for the aggregated link?

The port cost for Po1 is 12, and the port priority is 128.

```
S1# show interfaces trunk
```

```
Port      Mode          Encapsulation  Status        Native vlan
Po1       on            802.1q         trunking      99
```

```
Port      Vlans allowed on trunk
Po1       1-4094
```

Lab – Configuring EtherChannel

```
Port      Vlans allowed and active in management domain
Po1       1,10,99
```

```
Port      Vlans in spanning tree forwarding state and not pruned
Po1       1,10,99
```

S3# **show interfaces trunk**

```
Port      Mode           Encapsulation  Status      Native vlan
Po1       on             802.1q         trunking    99
```

```
Port      Vlans allowed on trunk
Po1       1-4094
```

```
Port      Vlans allowed and active in management domain
Po1       1,10,99
```

```
Port      Vlans in spanning tree forwarding state and not pruned
Po1       1,10,99
```

S1# **show spanning-tree**

VLAN0001

Spanning tree enabled protocol ieee

```
Root ID    Priority    32769
Address    0cd9.96e8.7400
Cost       12
Port       64 (Port-channel1)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

```
Bridge ID  Priority    32769 (priority 32768 sys-id-ext 1)
Address    0cd9.96e8.8a00
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec
```

```
Interface          Role Sts Cost      Prio.Nbr Type
-----
Po1                 Root FWD 12        128.64  P2p
```

VLAN0010

Spanning tree enabled protocol ieee

```
Root ID    Priority    32778
Address    0cd9.96e8.7400
Cost       12
Port       64 (Port-channel1)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
```

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```
Bridge ID Priority 32778 (priority 32768 sys-id-ext 10)
Address 0cd9.96e8.8a00
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec

Interface Role Sts Cost Prio.Nbr Type
-----
Fa0/6 Desg FWD 19 128.6 P2p
Po1 Root FWD 12 128.64 P2p

VLAN0099
Spanning tree enabled protocol ieee
Root ID Priority 32867
Address 0cd9.96e8.7400
Cost 12
Port 64 (Port-channel1)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32867 (priority 32768 sys-id-ext 99)
Address 0cd9.96e8.8a00
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec

Interface Role Sts Cost Prio.Nbr Type
-----
Po1 Root FWD 12 128.64 P2p

S3# show spanning-tree

VLAN0001
Spanning tree enabled protocol ieee
Root ID Priority 32769
Address 0cd9.96e8.7400
This bridge is the root
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)
Address 0cd9.96e8.7400
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300 sec

Interface Role Sts Cost Prio.Nbr Type
-----
Po1 Desg FWD 12 128.64 P2p

VLAN0010
Spanning tree enabled protocol ieee
Root ID Priority 32778
```

```
Address      0cd9.96e8.7400
This bridge is the root
Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Bridge ID    Priority    32778  (priority 32768 sys-id-ext 10)
Address      0cd9.96e8.7400
Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
Aging Time   300 sec

Interface          Role Sts Cost      Prio.Nbr Type
-----
Fa0/18             Desg FWD 19        128.18  P2p
Po1                Desg FWD 12        128.64  P2p

VLAN0099
Spanning tree enabled protocol ieee
Root ID        Priority    32867
Address        0cd9.96e8.7400
This bridge is the root
Hello Time     2 sec  Max Age 20 sec  Forward Delay 15 sec

Bridge ID      Priority    32867  (priority 32768 sys-id-ext 99)
Address        0cd9.96e8.7400
Hello Time     2 sec  Max Age 20 sec  Forward Delay 15 sec
Aging Time     300 sec

Interface          Role Sts Cost      Prio.Nbr Type
-----
Po1                Desg FWD 12        128.64  P2p
```

Part 3: Configure LACP

LACP is an open source protocol for link aggregation developed by the IEEE. In Part 3, the link between S1 and S2, and the link between S2 and S3 will be configured using LACP. Also, the individual links will be configured as trunks before they are bundled together as EtherChannels.

Step 1: Configure LACP between S1 and S2.

```
S1(config)# interface range f0/1-2
S1(config-if-range)# switchport mode trunk
S1(config-if-range)# switchport trunk native vlan 99
S1(config-if-range)# channel-group 2 mode active
Creating a port-channel interface Port-channel 2

S1(config-if-range)# no shutdown

S2(config)# interface range f0/1-2
S2(config-if-range)# switchport mode trunk
```

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```
S2(config-if-range)# switchport trunk native vlan 99
S2(config-if-range)# channel-group 2 mode passive
Creating a port-channel interface Port-channel 2

S2(config-if-range)# no shutdown
```

Step 2: Verify that the ports have been aggregated.

What protocol is Po2 using for link aggregation? Which ports are aggregated to form Po2? Record the command used to verify.

Po2 is using LACP and F0/1 and F0/2 are aggregated to form Po2.

```
S1# show etherchannel summary
Flags: D - down          P - bundled in port-channel
       I - stand-alone  s - suspended
       H - Hot-standby (LACP only)
       R - Layer3       S - Layer2
       U - in use       f - failed to allocate aggregator

       M - not in use, minimum links not met
       u - unsuitable for bundling
       w - waiting to be aggregated
       d - default port
```

```
Number of channel-groups in use: 2
Number of aggregators:          2
```

Group	Port-channel	Protocol	Ports
1	Po1 (SU)	PAgP	Fa0/3 (P) Fa0/4 (P)
2	Po2 (SU)	LACP	Fa0/1 (P) Fa0/2 (P)

```
S2# show etherchannel summary
Flags: D - down          P - bundled in port-channel
       I - stand-alone  s - suspended
       H - Hot-standby (LACP only)
       R - Layer3       S - Layer2
       U - in use       f - failed to allocate aggregator

       M - not in use, minimum links not met
       u - unsuitable for bundling
       w - waiting to be aggregated
       d - default port
```

```
Number of channel-groups in use: 1
```

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```
Number of aggregators:          1
```

```
Group  Port-channel  Protocol  Ports
-----+-----+-----+-----
2      Po2 (SU)          LACP     Fa0/1 (P)  Fa0/2 (P)
```

Step 3: Configure LACP between S2 and S3.

- a. Configure the link between S2 and S3 as Po3 and use LACP as the link aggregation protocol.

```
S2(config)# interface range f0/3-4
S2(config-if-range)# switchport mode trunk
S2(config-if-range)# switchport trunk native vlan 99
S2(config-if-range)# channel-group 3 mode active
Creating a port-channel interface Port-channel 3
S2(config-if-range)# no shutdown
```

```
S3(config)# interface range f0/1-2
S3(config-if-range)# switchport mode trunk
S3(config-if-range)# switchport trunk native vlan 99
S3(config-if-range)# channel-group 3 mode passive
Creating a port-channel interface Port-channel 3
```

```
S3(config-if-range)# no shutdown
```

- b. Verify that the EtherChannel has formed.

```
S2# show etherchannel summary
Flags: D - down          P - bundled in port-channel
       I - stand-alone  s - suspended
       H - Hot-standby (LACP only)
       R - Layer3       S - Layer2
       U - in use       f - failed to allocate aggregator

       M - not in use, minimum links not met
       u - unsuitable for bundling
       w - waiting to be aggregated
       d - default port
```

```
Number of channel-groups in use: 2
Number of aggregators:          2
```

```
Group  Port-channel  Protocol  Ports
-----+-----+-----+-----
2      Po2 (SU)          LACP     Fa0/1 (P)  Fa0/2 (P)
3      Po3 (SU)          LACP     Fa0/3 (P)  Fa0/4 (P)
```

```
S3# show etherchannel summary
Flags: D - down          P - bundled in port-channel
```

Lab – Configuring EtherChannel

I - stand-alone s - suspended
H - Hot-standby (LACP only)
R - Layer3 S - Layer2
U - in use f - failed to allocate aggregator

M - not in use, minimum links not met
u - unsuitable for bundling
w - waiting to be aggregated
d - default port

Number of channel-groups in use: 2
Number of aggregators: 2

Group	Port-channel	Protocol	Ports	
1	Po1 (SU)	PAgP	Fa0/3 (P)	Fa0/4 (P)
3	Po3 (SU)	LACP	Fa0/1 (P)	Fa0/2 (P)

Step 4: Verify end-to-end connectivity.

Verify that all devices can ping each other within the same VLAN. If not, troubleshoot until there is end-to-end connectivity.

Note: It may be necessary to disable the PC firewall to ping between PCs.

Reflection

What could prevent EtherChannels from forming?

Configuration mismatch, such as trunk port on one end and access port at the other end, different aggregation protocols and different port speed/duplex, would prevent the formation of EtherChannel.

Device Configs

Switch S1

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/5, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/18, Fa0/19, Fa0/20, Fa0/21 Fa0/22, Fa0/23, Fa0/24, Gi0/1 Gi0/2
10	Staff	active	Fa0/6
99	Management	active	
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	

Lab – Configuring EtherChannel

```
1004 fddinet-default          act/unsup
1005 trnet-default            act/unsup
```

```
S1# show run
```

```
Building configuration...
```

```
Current configuration : 2339 bytes
```

```
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
!
!
!
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
!
interface Port-channel1
 switchport trunk native vlan 99
 switchport mode trunk
!
interface Port-channel2
```

Lab – Configuring EtherChannel

```
switchport trunk native vlan 99
switchport mode trunk
!
interface FastEthernet0/1
switchport trunk native vlan 99
switchport mode trunk
channel-group 2 mode active
!
interface FastEthernet0/2
switchport trunk native vlan 99
switchport mode trunk
channel-group 2 mode active
!
interface FastEthernet0/3
switchport trunk native vlan 99
switchport mode trunk
channel-group 1 mode desirable
!
interface FastEthernet0/4
switchport trunk native vlan 99
switchport mode trunk
channel-group 1 mode desirable
!
interface FastEthernet0/5
shutdown
!
interface FastEthernet0/6
switchport access vlan 10
switchport mode access
!
interface FastEthernet0/7
shutdown
!
interface FastEthernet0/8
shutdown
!
interface FastEthernet0/9
shutdown
!
interface FastEthernet0/10
shutdown
!
interface FastEthernet0/11
shutdown
!
interface FastEthernet0/12
shutdown
!
interface FastEthernet0/13
```

Lab – Configuring EtherChannel

```
shutdown
!
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
shutdown
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
!
interface GigabitEthernet0/1
shutdown
!
interface GigabitEthernet0/2
shutdown
!
interface Vlan1
no ip address
!
interface Vlan99
ip address 192.168.99.11 255.255.255.0
!
ip http server
ip http secure-server
```

Lab – Configuring EtherChannel

```
!  
!  
banner motd ^C  
  Unauthorized Access Prohibited.^C  
!  
line con 0  
  password 7 0822455D0A16  
  logging synchronous  
  login  
line vty 0 4  
  password 7 0822455D0A16  
  login  
line vty 5 15  
  password 7 1511021F0725  
  login  
!  
end
```

Switch S2

```
S2# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/19, Fa0/20, Fa0/21 Fa0/22, Fa0/23, Fa0/24, Gi0/1 Gi0/2
10 Staff	active	Fa0/18
99 Management	active	
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

```
S2# show run
```

```
Building configuration...
```

```
Current configuration : 2333 bytes
```

```
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
service password-encryption  
!  
hostname S2  
!
```

Lab – Configuring EtherChannel

```
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
!
!
!
!
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
!
interface Port-channel2
 switchport trunk native vlan 99
 switchport mode trunk
!
interface Port-channel3
 switchport trunk native vlan 99
 switchport mode trunk
!
interface FastEthernet0/1
 switchport trunk native vlan 99
 switchport mode trunk
 channel-group 2 mode passive
!
interface FastEthernet0/2
 switchport trunk native vlan 99
 switchport mode trunk
 channel-group 2 mode passive
!
interface FastEthernet0/3
 switchport trunk native vlan 99
 switchport mode trunk
```

Lab – Configuring EtherChannel

```
channel-group 3 mode active
!
interface FastEthernet0/4
 switchport trunk native vlan 99
 switchport mode trunk
 channel-group 3 mode active
!
interface FastEthernet0/5
 shutdown
!
interface FastEthernet0/6
 shutdown
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
!
interface FastEthernet0/11
 shutdown
!
interface FastEthernet0/12
 shutdown
!
interface FastEthernet0/13
 shutdown
!
interface FastEthernet0/14
 shutdown
!
interface FastEthernet0/15
 shutdown
!
interface FastEthernet0/16
 shutdown
!
interface FastEthernet0/17
 shutdown
!
interface FastEthernet0/18
 switchport access vlan 10
 switchport mode access
```

Lab – Configuring EtherChannel

```
!  
interface FastEthernet0/19  
 shutdown  
!  
interface FastEthernet0/20  
 shutdown  
!  
interface FastEthernet0/21  
 shutdown  
!  
interface FastEthernet0/22  
 shutdown  
!  
interface FastEthernet0/23  
 shutdown  
!  
interface FastEthernet0/24  
 shutdown  
!  
interface GigabitEthernet0/1  
 shutdown  
!  
interface GigabitEthernet0/2  
 shutdown  
!  
interface Vlan1  
 no ip address  
!  
interface Vlan99  
 ip address 192.168.99.12 255.255.255.0  
!  
ip http server  
ip http secure-server  
!  
banner motd ^C  
  Unauthorized Access Prohibited.^C  
!  
line con 0  
 password 7 060506324F41  
 logging synchronous  
 login  
line vty 0 4  
 password 7 060506324F41  
 login  
line vty 5 15  
 password 7 121A0C041104  
 login  
!  
end
```

Lab – Configuring EtherChannel

Switch S3

```
S3# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/19, Fa0/20, Fa0/21 Fa0/22, Fa0/23, Fa0/24, Gi0/1 Gi0/2
10 Staff	active	Fa0/18
99 Management	active	
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

```
S3# show run
```

```
Building configuration...
```

```
Current configuration : 2331 bytes
```

```
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
service password-encryption  
!  
hostname S3  
!  
boot-start-marker  
boot-end-marker  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGholQM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
system mtu routing 1500  
!  
!  
no ip domain-lookup  
!  
!  
!  
!  
!  
!  
!
```

Lab – Configuring EtherChannel

```
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
!
interface Port-channel1
  switchport trunk native vlan 99
  switchport mode trunk
!
interface Port-channel3
  switchport trunk native vlan 99
  switchport mode trunk
!
interface FastEthernet0/1
  switchport trunk native vlan 99
  switchport mode trunk
  channel-group 3 mode passive
!
interface FastEthernet0/2
  switchport trunk native vlan 99
  switchport mode trunk
  channel-group 3 mode passive
!
interface FastEthernet0/3
  switchport trunk native vlan 99
  switchport mode trunk
  channel-group 1 mode auto
!
interface FastEthernet0/4
  switchport trunk native vlan 99
  switchport mode trunk
  channel-group 1 mode auto
!
interface FastEthernet0/5
  shutdown
!
interface FastEthernet0/6
  shutdown
!
interface FastEthernet0/7
  shutdown
!
interface FastEthernet0/8
  shutdown
```

Lab – Configuring EtherChannel

```
!  
interface FastEthernet0/9  
shutdown  
!  
interface FastEthernet0/10  
shutdown  
!  
interface FastEthernet0/11  
shutdown  
!  
interface FastEthernet0/12  
shutdown  
!  
interface FastEthernet0/13  
shutdown  
!  
interface FastEthernet0/14  
shutdown  
!  
interface FastEthernet0/15  
shutdown  
!  
interface FastEthernet0/16  
shutdown  
!  
interface FastEthernet0/17  
shutdown  
!  
interface FastEthernet0/18  
switchport access vlan 10  
switchport mode access  
!  
interface FastEthernet0/19  
shutdown  
!  
interface FastEthernet0/20  
shutdown  
!  
interface FastEthernet0/21  
shutdown  
!  
interface FastEthernet0/22  
shutdown  
!  
interface FastEthernet0/23  
shutdown  
!  
interface FastEthernet0/24  
shutdown
```

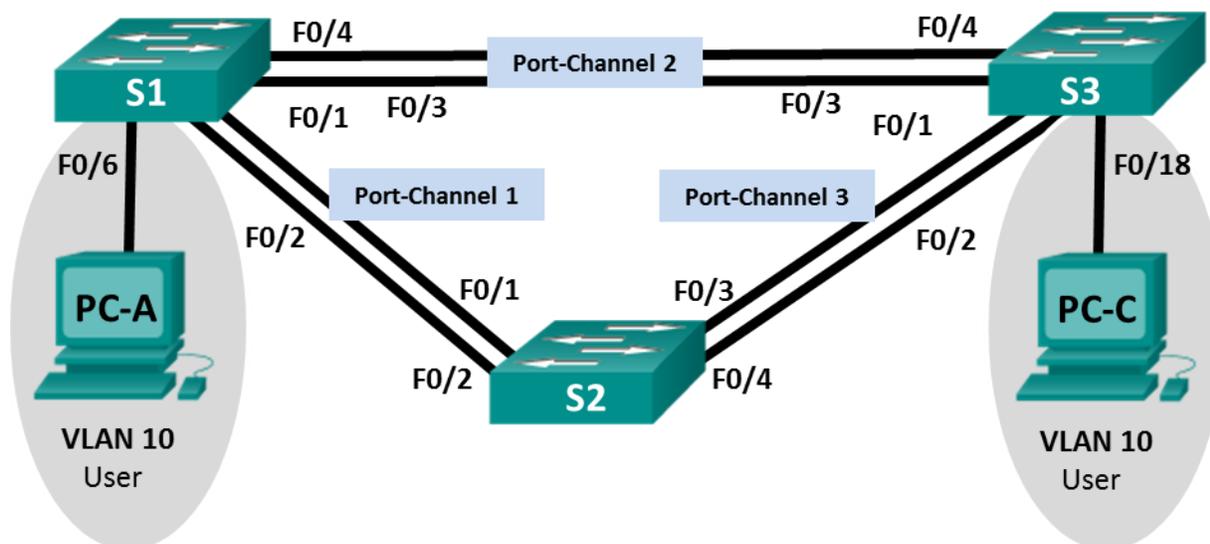
Lab – Configuring EtherChannel

```
!  
interface GigabitEthernet0/1  
 shutdown  
!  
interface GigabitEthernet0/2  
 shutdown  
!  
interface Vlan1  
 no ip address  
!  
interface Vlan99  
 ip address 192.168.99.13 255.255.255.0  
!  
ip http server  
ip http secure-server  
!  
!  
banner motd ^C  
  Unauthorized Access Prohibited.^C  
!  
line con 0  
 password 7 045802150C2E  
 logging synchronous  
 login  
line vty 0 4  
 password 7 110A1016141D  
 login  
line vty 5 15  
 password 7 070C285F4D06  
 login  
!  
end
```

Lab – Troubleshooting EtherChannel (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask
S1	VLAN 99	192.168.1.11	255.255.255.0
S2	VLAN 99	192.168.1.12	255.255.255.0
S3	VLAN 99	192.168.1.13	255.255.255.0
PC-A	NIC	192.168.0.2	255.255.255.0
PC-C	NIC	192.168.0.3	255.255.255.0

VLAN Assignments

VLAN	Name
10	User
99	Management

Objectives

Part 1: Build the Network and Load Device Configurations

Part 2: Troubleshoot EtherChannel

Background / Scenario

The switches at your company were configured by an inexperienced network administrator. Several errors in the configuration have resulted in speed and connectivity issues. Your manager has asked you to troubleshoot and correct the configuration errors and document your work. Using your knowledge of EtherChannel and standard testing methods, find and correct the errors. Ensure that all of the EtherChannels use Port Aggregation Protocol (PAgP), and that all hosts are reachable.

Note: The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs.

Note: Make sure that the switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with a terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Load Device Configurations

In Part 1, you will set up the network topology, configure basic settings on the PC hosts, and load configurations on the switches.

Step 1: Cable the network as shown in the topology.

Step 2: Configure the PC hosts.

Step 3: Erase the startup and VLAN configurations and reload the switches.

Step 4: Load switch configurations.

Load the following configurations into the appropriate switch. All switches have the same passwords. The privileged EXEC password is **class**. The password for console and vty access is **cisco**. As all switches are Cisco devices, the network administrator decided to use Cisco's PAgP on all port channels configured with EtherChannel. Switch S2 is the root bridge for all VLANs in the topology.

Switch S1 Configuration:

```
hostname S1
interface range f0/1-24, g0/1-2
shutdown
exit
enable secret class
no ip domain lookup
line vty 0 15
password cisco
login
line con 0
```

Lab – Troubleshooting EtherChannel

```
password cisco
logging synchronous
login
exit
vlan 10
name User
vlan 99
Name Management
interface range f0/1-2
switchport mode trunk
! channel-group 1 mode desirable
channel-group 1 mode active
switchport trunk native vlan 99
no shutdown
interface range f0/3-4
channel-group 2 mode desirable
switchport trunk native vlan 99
! switchport mode trunk
no shutdown
interface f0/6
switchport mode access
switchport access vlan 10
no shutdown
interface vlan 99
ip address 192.168.1.11 255.255.255.0
interface port-channel 1
switchport trunk native vlan 99
switchport mode trunk
interface port-channel 2
switchport trunk native vlan 99
switchport mode access
! switchport mode trunk
```

Switch S2 Configuration:

```
hostname S2
interface range f0/1-24, g0/1-2
shutdown
exit
enable secret class
no ip domain lookup
line vty 0 15
password cisco
login
line con 0
password cisco
logging synchronous
```

Lab – Troubleshooting EtherChannel

```
login
exit
vlan 10
  name User
vlan 99
  name Management
spanning-tree vlan 1,10,99 root primary
interface range f0/1-2
  switchport mode trunk
  channel-group 1 mode desirable
  switchport trunk native vlan 99
  no shutdown
interface range f0/3-4
  switchport mode trunk
  channel-group 3 mode desirable
  switchport trunk native vlan 99
! no shutdown
interface vlan 99
  ip address 192.168.1.12 255.255.255.0
interface port-channel 1
  switchport trunk native vlan 99
  switchport trunk allowed vlan 1,99
! switchport trunk allowed 1,10,99
interface port-channel 3
  switchport trunk native vlan 99
  switchport trunk allowed vlan 1,10,99
  switchport mode trunk
```

Switch S3 Configuration:

```
hostname S3
interface range f0/1-24, g0/1-2
  shutdown
  exit
enable secret class
no ip domain lookup
line vty 0 15
  password cisco
  login
line con 0
  password cisco
  logging synchronous
  login
  exit
vlan 10
  name User
vlan 99
```

Lab – Troubleshooting EtherChannel

```
name Management
interface range f0/1-2
! switchport mode trunk
! channel-group 3 mode desirable
! switchport trunk native vlan 99
! no shutdown
interface range f0/3-4
switchport mode trunk
! channel-group 2 mode desirable
channel-group 3 mode desirable
switchport trunk native vlan 99
no shutdown
interface f0/18
switchport mode access
switchport access vlan 10
no shutdown
interface vlan 99
ip address 192.168.1.13 255.255.255.0
! interface port-channel 2
! switchport trunk native vlan 99
! switchport mode trunk
interface port-channel 3
switchport trunk native vlan 99
switchport mode trunk
```

Step 5: Save your configuration.

Part 2: Troubleshoot EtherChannel

In Part 2, you must examine the configurations on all switches, make corrections if needed, and verify full functionality.

Step 1: Troubleshoot S1.

- Use the **show interfaces trunk** command to verify that the port channels are functioning as trunk ports.

```
S1# show interfaces trunk
```

Port	Mode	Encapsulation	Status	Native vlan
Fa0/1	on	802.1q	trunking	99
Fa0/2	on	802.1q	trunking	99

```
Port Vlans allowed on trunk
```

```
Fa0/1 1-4094
Fa0/2 1-4094
```

```
Port Vlans allowed and active in management domain
```

```
Fa0/1 1,10,99
Fa0/2 1,10,99
```

Lab – Troubleshooting EtherChannel

```
Port          Vlans in spanning tree forwarding state and not pruned
Fa0/1         none
Fa0/2         none
```

Do port channels 1 and 2 appear as trunked ports? _____ **No**

- b. Use the **show etherchannel summary** command to verify that interfaces are configured in the correct port channel, the proper protocol is configured, and the interfaces are in use.

```
S1# show etherchannel summary
```

```
Flags:  D - down          P - bundled in port-channel
         I - stand-alone   s - suspended
         H - Hot-standby (LACP only)
         R - Layer3       S - Layer2
         U - in use       f - failed to allocate aggregator

         M - not in use, minimum links not met
         u - unsuitable for bundling
         w - waiting to be aggregated
         d - default port
```

```
Number of channel-groups in use: 2
```

```
Number of aggregators:          2
```

```
Group  Port-channel  Protocol  Ports
-----+-----+-----+-----
1      Po1 (SD)        LACP      Fa0/1 (I) Fa0/2 (I)
2      Po2 (SD)        PAgP      Fa0/3 (I) Fa0/4 (I)
```

Based on the output, are there any EtherChannel issues? If issues are found, record them in the space provided below.

Yes. Port Channel 1 is configured with the Link Aggregation Control Protocol (LACP), and the ports in Port Channel 2 are functioning independently (I = stand-alone).

- c. Use the command **show run | begin interface Port-channel** command to view the running configuration beginning with the first port channel interface.

```
S1# show run | begin interface Port-channel
```

```
interface Port-channel1
  switchport trunk native vlan 99
  switchport mode trunk
!
interface Port-channel2
  switchport trunk native vlan 99
  switchport mode access
!
interface FastEthernet0/1
  switchport trunk native vlan 99
  switchport mode trunk
```

Lab – Troubleshooting EtherChannel

```
channel-group 1 mode active
!
interface FastEthernet0/2
  switchport trunk native vlan 99
  switchport mode trunk
channel-group 1 mode active
!
interface FastEthernet0/3
  switchport trunk native vlan 99
switchport mode access
channel-group 2 mode desirable
!
interface FastEthernet0/4
  switchport trunk native vlan 99
switchport mode access
channel-group 2 mode desirable
!
interface FastEthernet0/5
  shutdown
!
interface FastEthernet0/6
  switchport access vlan 10
  switchport mode access
!
interface FastEthernet0/7
  shutdown
!
<output omitted>
```

- d. Resolve all problems found in the outputs from the previous **show** commands. Record the commands used to correct the configurations.

```
S1(config)# interface range f0/1-2
S1(config-if-range)# no channel-group 1 mode active
S1(config-if-range)# channel-group 1 mode desirable
S1(config-if-range)# exit
S1(config)# interface port-channel 2
S1(config-if)# switchport mode trunk
```

- e. Use the **show interfaces trunk** command to verify trunk settings.

```
S1# show interfaces trunk
Port      Mode      Encapsulation  Status      Native vlan
Po1       on        802.1q         trunking    99
Po2       on        802.1q         trunking    99
```

Lab – Troubleshooting EtherChannel

```
Port          Vlans allowed on trunk
Po1           1-4094
Po2           1-4094

Port          Vlans allowed and active in management domain
Po1           1,10,99
Po2           1,10,99

Port          Vlans in spanning tree forwarding state and not pruned
Po1           1,10,99
Po2           1,10,99
```

- f. Use the **show etherchannel summary** command to verify that the port channels are up and in use.

```
S1# show etherchannel summary
Flags:  D - down          P - bundled in port-channel
        I - stand-alone  s - suspended
        H - Hot-standby (LACP only)
        R - Layer3       S - Layer2
        U - in use       f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port

Number of channel-groups in use: 2
Number of aggregators:          2

Group  Port-channel  Protocol    Ports
-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
1      Po1(SU)        PAgP        Fa0/1(P)   Fa0/2(P)
2      Po2(SU)        PAgP        Fa0/3(P)   Fa0/4(P)
```

Step 2: Troubleshoot S2.

- a. Issue the command to verify that the port channels are functioning as trunk ports. Record the command used in the space provided below.

```
S2# show interfaces trunk
S2# show interfaces trunk
Port          Mode          Encapsulation  Status        Native vlan
Po1           on            802.1q         trunking      99

Port          Vlans allowed on trunk
Po1           1,99

Port          Vlans allowed and active in management domain
```


Lab – Troubleshooting EtherChannel

```
switchport mode trunk
!
interface FastEthernet0/1
switchport trunk native vlan 99
switchport trunk allowed vlan 1,99
switchport mode trunk
channel-group 1 mode desirable
!
interface FastEthernet0/2
switchport trunk native vlan 99
switchport trunk allowed vlan 1,99
switchport mode trunk
channel-group 1 mode desirable
!
interface FastEthernet0/3
switchport trunk native vlan 99
switchport trunk allowed vlan 1,10,99
switchport mode trunk
shutdown
channel-group 3 mode desirable
!
interface FastEthernet0/4
switchport trunk native vlan 99
switchport trunk allowed vlan 1,10,99
switchport mode trunk
shutdown
channel-group 3 mode desirable
!
interface FastEthernet0/5
shutdown
!
interface FastEthernet0/6
shutdown
!
<output omitted>
```

- d. Resolve all problems found in the outputs from the previous **show** commands. Record the commands used to correct the configuration.

```
S2(config)# interface range f0/3-4
S2(config-if-range)# no shutdown
S2(config-if-range)# exit
S2(config)# interface port-channel 1
```

Lab – Troubleshooting EtherChannel

```
S2(config-if)# switchport trunk allowed vlan 1,10,99
```

- e. Issue the command to verify trunk settings.

```
S2# show interfaces trunk
Port      Mode           Encapsulation  Status        Native vlan
Po1       on             802.1q         trunking      99

Port      Vlans allowed on trunk
Po1       1,10,99

Port      Vlans allowed and active in management domain
Po1       1,10,99

Port      Vlans in spanning tree forwarding state and not pruned
Po1       1,10,99
```

- f. Issue the command to verify that the port channels are functioning. Remember that port channel issues can be caused by either end of the link.

```
S2# show etherchannel summary
Flags: D - down          P - bundled in port-channel
       I - stand-alone   s - suspended
       H - Hot-standby (LACP only)
       R - Layer3       S - Layer2
       U - in use       f - failed to allocate aggregator

       M - not in use, minimum links not met
       u - unsuitable for bundling
       w - waiting to be aggregated
       d - default port

Number of channel-groups in use: 2
Number of aggregators:          2

Group  Port-channel  Protocol    Ports
-----+-----+-----+-----+-----
1      Po1(SU)       PAgP        Fa0/1(P)   Fa0/2(P)
3      Po3(SD)       PAgP        Fa0/3(D)   Fa0/4(D)
```

Step 3: Troubleshoot S3.

- a. Issue the command to verify that the port channels are functioning as trunk ports.

```
S3# show interfaces trunk
Port      Mode           Encapsulation  Status        Native vlan
Po3       on             802.1q         trunking      99

Port      Vlans allowed on trunk
Po3       1-4094

Port      Vlans allowed and active in management domain
```

Lab – Troubleshooting EtherChannel

```
Po3          1,10,99
```

```
Port          Vlans in spanning tree forwarding state and not pruned
Po3          1,10,99
```

Based on the output, are there any issues with the configurations? If issues are found, record them in the space provided below.

Port Channel 2 is not present in the output.

- b. Issue the command to verify that the interfaces are configured in the correct port channel and that the proper protocol is configured.

```
S3# show etherchannel summary
```

```
Flags:  D - down          P - bundled in port-channel
        I - stand-alone  s - suspended
        H - Hot-standby (LACP only)
        R - Layer3       S - Layer2
        U - in use       f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port
```

```
Number of channel-groups in use: 1
Number of aggregators:          1
```

```
Group  Port-channel  Protocol  Ports
-----+-----+-----+-----
3      Po3(SU)        PAgP     Fa0/3 (P)  Fa0/4 (P)
```

Based on the output, are there any EtherChannel issues? If issues are found, record them in the space provided below.

Port Channel 2 is not present, and Port Channel 3 is incorrectly configured for interfaces f0/3 and f0/4.

- c. Use the command **show run | begin interface Port-channel** command to view the running configuration beginning with the first port channel interface.

```
S3# show run | begin interface Port-channel
interface Port-channel3
  switchport trunk native vlan 99
  switchport mode trunk
!
interface FastEthernet0/1
shutdown
!
```

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```
interface FastEthernet0/2
shutdown
!
interface FastEthernet0/3
switchport trunk native vlan 99
switchport mode trunk
channel-group 3 mode desirable
!
interface FastEthernet0/4
switchport trunk native vlan 99
switchport mode trunk
channel-group 3 mode desirable
!
interface FastEthernet0/5
shutdown
!
interface FastEthernet0/6
shutdown
!
<output omitted>
```

- d. Resolve all problems found. Record the commands used to correct the configuration.

```
S3(config)# interface range f0/3-4
S3(config-if-range)# channel-group 2 mode desirable
S3(config-if-range)# interface range f0/1-2
S3(config-if-range)# switchport mode trunk
S3(config-if-range)# switchport trunk native vlan 99
S3(config-if-range)# channel-group 3 mode desirable
S3(config-if-range)# no shutdown
```

- e. Issue the command to verify trunk settings. Record the command used in the space provided below.

```
S3# show interfaces trunk
S3# show interfaces trunk
Port          Mode          Encapsulation  Status        Native vlan
Po2           on            802.1q         trunking      99
Po3           on            802.1q         trunking      99

Port          Vlans allowed on trunk
```

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```
Po2      1-4094
Po3      1-4094
```

```
Port      Vlans allowed and active in management domain
Po2      1,10,99
Po3      1,10,99
```

```
Port      Vlans in spanning tree forwarding state and not pruned
Po2      1,10,99
Po3      1,10,99
```

- f. Issue the command to verify that the port channels are functioning. Record the command used in the space provided below.

```
S3# show etherchannel summary
```

```
S3# show etherchannel summary
```

```
Flags:  D - down                P - bundled in port-channel
        I - stand-alone          s - suspended
        H - Hot-standby (LACP only)
        R - Layer3              S - Layer2
        U - in use              f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port
```

```
Number of channel-groups in use: 2
Number of aggregators:           2
```

Group	Port-channel	Protocol	Ports	
2	Po2(SU)	PAgP	Fa0/3(P)	Fa0/4(P)
3	Po3(SU)	PAgP	Fa0/1(P)	Fa0/2(P)

Step 4: Verify EtherChannel and Connectivity.

- a. Use the **show interfaces etherchannel** command to verify full functionality of the port channels.

```
S1# show interfaces etherchannel
```

```
----
```

```
FastEthernet0/1:
```

```
Port state = Up Mstr In-Bndl
```

```
Channel group = 1 Mode = Desirable-S1 Gcchange = 0
```

```
Port-channel = Po1 GC = 0x00010001 Pseudo port-channel = Po1
```

```
Port index = 0 Load = 0x00 Protocol = PAgP
```

```
Flags:  S - Device is sending Slow hello.  C - Device is in Consistent state.
        A - Device is in Auto mode.        P - Device learns on physical port.
```

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```

    d - PAgP is down.
Timers: H - Hello timer is running.      Q - Quit timer is running.
        S - Switching timer is running.   I - Interface timer is running.

Local information:

Port      Flags State   Timers  Hello  Partner PAgP    Learning Group
         SC   U6/S7   H       Interval Count  Priority Method  Ifindex
Fa0/1     SC   U6/S7   H       30s    1       128    Any    5001

Partner's information:

Port      Partner          Partner          Partner          Partner Group
         Name           Device ID       Port            Age  Flags  Cap.
Fa0/1     S2              0cd9.96e8.6f80  Fa0/1           23s SC    10001

Age of the port in the current state: 0d:00h:38m:38s

----
FastEthernet0/2:
Port state      = Up Mstr In-Bndl
Channel group = 1          Mode = Desirable-Sl      Gchange = 0
Port-channel   = Po1      GC   = 0x00010001        Pseudo port-channel = Po1
Port index     = 0          Load = 0x00             Protocol = PAgP

Flags: S - Device is sending Slow hello.  C - Device is in Consistent state.
      A - Device is in Auto mode.         P - Device learns on physical port.
      d - PAgP is down.

Timers: H - Hello timer is running.      Q - Quit timer is running.
        S - Switching timer is running.   I - Interface timer is running.

Local information:

Port      Flags State   Timers  Hello  Partner PAgP    Learning Group
         SC   U6/S7   H       Interval Count  Priority Method  Ifindex
Fa0/2     SC   U6/S7   H       30s    1       128    Any    5001

Partner's information:

Port      Partner          Partner          Partner          Partner Group
         Name           Device ID       Port            Age  Flags  Cap.
Fa0/2     S2              0cd9.96e8.6f80  Fa0/2           7s  SC    10001

Age of the port in the current state: 0d:00h:38m:38s

----
FastEthernet0/3:
Port state      = Up Mstr In-Bndl
Channel group = 2          Mode = Desirable-Sl      Gchange = 0
Port-channel   = Po2      GC   = 0x00020001        Pseudo port-channel = Po2
Port index     = 0          Load = 0x00             Protocol = PAgP
```

Lab – Troubleshooting EtherChannel

Flags: S - Device is sending Slow hello. C - Device is in Consistent state.
A - Device is in Auto mode. P - Device learns on physical port.
d - PAgP is down.

Timers: H - Hello timer is running. Q - Quit timer is running.
S - Switching timer is running. I - Interface timer is running.

Local information:

Port	Flags	State	Timers	Hello Interval	Partner Count	PAgP Priority	Learning Method	Group Ifindex
Fa0/3	SC	U6/S7	H	30s	1	128	Any	5002

Partner's information:

Port	Partner Name	Partner Device ID	Partner Port	Partner Age	Partner Flags	Partner Group Cap.
Fa0/3	S3	0cd9.96d2.5100	Fa0/3	5s	SC	20001

Age of the port in the current state: 0d:00h:28m:48s

FastEthernet0/4:

Port state = Up Mstr In-Bndl
Channel group = 2 Mode = Desirable-S1 Gchange = 0
Port-channel = Po2 GC = 0x00020001 Pseudo port-channel = Po2
Port index = 0 Load = 0x00 Protocol = PAgP

Flags: S - Device is sending Slow hello. C - Device is in Consistent state.
A - Device is in Auto mode. P - Device learns on physical port.
d - PAgP is down.

Timers: H - Hello timer is running. Q - Quit timer is running.
S - Switching timer is running. I - Interface timer is running.

Local information:

Port	Flags	State	Timers	Hello Interval	Partner Count	PAgP Priority	Learning Method	Group Ifindex
Fa0/4	SC	U6/S7	H	30s	1	128	Any	5002

Partner's information:

Port	Partner Name	Partner Device ID	Partner Port	Partner Age	Partner Flags	Partner Group Cap.
Fa0/4	S3	0cd9.96d2.5100	Fa0/4	6s	SC	20001

Age of the port in the current state: 0d:00h:28m:48s

Port-channel1:

Age of the Port-channel = 0d:00h:57m:52s

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```
Logical slot/port = 2/1          Number of ports = 2
GC                = 0x00010001   HotStandBy port = null
Port state       = Port-channel Ag-Inuse
Protocol         = PAgP
Port security    = Disabled
```

Ports in the Port-channel:

Index	Load	Port	EC state	No of bits
0	00	Fa0/1	Desirable-Sl	0
0	00	Fa0/2	Desirable-Sl	0

```
Time since last port bundled: 0d:00h:38m:38s Fa0/1
Time since last port Un-bundled: 0d:00h:42m:15s Fa0/2
----
```

Port-channel2:

```
Age of the Port-channel = 0d:00h:57m:48s
Logical slot/port = 2/2          Number of ports = 2
GC                = 0x00020001   HotStandBy port = null
Port state       = Port-channel Ag-Inuse
Protocol         = PAgP
Port security    = Disabled
```

Ports in the Port-channel:

Index	Load	Port	EC state	No of bits
0	00	Fa0/3	Desirable-Sl	0
0	00	Fa0/4	Desirable-Sl	0

```
Time since last port bundled: 0d:00h:28m:48s Fa0/4
Time since last port Un-bundled: 0d:00h:28m:51s Fa0/4
```

b. Verify connectivity of the management VLAN.

Can S1 ping S2? Yes

Can S1 ping S3? Yes

Can S2 ping S3? Yes

c. Verify connectivity of PCs.

Can PC-A ping PC-C? Yes

If EtherChannels are not fully functional, connectivity between switches does not exist, or connectivity between hosts does not exist. Troubleshoot to resolve any remaining issues.

Note: It may be necessary to disable the PC firewall for pings between the PCs to succeed.

Device Configs - Final

Switch S1

```
S1#show run
Building configuration...

Current configuration : 2241 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface Port-channel1
 switchport trunk native vlan 99
 switchport mode trunk
!
interface Port-channel2
 switchport trunk native vlan 99
 switchport mode trunk
!
interface FastEthernet0/1
 switchport trunk native vlan 99
 switchport mode trunk
 channel-group 1 mode desirable
!
interface FastEthernet0/2
 switchport trunk native vlan 99
 switchport mode trunk
 channel-group 1 mode desirable
!
interface FastEthernet0/3
 switchport trunk native vlan 99
 switchport mode trunk
 channel-group 2 mode desirable
!
interface FastEthernet0/4
 switchport trunk native vlan 99
```

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```
switchport mode trunk
channel-group 2 mode desirable
!
interface FastEthernet0/5
shutdown
!
interface FastEthernet0/6
switchport access vlan 10
switchport mode access
!
interface FastEthernet0/7
shutdown
!
interface FastEthernet0/8
shutdown
!
interface FastEthernet0/9
shutdown
!
interface FastEthernet0/10
shutdown
!
interface FastEthernet0/11
shutdown
!
interface FastEthernet0/12
shutdown
!
interface FastEthernet0/13
shutdown
!
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
shutdown
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
```

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```
!  
interface FastEthernet0/23  
shutdown  
!  
interface FastEthernet0/24  
shutdown  
!  
interface GigabitEthernet0/1  
shudown  
!  
interface GigabitEthernet0/2  
shudown  
!  
interface Vlan1  
no ip address  
!  
interface Vlan99  
ip address 192.168.1.11 255.255.255.0  
!  
ip http server  
ip http secure-server  
!  
line con 0  
password cisco  
logging synchronous  
login  
line vty 0 4  
password cisco  
login  
line vty 5 15  
password cisco  
login  
!  
end
```

Switch S2

```
S2#show run  
Building configuration...  
  
Current configuration : 2476 bytes  
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname S2  
!  
boot-start-marker  
boot-end-marker  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
system mtu routing 1500
```

Lab – Troubleshooting EtherChannel

```
!  
no ip domain-lookup  
!  
spanning-tree mode pvst  
spanning-tree extend system-id  
spanning-tree vlan 1,10,99 priority 24576  
!  
vlan internal allocation policy ascending  
!  
interface Port-channel1  
  switchport trunk native vlan 99  
  switchport trunk allowed vlan 1,10,99  
  switchport mode trunk  
!  
interface Port-channel3  
  switchport trunk native vlan 99  
  switchport trunk allowed vlan 1,10,99  
  switchport mode trunk  
!  
interface FastEthernet0/1  
  switchport trunk native vlan 99  
  switchport trunk allowed vlan 1,10,99  
  switchport mode trunk  
  channel-group 1 mode desirable  
!  
interface FastEthernet0/2  
  switchport trunk native vlan 99  
  switchport trunk allowed vlan 1,10,99  
  switchport mode trunk  
  channel-group 1 mode desirable  
!  
interface FastEthernet0/3  
  switchport trunk native vlan 99  
  switchport trunk allowed vlan 1,10,99  
  switchport mode trunk  
  channel-group 3 mode desirable  
!  
interface FastEthernet0/4  
  switchport trunk native vlan 99  
  switchport trunk allowed vlan 1,10,99  
  switchport mode trunk  
  channel-group 3 mode desirable  
!  
interface FastEthernet0/5  
  shutdown  
!  
interface FastEthernet0/6  
  shutdown  
!  
interface FastEthernet0/7  
  shutdown  
!  
interface FastEthernet0/8  
  shutdown  
!  
interface FastEthernet0/9  
  shutdown
```

Lab – Troubleshooting EtherChannel

```
!  
interface FastEthernet0/10  
shutdown  
!  
interface FastEthernet0/11  
shutdown  
!  
interface FastEthernet0/12  
shutdown  
!  
interface FastEthernet0/13  
shutdown  
!  
interface FastEthernet0/14  
shutdown  
!  
interface FastEthernet0/15  
shutdown  
!  
interface FastEthernet0/16  
shutdown  
!  
interface FastEthernet0/17  
shutdown  
!  
interface FastEthernet0/18  
shutdown  
!  
interface FastEthernet0/19  
shutdown  
!  
interface FastEthernet0/20  
shutdown  
!  
interface FastEthernet0/21  
shutdown  
!  
interface FastEthernet0/22  
shutdown  
!  
interface FastEthernet0/23  
shutdown  
!  
interface FastEthernet0/24  
shutdown  
!  
interface GigabitEthernet0/1  
shudown  
!  
interface GigabitEthernet0/2  
shudown  
!  
interface Vlan1  
no ip address  
!  
interface Vlan99  
ip address 192.168.1.12 255.255.255.0
```

Lab – Troubleshooting EtherChannel

```
!  
ip http server  
ip http secure-server  
!  
line con 0  
  password cisco  
  logging synchronous  
  login  
line vty 0 4  
  password cisco  
  login  
line vty 5 15  
  password cisco  
  login  
!  
end
```

Switch S3

```
S3#show run  
Building configuration...  
  
Current configuration : 2239 bytes  
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname S3  
!  
boot-start-marker  
boot-end-marker  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
system mtu routing 1500  
!  
no ip domain-lookup  
!  
spanning-tree mode pvst  
spanning-tree extend system-id  
!  
vlan internal allocation policy ascending  
!  
interface Port-channel2  
  switchport trunk native vlan 99  
  switchport mode trunk  
!  
interface Port-channel3  
  switchport trunk native vlan 99  
  switchport mode trunk  
!  
interface FastEthernet0/1  
  switchport trunk native vlan 99
```

Lab – Troubleshooting EtherChannel

```
switchport mode trunk
channel-group 3 mode desirable
!
interface FastEthernet0/2
switchport trunk native vlan 99
switchport mode trunk
channel-group 3 mode desirable
!
interface FastEthernet0/3
switchport trunk native vlan 99
switchport mode trunk
channel-group 2 mode desirable
!
interface FastEthernet0/4
switchport trunk native vlan 99
switchport mode trunk
channel-group 2 mode desirable
!
interface FastEthernet0/5
shutdown
!
interface FastEthernet0/6
shutdown
!
interface FastEthernet0/7
shutdown
!
interface FastEthernet0/8
shutdown
!
interface FastEthernet0/9
shutdown
!
interface FastEthernet0/10
shutdown
!
interface FastEthernet0/11
shutdown
!
interface FastEthernet0/12
shutdown
!
interface FastEthernet0/13
shutdown
!
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
```

Lab – Troubleshooting EtherChannel

```
interface FastEthernet0/18
  switchport access vlan 10
  switchport mode access
!
interface FastEthernet0/19
  shutdown
!
interface FastEthernet0/20
  shutdown
!
interface FastEthernet0/21
  shutdown
!
interface FastEthernet0/22
  shutdown
!
interface FastEthernet0/23
  shutdown
!
interface FastEthernet0/24
  shutdown
!
interface GigabitEthernet0/1
  shutdown
!
interface GigabitEthernet0/2
  shutdown
!
interface Vlan1
  no ip address
!
interface Vlan99
  ip address 192.168.1.13 255.255.255.0
!
ip http server
ip http secure-server
!
line con 0
  password cisco
  logging synchronous
  login
line vty 0 4
  password cisco
  login
line vty 5 15
  password cisco
  login
!
end
```

Linking Up (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Describe link aggregation.

Instructor Note: This modeling activity is best completed in very small groups and then shared with another group or the class.

Scenario

Many bottlenecks occur on your small- to medium-sized business network, even though you have configured VLANs, STP, and other network traffic options on the company's switches.

Instead of keeping the switches as they are currently configured, you would like to try EtherChannel as an option for, at least, part of the network to see if it will lesson traffic congestion between your access and distribution layer switches.

Your company uses Catalyst 3560 switches at the distribution layer and Catalyst 2960 and 2950 switches at the access layer of the network. To verify if these switches can perform EtherChannel, you visit the [System Requirements to Implement EtherChannel on Catalyst Switches](#). This site allows you to gather more information to determine if EtherChannel is a good option for the equipment and network currently in place.

After researching the models, you decide to use a simulation software program to practice configuring EtherChannel before implementing it live on your network. As a part of this procedure, you ensure that the equipment simulated in Packet Tracer will support these practice configurations.

Resources

- World Wide Web connectivity
- Packet Tracer software
- Word processing or spreadsheet software

Directions

Step 1: Visit [System Requirements to Implement EtherChannel on Catalyst Switches](#).

- a. Pay particular attention to the Catalyst 3560, 2960, and 2950 model information.
- b. Record any information you feel would be useful to deciding whether to use EtherChannel in your company.

Step 2: Create a matrix to record the information you recorded in Step 1b, including:

- a. Number of ports allowed to be bundled for an EtherChannel group
- b. Maximum group bandwidth supported by bundling the ports
- c. IOS version needed to support EtherChannel on the switch model
- d. Load balancing availability
- e. Load balancing configuration options
- f. Network layers supported for EtherChannel operation

Step 3: Open Packet Tracer.

- a. Notice how many ports are available to bundle for EtherChannel on all three switch models.
- b. Check all three models to see how many EtherChannel groups you could create on each model.
- c. Make sure the IOS version is recent enough to support all EtherChannel configurations.
- d. Do not configure your simulated network, but do check the models available in the Packet Tracer to make sure they will support all the EtherChannel configuration options.

Step 4: Share your matrix with another group or the class.

Instructor – Example Activity Solution

EtherChannel Requirements	Catalyst 3560	Catalyst 2960	Catalyst 2950
Maximum number of ports allowed for channel groups	8	8	8
Etherchannel bandwidth created per group	800 Mbps 8 Gbps	800 Mbps 2 Gbps	800 Mbps 2 Gbps
Minimum IOS Version supported	12.1(19)EA	12.2(25)FX	12.0(5.2)WC(1)
Load balancing types	MAC or IP address Source or destination Source and destination	MAC or IP address Source or destination Source and destination	MAC address Source or destination
OSI Model layers supported for configuration	Layers 2 and 3	Layers 2 and 3	Layer 2
Packet Tracer program IOS version	1.2(37)SE1	12.2(25r)FX	12.1(22)EA4
Number of Packet Tracer ports available for channel groups	24 FastEthernet 2 GigabitEthernet	24 FastEthernet 2 GigabitEthernet	24 FastEthernet

Identify elements of the model that map to IT-related content:

- EtherChannel
- EtherChannel switch models
- Bandwidth for channel groups
- EtherChannel configuration layers
- IOS for switch models using EtherChannel

Switching to Local-Network Channels (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Configure routing between VLANs in a small to medium-sized business network.

This activity introduces students to the concept of using switches and routers to allow virtual networks to communicate with each other.

Scenario

You work for a small- to medium-sized business. As the network administrator, you are responsible for ensuring that your network operates efficiently and securely.

Several years ago, you created VLANs on your only switch for two of your departments, Accounting and Sales. As the business has grown, it has become apparent that sometimes these two departments must share company files and network resources.

You discuss this scenario with network administrators in a few branches of your company. They tell you to consider using inter-VLAN routing.

Research the concept of inter-VLAN routing. Design a simple presentation to show your manager how you would use inter-VLAN routing to allow the Accounting and Sales departments to remain separate, but share company files and network resources.

Resources

- Internet connection
- Software presentation program

Directions

Work with a partner to complete this activity.

Step 1: Use your Internet connection to research how inter-VLANs operate.

- Use a search engine to locate a few basic articles, or short videos, that discuss the concept of inter-VLAN routing.
- Read the articles, or view the videos, and take notes about how VLANs operate.
- Make sure you record where the information was found so that you can include the sources in Step 2 of this activity.

Step 2: Create a presentation for your manager.

- Design a small presentation for your manager listing how you would set up an inter-VLAN routing-based network for your small- to medium-sized business, using no more than five slides.
- Include slides which focus on:
 - A synopsis of reasons you would change your current network to an inter-VLAN-switched network. Restate what you are trying to accomplish in your design proposal.
 - A basic, easily understood definition and benefits of using inter-VLAN routing.
 - A graphic depicting how you would modify your current network to use inter-VLAN routing.

Switching to Local-Network Channels

- a) Your current network utilizes one Cisco 2960 switch and one Cisco 1941 series router.
 - b) Funding for new equipment is not negotiable.
 - 4) How inter-VLANs could continue to assist with network traffic yet allow departments to communicate with each other.
 - 5) How inter-VLAN routing would scale for the future.
- c. Make sure you quote the sources upon which you are basing your presentation.

Step 3: Present your proposal to the entire class.

Instructor Resource Information

Two possible sources of Internet information sites to support this activity might include:

- VLAN Guide for Networking Professionals - <http://www.computerweekly.com/tutorial/VLAN-guide-for-networking-professionals>
- InterVLAN Routing Tutorial – Premium Tutorial <http://www.9tut.com/intervlan-routing-tutorial>
- Chapter 5. Inter-VLAN Routing
http://www.informit.com/library/content.aspx?b=CCNP_Studies_Switching&seqNum=44
- Basic Configuration of VLANS, Switchports and InterVLAN Routing
http://www.youtube.com/watch?v=ojh8_BDcXyl

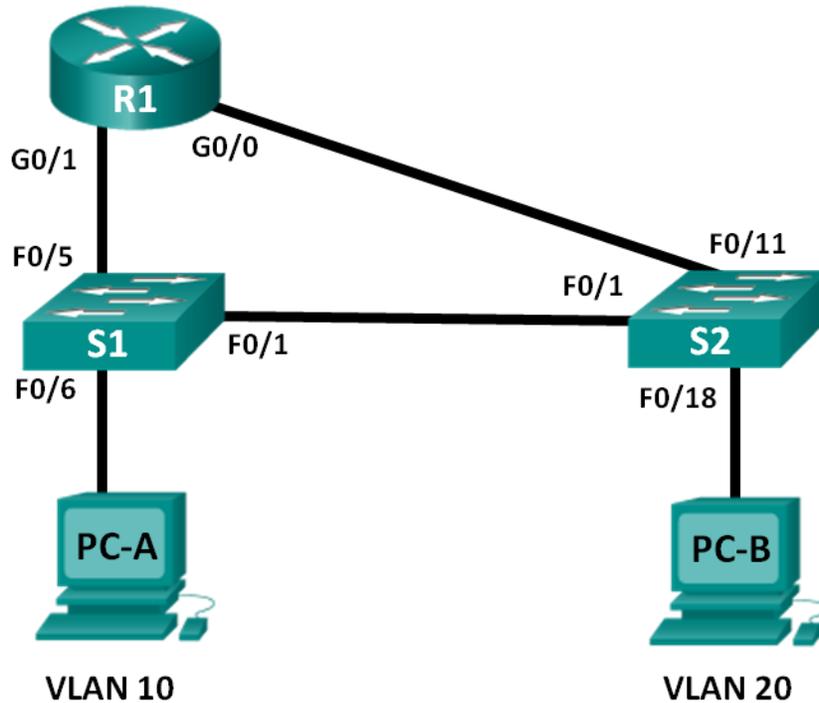
Identify elements of the model that map to IT-related content:

- Inter-VLAN routing definition
- Inter-VLAN design
- Inter-VLAN broadcast domains

Lab – Configuring Per-Interface Inter-VLAN Routing (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/0	192.168.20.1	255.255.255.0	N/A
	G0/1	192.168.10.1	255.255.255.0	N/A
S1	VLAN 10	192.168.10.11	255.255.255.0	192.168.10.1
S2	VLAN 10	192.168.10.12	255.255.255.0	192.168.10.1
PC-A	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC-B	NIC	192.168.20.3	255.255.255.0	192.168.20.1

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure Switches with VLANs and Trunking

Part 3: Verify Trunking, VLANs, Routing, and Connectivity

Background / Scenario

Legacy inter-VLAN routing is seldom used in today's networks; however, it is helpful to configure and understand this type of routing before moving on to router-on-a-stick (trunk-based) inter-VLAN routing or configuring Layer-3 switching. Also, you may encounter per-interface inter-VLAN routing in organizations with very small networks. One of the benefits of legacy inter-VLAN routing is ease of configuration.

In this lab, you will set up one router with two switches attached via the router Gigabit Ethernet interfaces. Two separate VLANs will be configured on the switches, and you will set up routing between the VLANs.

Note: This lab provides minimal assistance with the actual commands necessary to configure the router and switches. The required switch VLAN configuration commands are provided in Appendix A of this lab. Test your knowledge by trying to configure the devices without referring to the appendix.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS, Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS, Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and clear any configurations, if necessary.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the router and switches.

Step 3: Configure basic settings for R1.

- a. Disable DNS lookup.
- b. Assign the device name.
- c. Assign **class** as the privileged EXEC mode encrypted password.
- d. Assign **cisco** as the console and vty line password and enable login.
- e. Configure addressing on G0/0 and G0/1 and enable both interfaces.

Step 4: Configure basic settings on S1 and S2.

- a. Disable DNS lookup.
- b. Assign the device name.

Lab – Configuring Per-Interface Inter-VLAN Routing

- c. Assign **class** as the privileged EXEC mode encrypted password.
- d. Assign **cisco** as the console and vty line password and enable login.

Step 5: Configure basic settings on PC-A and PC-B.

Configure PC-A and PC-B with IP addresses and a default gateway address according to the Addressing Table.

Part 2: Configure Switches with VLANs and Trunking

In Part 2, you will configure the switches with VLANs and trunking.

Step 1: Configure VLANs on S1.

- a. On S1, create VLAN 10. Assign **Student** as the VLAN name.
- b. Create VLAN 20. Assign **Faculty-Admin** as the VLAN name.
- c. Configure F0/1 as a trunk port.
- d. Assign ports F0/5 and F0/6 to VLAN 10 and configure both F0/5 and F0/6 as access ports.
- e. Assign an IP address to VLAN 10 and enable it. Refer to the Addressing Table.
- f. Configure the default gateway according to the Addressing Table.

Step 2: Configure VLANs on S2.

- a. On S2, create VLAN 10. Assign **Student** as the VLAN name.
- b. Create VLAN 20. Assign **Faculty-Admin** as the VLAN name.
- c. Configure F0/1 as a trunk port.
- d. Assign ports F0/11 and F0/18 to VLAN 20 and configure both F0/11 and F0/18 as access ports.
- e. Assign an IP address to VLAN 10 and enable it. Refer to the Addressing Table.
- f. Configure the default gateway according to the Addressing Table.

Part 3: Verify Trunking, VLANs, Routing, and Connectivity

Step 1: Verify the R1 routing table.

- a. On R1, issue the **show ip route** command. What routes are listed on R1?

The 192.168.10.0/24 and 192.168.20.0/24 networks are listed on R1.

```
R1# show ip route
*Mar 25 15:05:00.003: %SYS-5-CONFIG_I: Configured from console by console
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
```

Lab – Configuring Per-Interface Inter-VLAN Routing

```
+ - replicated route, % - next hop override
Gateway of last resort is not set
  192.168.10.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.10.0/24 is directly connected, GigabitEthernet0/1
L       192.168.10.1/32 is directly connected, GigabitEthernet0/1
  192.168.20.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.20.0/24 is directly connected, GigabitEthernet0/0
L       192.168.20.1/32 is directly connected, GigabitEthernet0/0
```

- b. On both S1 and S2, issue the **show interface trunk** command. Is the F0/1 port on both switches set to trunk? _____ **Yes**

```
S1# show interface trunk
```

```
Port      Mode          Encapsulation  Status        Native vlan
Fa0/1     on            802.1q         trunking      1
```

```
Port      Vlans allowed on trunk
Fa0/1     1-4094
```

```
Port      Vlans allowed and active in management domain
Fa0/1     1,10,20
```

```
Port      Vlans in spanning tree forwarding state and not pruned
Fa0/1     1,10,20
```

- c. Issue a **show vlan brief** command on both S1 and S2. Verify that VLANs 10 and 20 are active and that the proper ports on the switches are in the correct VLANs. Why is F0/1 not listed in any of the active VLANs?

It is a trunk port and is not assigned to a VLAN.

```
S1# show vlan brief
```

```
VLAN Name                Status    Ports
----  -
1     default                active    Fa0/2, Fa0/3, Fa0/4, Fa0/7
                                           Fa0/8, Fa0/9, Fa0/10, Fa0/11
                                           Fa0/12, Fa0/13, Fa0/14, Fa0/15
                                           Fa0/16, Fa0/17, Fa0/18, Fa0/19
                                           Fa0/20, Fa0/21, Fa0/22, Fa0/23
                                           Fa0/24, Gi0/1, Gi0/2
10    Student                active    Fa0/5, Fa0/6
20    Faculty-Admin         active
1002  fddi-default          act/unsup
1003  token-ring-default    act/unsup
1004  fddinet-default       act/unsup
1005  trnet-default         act/unsup
```

```
S2# show vlan brief
```

Lab – Configuring Per-Interface Inter-VLAN Routing

VLAN Name	Status	Ports
1 default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/19 Fa0/20, Fa0/21, Fa0/22, Fa0/23 Fa0/24, Gi0/1, Gi0/2
10 Student	active	
20 Faculty-Admin	active	Fa0/11, Fa0/18
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

- d. Ping from PC-A in VLAN 10 to PC-B in VLAN 20. If Inter-VLAN routing is functioning correctly, the pings between the 192.168.10.0 network and the 192.168.20.0 should be successful.
- Note:** It may be necessary to disable the PC firewall to ping between PCs.
- e. Verify connectivity between devices. You should be able to ping between all devices. Troubleshoot if you are not successful.

Reflection

What is an advantage of using legacy inter-VLAN routing?

Answers may vary. Configuration of both the router and switches is relatively easy and straightforward. No subinterfaces are required on the router and trunking does NOT have to be configured between the router and switch.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Appendix A: Configuration Commands

Switch S1

```
S1(config)# vlan 10
S1(config-vlan)# name Student
S1(config-vlan)# exit
S1(config)# vlan 20
S1(config-vlan)# name Faculty-Admin
S1(config-vlan)# exit
S1(config)# interface f0/1
S1(config-if)# switchport mode trunk
S1(config-if)# interface range f0/5 - 6
S1(config-if-range)# switchport mode access
S1(config-if-range)# switchport access vlan 10
S1(config-if-range)# interface vlan 10
S1(config-if)# ip address 192.168.10.11 255.255.255.0
S1(config-if)# no shut
S1(config-if)# exit
S1(config)# ip default-gateway 192.168.10.1
```

Switch S2

```
S2(config)# vlan 10
S2(config-vlan)# name Student
```

Lab – Configuring Per-Interface Inter-VLAN Routing

```
S2(config-vlan)# exit
S2(config)# vlan 20
S2(config-vlan)# name Faculty-Admin
S2(config-vlan)# exit
S2(config)# interface f0/1
S2(config-if)# switchport mode trunk
S2(config-if)# interface f0/11
S2(config-if)# switchport mode access
S2(config-if)# switchport access vlan 20
S2(config-if)# interface f0/18
S2(config-if)# switchport mode access
S2(config-if)# switchport access vlan 20
S2(config-if-range)# interface vlan 10
S2(config-if)# ip address 192.168.10.12 255.255.255.0
S2(config-if)# no shut
S2(config-if)# exit
S2(config)# ip default-gateway 192.168.10.1
```

Device Configs

Instructor Note: The VLANs configured do not display in the switch running configuration but are stored in the `vlan.dat` file.

Router R1

```
R1#show run
Building configuration...

Current configuration : 1640 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
!
!
!
no ip domain lookup
```

Lab – Configuring Per-Interface Inter-VLAN Routing

```
ip cef
no ipv6 cef
!
multilink bundle-name authenticated
!
!
!
!
redundancy
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
ip address 192.168.20.1 255.255.255.0
duplex auto
speed auto
!
interface GigabitEthernet0/1
ip address 192.168.10.1 255.255.255.0
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
!
control-plane
!
```

Lab – Configuring Per-Interface Inter-VLAN Routing

```
!  
!  
line con 0  
  password cisco  
  login  
line aux 0  
line 2  
  no activation-character  
  no exec  
  transport preferred none  
  transport input all  
  transport output pad telnet rlogin lapb-ta mop udptn v120 ssh  
  stopbits 1  
line vty 0 4  
  password cisco  
  login  
  transport input all  
!  
scheduler allocate 20000 1000  
!  
end
```

Switch S1

```
S1# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/7 Fa0/8, Fa0/9, Fa0/10, Fa0/11 Fa0/12, Fa0/13, Fa0/14, Fa0/15 Fa0/16, Fa0/17, Fa0/18, Fa0/19 Fa0/20, Fa0/21, Fa0/22, Fa0/23 Fa0/24, Gi0/1, Gi0/2
10 Student	active	Fa0/5, Fa0/6
20 Faculty-Admin	active	
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

```
S1#show run
```

```
Building configuration...
```

```
Current configuration : 1644 bytes
```

```
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec
```

Lab – Configuring Per-Interface Inter-VLAN Routing

```
no service password-encryption
!
hostname S1
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGholQM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
interface FastEthernet0/1
  switchport mode trunk
!
interface FastEthernet0/2
!
interface FastEthernet0/3
!
interface FastEthernet0/4
!
interface FastEthernet0/5
  switchport access vlan 10
  switchport mode access
!
interface FastEthernet0/6
  switchport access vlan 10
  switchport mode access
!
interface FastEthernet0/7
!
interface FastEthernet0/8
!
interface FastEthernet0/9
!
interface FastEthernet0/10
!
interface FastEthernet0/11
!
interface FastEthernet0/12
!
interface FastEthernet0/13
!
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
```

Lab – Configuring Per-Interface Inter-VLAN Routing

```
!  
interface FastEthernet0/17  
!  
interface FastEthernet0/18  
!  
interface FastEthernet0/19  
!  
interface FastEthernet0/20  
!  
interface FastEthernet0/21  
!  
interface FastEthernet0/22  
!  
interface FastEthernet0/23  
!  
interface FastEthernet0/24  
!  
interface GigabitEthernet0/1  
!  
interface GigabitEthernet0/2  
!  
interface Vlan1  
no ip address  
shutdown  
!  
interface Vlan10  
ip address 192.168.10.11 255.255.255.0  
!  
ip default-gateway 192.168.10.1  
ip http server  
ip http secure-server  
!  
!  
line con 0  
password cisco  
login  
line vty 0 4  
password cisco  
login  
line vty 5 15  
password cisco  
login  
!  
end
```

Switch S2

```
S2# show vlan brief
```

VLAN Name	Status	Ports
-----------	--------	-------

Lab – Configuring Per-Interface Inter-VLAN Routing

```
-----  
1    default                active    Fa0/2, Fa0/3, Fa0/4, Fa0/5  
                                           Fa0/6, Fa0/7, Fa0/8, Fa0/9  
                                           Fa0/10, Fa0/12, Fa0/13, Fa0/14  
                                           Fa0/15, Fa0/16, Fa0/17, Fa0/19  
                                           Fa0/20, Fa0/21, Fa0/22, Fa0/23  
                                           Fa0/24, Gi0/1, Gi0/2  
10   Student                active  
20   Faculty-Admin         active    Fa0/11, Fa0/18  
1002 fddi-default          act/unsup  
1003 token-ring-default    act/unsup  
1004 fddinet-default       act/unsup  
1005 trnet-default         act/unsup
```

```
S2#sh run
```

```
Building configuration...
```

```
Current configuration : 1644 bytes
```

```
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname S2  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
system mtu routing 1500  
!  
!  
no ip domain-lookup  
!  
interface FastEthernet0/1  
  switchport mode trunk  
!  
<Output Omitted>  
interface FastEthernet0/10  
!  
interface FastEthernet0/11  
  switchport access vlan 20  
  switchport mode access  
!  
interface FastEthernet0/12  
!  
interface FastEthernet0/13  
!  
!
```

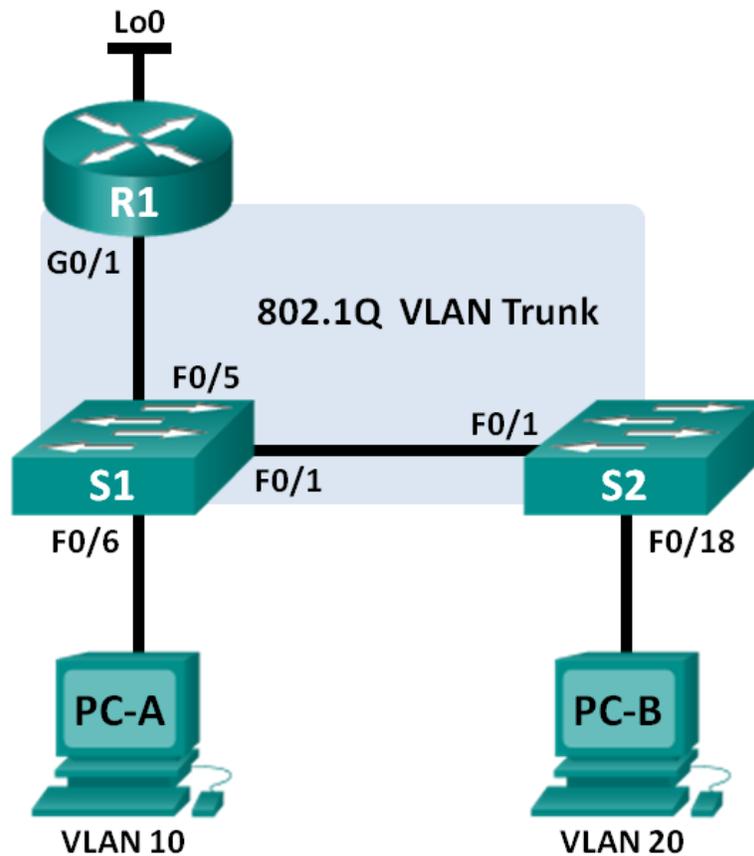
Lab – Configuring Per-Interface Inter-VLAN Routing

```
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
!
interface FastEthernet0/17
!
interface FastEthernet0/18
  switchport access vlan 20
  switchport mode access
!
!interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
  no ip address
  shutdown
!
interface Vlan10
  ip address 192.168.10.12 255.255.255.0
!
ip default-gateway 192.168.10.1
ip http server
ip http secure-server
!
line con 0
line vty 0 4
  password cisco
  login
line vty 5 15
  password cisco
  login
end
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/1.1	192.168.1.1	255.255.255.0	N/A
	G0/1.10	192.168.10.1	255.255.255.0	N/A
	G0/1.20	192.168.20.1	255.255.255.0	N/A
	Lo0	209.165.200.225	255.255.255.224	N/A
S1	VLAN 1	192.168.1.11	255.255.255.0	192.168.1.1
S2	VLAN 1	192.168.1.12	255.255.255.0	192.168.1.1
PC-A	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC-B	NIC	192.168.20.3	255.255.255.0	192.168.20.1

Switch Port Assignment Specifications

Ports	Assignment	Network
S1 F0/1	802.1Q Trunk	N/A
S2 F0/1	802.1Q Trunk	N/A
S1 F0/5	802.1Q Trunk	N/A
S1 F0/6	VLAN 10 – Students	192.168.10.0/24
S2 F0/18	VLAN 20 – Faculty	192.168.20.0/24

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure Switches with VLANs and Trunking

Part 3: Configure Trunk-Based Inter-VLAN Routing

Background / Scenario

A second method of providing routing and connectivity for multiple VLANs is through the use of an 802.1Q trunk between one or more switches and a single router interface. This method is also known as router-on-a-stick inter-VLAN routing. In this method, the physical router interface is divided into multiple subinterfaces that provide logical pathways to all VLANs connected.

In this lab, you will configure trunk-based inter-VLAN routing and verify connectivity to hosts on different VLANs as well as with a loopback on the router.

Note: This lab provides minimal assistance with the actual commands necessary to configure trunk-based inter-VLAN routing. However, the required configuration commands are provided in Appendix A of this lab. Test your knowledge by trying to configure the devices without referring to the appendix.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS, Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS, Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary

from what is shown in the labs. Refer to the Router Interface Summary Table at the end of the lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS, release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS, release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings on the PC hosts, switches, and router.

Step 1: Cable the network as shown in the topology.

Step 2: Configure PC hosts.

Step 3: Initialize and reload the router and switches as necessary.

Step 4: Configure basic settings for each switch.

- Disable DNS lookup.
- Configure device names as shown in the topology.
- Assign **class** as the privileged EXEC password.
- Assign **cisco** as the console and vty passwords.
- Configure **logging synchronous** for the console line.
- Configure the IP address listed in the Addressing Table for VLAN 1 on both switches.
- Configure the default gateway on both switches.
- Administratively deactivate all unused ports on the switch.
- Copy the running configuration to the startup configuration.

Step 5: Configure basic settings for the router.

- Disable DNS lookup.
- Configure device names as shown in the topology.
- Configure the Lo0 IP address as shown in the Address Table. Do not configure subinterfaces at this time as they will be configured in Part 3.
- Assign **cisco** as the console and vty passwords.
- Assign **class** as the privileged EXEC password.

- f. Configure **logging synchronous** to prevent console messages from interrupting command entry.
- g. Copy the running configuration to the startup configuration.

Part 2: Configure Switches with VLANs and Trunking

In Part 2, you will configure the switches with VLANs and trunking.

Note: The required commands for Part 2 are provided in Appendix A. Test your knowledge by trying to configure S1 and S2 without referring to the appendix.

Step 1: Configure VLANs on S1.

- a. On S1, configure the VLANs and names listed in the Switch Port Assignment Specifications table. Write the commands you used in the space provided.

```
S1(config)# vlan 10
S1(config-vlan)# name Students
S1(config-vlan)# vlan 20
S1(config-vlan)# name Faculty
S1(config-vlan)# exit
```

- b. On S1, configure the interface connected to R1 as a trunk. Also configure the interface connected to S2 as a trunk. Write the commands you used in the space provided.

```
S1(config)# interface f0/5
S1(config-if)# switchport mode trunk
S1(config-if)# interface f0/1
S1(config-if)# switchport mode trunk
```

- c. On S1, assign the access port for PC-A to VLAN 10. Write the commands you used in the space provided.

```
S1(config)# interface f0/6
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 10
```

Step 2: Configure VLANs on Switch 2.

- a. On S2, configure the VLANs and names listed in the Switch Port Assignment Specifications table.
- b. On S2, verify that the VLAN names and numbers match those on S1. Write the command you used in the space provided.

```
S2# show vlan brief
```

```
S2# show vlan brief
```

```
VLAN Name                Status    Ports
-----
1    default                active    Fa0/1, Fa0/2, Fa0/3, Fa0/4, Fa0/5
                                Fa0/6, Fa0/7, Fa0/8, Fa0/9
                                Fa0/10, Fa0/11, Fa0/12, Fa0/13
                                Fa0/14, Fa0/15, Fa0/16, Fa0/17
                                Fa0/18, Fa0/19, Fa0/20, Fa0/21
                                Fa0/22, Fa0/23, Fa0/24, Gi0/1
                                Gi0/2
10   Students                active
20   Faculty                 active
1002 fddi-default            active
1003 token-ring-default    active
1004 fddinet-default        active
1005 trnet-default          active
```

- c. On S2, assign the access port for PC-B to VLAN 20.
- d. On S2, configure the interface connected to S1 as a trunk.

Part 3: Configure Trunk-Based Inter-VLAN Routing

In Part 3, you will configure R1 to route to multiple VLANs by creating subinterfaces for each VLAN. This method of inter-VLAN routing is called router-on-a-stick.

Note: The required commands for Part 3 are provided in Appendix A. Test your knowledge by trying to configure trunk-based or router-on-a-stick inter-VLAN routing without referring to the appendix.

Step 1: Configure a subinterface for VLAN 1.

- a. Create a subinterface on R1 G0/1 for VLAN 1 using 1 as the subinterface ID. Write the command you used in the space provided.

```
R1(config)# interface g0/1.1
```

- b. Configure the subinterface to operate on VLAN 1. Write the command you used in the space provided.

```
R1(config-subif)# encapsulation dot1q 1
```

- c. Configure the subinterface with the IP address from the Address Table. Write the command you used in the space provided.

```
R1(config-subif)# ip address 192.168.1.1 255.255.255.0
```

Step 2: Configure a subinterface for VLAN 10.

- a. Create a subinterface on R1 G0/1 for VLAN 10 using 10 as the subinterface ID.
- b. Configure the subinterface to operate on VLAN 10.

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

- c. Configure the subinterface with the address from the Address Table.

Step 3: Configure a subinterface for VLAN 20.

- a. Create a subinterface on R1 G0/1 for VLAN 20 using 20 as the subinterface ID.
- b. Configure the subinterface to operate on VLAN 20.
- c. Configure the subinterface with the address from the Address Table.

Step 4: Enable the G0/1 interface.

Enable the G0/1 interface. Write the commands you used in the space provided.

```
R1(config)# interface g0/1
R1(config-if)# no shutdown
```

Step 5: Verify connectivity.

Enter the command to view the routing table on R1. What networks are listed?

```
192.168.1.0, 192.168.10.0, 192.168.20.0, and 209.165.200.224
```

```
R1# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route
```

```
Gateway of last resort is not set
```

```

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.1.0/24 is directly connected, GigabitEthernet0/1.1
L       192.168.1.1/32 is directly connected, GigabitEthernet0/1.1
192.168.10.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.10.0/24 is directly connected, GigabitEthernet0/1.10
L       192.168.10.1/32 is directly connected, GigabitEthernet0/1.10
192.168.20.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.20.0/24 is directly connected, GigabitEthernet0/1.20
L       192.168.20.1/32 is directly connected, GigabitEthernet0/1.20
209.165.200.0/24 is variably subnetted, 2 subnets, 2 masks
C       209.165.200.224/27 is directly connected, Loopback0
L       209.165.200.225/32 is directly connected, Loopback0
```

From PC-A, is it possible to ping the default gateway for VLAN 10? _____ **Yes**

From PC-A, is it possible to ping PC-B? _____ **Yes**

From PC-A, is it possible to ping Lo0? _____ **Yes**

From PC-A, is it possible to ping S2? _____ **Yes**

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

If the answer is **no** to any of these questions, troubleshoot the configurations and correct any errors.

Reflection

What are the advantages of trunk-based or router-on-a-stick inter-VLAN routing?

Router-on-a-stick inter-VLAN routing allows for one interface to route to multiple VLANs unlike the legacy inter-VLAN method which requires one port per VLAN.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Appendix A – Configuration Commands

Switch S1

```
S1(config)# vlan 10
S1(config-vlan)# name Students
S1(config-vlan)# vlan 20
S1(config-vlan)# name Faculty
S1(config-vlan)# exit
S1(config)# interface f0/1
S1(config-if)# switchport mode trunk
S1(config-if)# interface f0/5
S1(config-if)# switchport mode trunk
S1(config-if)# interface f0/6
S1(config-if)# switchport mode access
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
S1(config-if)# switchport access vlan 10
```

Switch S2

```
S2(config)# vlan 10
S2(config-vlan)# name Students
S2(config-vlan)# vlan 20
S2(config-vlan)# name Faculty
S2(config)# interface f0/1
S2(config-if)# switchport mode trunk
S2(config-if)# interface f0/18
S2(config-if)# switchport mode access
S2(config-if)# switchport access vlan 20
```

Router R1

```
R1(config)# interface g0/1.1
R1(config-subif)# encapsulation dot1Q 1
R1(config-subif)# ip address 192.168.1.1 255.255.255.0
R1(config-subif)# interface g0/1.10
R1(config-subif)# encapsulation dot1Q 10
R1(config-subif)# ip address 192.168.10.1 255.255.255.0
R1(config-subif)# interface g0/1.20
R1(config-subif)# encapsulation dot1Q 20
R1(config-subif)# ip address 192.168.20.1 255.255.255.0
R1(config-subif)# exit
R1(config)# interface g0/1
R1(config-if)# no shutdown
```

Device Configs

Instructor Note: The VLANs configured do not display in the switch running configuration but are stored in the `vlan.dat` file. The output from the `show vlan brief` command is provided.

Router R1

```
R1# show run
Building configuration...

Current configuration : 1731 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
!  
!  
!  
!  
!  
!  
!  
no ip domain lookup  
ip cef  
no ipv6 cef  
!  
multilink bundle-name authenticated  
!  
!  
!  
!  
redundancy  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
interface Loopback0  
ip address 209.165.200.225 255.255.255.224  
!  
interface Embedded-Service-Engine0/0  
no ip address  
shutdown  
!  
interface GigabitEthernet0/0  
no ip address  
shutdown  
duplex auto  
speed auto  
!  
interface GigabitEthernet0/1  
no ip address
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
duplex auto
speed auto
!
interface GigabitEthernet0/1.1
encapsulation dot1Q 1
ip address 192.168.1.1 255.255.255.0
!
interface GigabitEthernet0/1.10
encapsulation dot1Q 10
ip address 192.168.10.1 255.255.255.0
!
interface GigabitEthernet0/1.20
encapsulation dot1Q 20
ip address 192.168.20.1 255.255.255.0
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
line vty 0 4
 password cisco
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1

```
S1# show vlan brief
```

VLAN	Name	Status	Ports
1	default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10	Students	active	Fa0/6
20	Faculty	active	
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

```
S1# show run
```

```
Building configuration...
```

```
Current configuration : 1627 bytes
```

```
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
no ip domain-lookup
!
!
!
!
!
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
interface FastEthernet0/1
 switchport mode trunk
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 shutdown
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
 switchport mode trunk
!
interface FastEthernet0/6
 switchport access vlan 10
 switchport mode access
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
!  
interface FastEthernet0/11  
shutdown  
!  
interface FastEthernet0/12  
shutdown  
!  
interface FastEthernet0/13  
shutdown  
!  
interface FastEthernet0/14  
shutdown  
!  
interface FastEthernet0/15  
shutdown  
!  
interface FastEthernet0/16  
shutdown  
!  
interface FastEthernet0/17  
shutdown  
!  
interface FastEthernet0/18  
shutdown  
!  
interface FastEthernet0/19  
shutdown  
!  
interface FastEthernet0/20  
shutdown  
!  
interface FastEthernet0/21  
shutdown  
!  
interface FastEthernet0/22  
shutdown  
!  
interface FastEthernet0/23  
shutdown  
!  
interface FastEthernet0/24  
shutdown  
!  
interface GigabitEthernet0/1  
shutdown  
!  
interface GigabitEthernet0/2  
shutdown  
!
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
interface Vlan1
ip address 192.168.1.11 255.255.255.0
!
ip default-gateway 192.168.1.1
ip http server
ip http secure-server
!
!
!
line con 0
password cisco
logging synchronous
login
line vty 0 4
password cisco
login
line vty 5 15
password cisco
login
!
end
```

Switch S2

```
S2# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10 Students	active	
20 Faculty	active	Fa0/18
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

```
S2# show run
```

```
Building configuration...
```

```
Current configuration : 1633 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
no service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
!
!
!
!
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
!
interface FastEthernet0/1
 switchport mode trunk
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 shutdown
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
 shutdown
!
interface FastEthernet0/6
 shutdown
```

Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
!  
interface FastEthernet0/7  
shutdown  
!  
interface FastEthernet0/8  
shutdown  
!  
interface FastEthernet0/9  
shutdown  
!  
interface FastEthernet0/10  
shutdown  
!  
interface FastEthernet0/11  
shutdown  
!  
interface FastEthernet0/12  
shutdown  
!  
interface FastEthernet0/13  
shutdown  
!  
interface FastEthernet0/14  
shutdown  
!  
interface FastEthernet0/15  
shutdown  
!  
interface FastEthernet0/16  
shutdown  
!  
interface FastEthernet0/17  
shutdown  
!  
interface FastEthernet0/18  
switchport access vlan 20  
switchport mode access  
!  
interface FastEthernet0/19  
shutdown  
!  
interface FastEthernet0/20  
shutdown  
!  
interface FastEthernet0/21  
shutdown  
!  
interface FastEthernet0/22  
shutdown
```

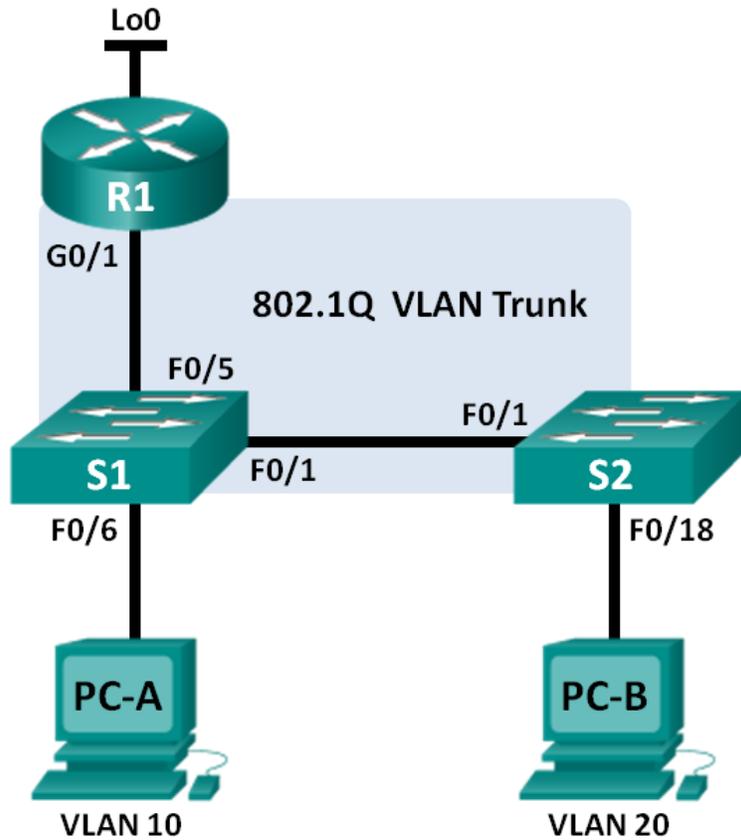
Lab – Configuring 802.1Q Trunk-Based Inter-VLAN Routing

```
!  
interface FastEthernet0/23  
shutdown  
!  
interface FastEthernet0/24  
shutdown  
!  
interface GigabitEthernet0/1  
shutdown  
!  
interface GigabitEthernet0/2  
shutdown  
!  
interface Vlan1  
 ip address 192.168.1.12 255.255.255.0  
!  
ip default-gateway 192.168.1.1  
ip http server  
ip http secure-server  
!  
!  
line con 0  
 password cisco  
 logging synchronous  
 login  
line vty 0 4  
 password cisco  
 login  
line vty 5 15  
 password cisco  
 login  
!  
end
```

Lab – Troubleshooting Inter-VLAN Routing (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/1.1	192.168.1.1	255.255.255.0	N/A
	G0/1.10	192.168.10.1	255.255.255.0	N/A
	G0/1.20	192.168.20.1	255.255.255.0	N/A
	Lo0	209.165.200.225	255.255.255.224	N/A
S1	VLAN 1	192.168.1.11	255.255.255.0	192.168.1.1
S2	VLAN 1	192.168.1.12	255.255.255.0	192.168.1.1
PC-A	NIC	192.168.10.3	255.255.255.0	192.168.10.1
PC-B	NIC	192.168.20.3	255.255.255.0	192.168.20.1

Switch Port Assignment Specifications

Ports	Assignment	Network
S1 F0/1	802.1Q Trunk	N/A
S2 F0/1	802.1Q Trunk	N/A
S1 F0/5	802.1Q Trunk	N/A
S1 F0/6	VLAN 10 – R&D	192.168.10.0/24
S2 F0/18	VLAN 20 – Engineering	192.168.20.0/24

Objectives

Part 1: Build the Network and Load Device Configurations

Part 2: Troubleshoot the Inter-VLAN Routing Configuration

Part 3: Verify VLAN Configuration, Port Assignment, and Trunking

Part 4: Test Layer 3 Connectivity

Background / Scenario

The network has been designed and configured to support three VLANs. Inter-VLAN routing is provided by an external router using an 802.1Q trunk, also known as router-on-a-stick. Routing to a remote web server, which is simulated by Lo0, is also provided by R1. However, it is not working as designed, and user complaints have not given much insight into the source of the problems.

In this lab, you must first define what is not working as expected, and then analyze the existing configurations to determine and correct the source of the problems. This lab is complete when you can demonstrate IP connectivity between each of the user VLANs and the external web server network, and between the switch management VLAN and the web server network.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches, and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary

from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Load Device Configurations

In Part 1, you will set up the network topology and configure basic settings on the PC hosts, switches, and router.

Step 1: Cable the network as shown in the topology.

Step 2: Configure PC hosts.

Refer to the Addressing Table for PC host address information.

Step 3: Load router and switch configurations.

Load the following configurations into the appropriate router or switch. All devices have the same passwords; the enable password is **class**, and the line password is **cisco**.

Router R1 Configuration:

```
hostname R1
enable secret class
no ip domain lookup
line con 0
  password cisco
  login
  logging synchronous
line vty 0 4
  password cisco
  login
interface loopback0
  ip address 209.165.200.225 255.255.255.224
interface gigabitEthernet0/1
  no ip address
  ! no shutdown
interface gigabitEthernet0/1.1
  encapsulation dot1q 11
  ! encapsulation dot1q 1
```

Lab – Troubleshooting Inter-VLAN Routing

```
ip address 192.168.1.1 255.255.255.0
interface gigabitEthernet0/1.10
encapsulation dot1q 10
ip address 192.168.11.1 255.255.255.0
! ip address 192.168.10.1 255.255.255.0
interface gigabitEthernet0/1.20
encapsulation dot1q 20
ip address 192.168.20.1 255.255.255.0
end
```

Switch S1 Configuration:

```
hostname S1
enable secret class
no ip domain-lookup
line con 0
password cisco
login
logging synchronous
line vty 0 15
password cisco
login
vlan 10
name R&D
exit
!vlan 20
! name Engineering
! exit
interface fastethernet0/1
switchport mode access
! switchport mode trunk
interface fastethernet0/5
switchport mode trunk
!interface fastethernet0/6
! switchport access vlan 10
! switchport mode access
interface vlan1
ip address 192.168.1.11 255.255.255.0
ip default-gateway 192.168.1.1
end
```

Switch S2 Configuration:

```
hostname S2
enable secret class
no ip domain-lookup
line con 0
password cisco
```

```
login
logging synchronous
line vty 0 15
password cisco
login
!vlan 10
! name R&D
! exit
vlan 20
name Engineering
exit
interface fastethernet0/1
switchport mode trunk
interface fastethernet0/18
switchport access vlan 10
switchport mode access
! switchport access vlan 20
interface vlan1
ip address 192.168.1.12 255.255.255.0
ip default-gateway 192.168.1.1
end
```

Step 4: Save the running configuration to the startup configuration.

Part 2: Troubleshoot the Inter-VLAN Routing Configuration

In Part 2, you will verify the inter-VLAN routing configuration.

- a. On R1, enter the **show ip route** command to view the routing table.

```
R1# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override
```

```
Gateway of last resort is not set
```

```
          209.165.200.0/24 is variably subnetted, 2 subnets, 2 masks
C          209.165.200.224/27 is directly connected, Loopback0
L          209.165.200.225/32 is directly connected, Loopback0
```

Which networks are listed?

Only the 209.165.200.224 network.

Lab – Troubleshooting Inter-VLAN Routing

Are there any networks missing in the routing table? If so, which networks?

192.168.1.0, 192.168.10.0, 192.168.20.0

What is one possible reason that a route would be missing from the routing table?

Interface administratively down, no ip address

- b. On R1, issue the **show ip interface brief** command.

R1# **show ip interface brief**

Interface	IP-Address	OK?	Method	Status	Protocol
Embedded-Service-Engine0/0	unassigned	YES	unset	administratively down	down
GigabitEthernet0/0	unassigned	YES	unset	administratively down	down
GigabitEthernet0/1	unassigned	YES	unset	administratively down	down
GigabitEthernet0/1.1	192.168.1.1	YES	manual	administratively down	down
GigabitEthernet0/1.10	192.168.11.1	YES	manual	administratively down	down
GigabitEthernet0/1.20	192.168.20.1	YES	manual	administratively down	down
Serial0/0/0	unassigned	YES	unset	administratively down	down
Serial0/0/1	unassigned	YES	unset	administratively down	down
Loopback0	209.165.200.225	YES	manual	up	up

Based on the output, are there any interface issues on the router? If so, what commands would resolve the issues?

R1(config)# **interface g0/1**

R1(config-if)# **no shutdown**

R1(config-if)# **interface g0/1.10**

R1(configs-if) **ip address 192.168.10.1 255.255.255.0**

- c. On R1, re-issue the **show ip route** command.

R1# **show ip route**

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
+ - replicated route, % - next hop override

Gateway of last resort is not set

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.1.0/24 is directly connected, GigabitEthernet0/1.1
L 192.168.1.1/32 is directly connected, GigabitEthernet0/1.1
192.168.11.0/24 is variably subnetted, 2 subnets, 2 masks

Lab – Troubleshooting Inter-VLAN Routing

```
C      192.168.11.0/24 is directly connected, GigabitEthernet0/1.10
L      192.168.11.1/32 is directly connected, GigabitEthernet0/1.10
      192.168.20.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.20.0/24 is directly connected, GigabitEthernet0/1.20
L      192.168.20.1/32 is directly connected, GigabitEthernet0/1.20
      209.165.200.0/24 is variably subnetted, 2 subnets, 2 masks
C      209.165.200.224/27 is directly connected, Loopback0
L      209.165.200.225/32 is directly connected, Loopback0
```

Verify that all networks are available in the routing table. If not, continue to troubleshoot until all networks are present.

Part 3: Verify VLAN Configuration, Port Assignment, and Trunking

In Part 3, you will verify that the correct VLANs exist on both S1 and S2 and that trunking is configured correctly.

Step 1: Verify VLAN configuration and port assignments.

- On S1, enter the `show vlan brief` command to view the VLAN database.

```
S1# show vlan brief
```

```
VLAN Name                Status    Ports
-----
1    default                active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                           Fa0/6, Fa0/7, Fa0/8, Fa0/9
                                           Fa0/10, Fa0/11, Fa0/12, Fa0/13
                                           Fa0/14, Fa0/15, Fa0/16, Fa0/17
                                           Fa0/18, Fa0/19, Fa0/20, Fa0/21
                                           Fa0/22, Fa0/23, Fa0/24, Gi0/1
                                           Gi0/2
10   R&D                    active
1002 fddi-default           act/unsup
1003 token-ring-default    act/unsup
1004 fddinet-default       act/unsup
1005 trnet-default         act/unsup
```

Which VLANs are listed? Ignore VLANs 1002 to 1005.

VLAN 1, VLAN 10

Are there any VLANs numbers or names missing in the output? If so, list them.

VLAN 20 name Engineering

Are the access ports assigned to the correct VLANs? If not, list the missing or incorrect assignments.

Fa0/6 needs to be assigned to the VLAN 10

If required, what commands would resolve the VLAN issues?

```
S1(config)# vlan 20
S1(config-vlan)# name Engineering
S1(config-vlan)# exit
S1(config)# interface fa0/6
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 10
```

- b. On S1, re-issue the **show vlan brief** command to verify configuration.

```
S1# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10 R&D	active	Fa0/6
20 Engineering	active	
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

- c. On S2, enter the **show vlan brief** command to view the VLAN database.

```
S2# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/6, Fa0/7, Fa0/8, Fa0/9 Fa0/10, Fa0/11, Fa0/12, Fa0/13 Fa0/14, Fa0/15, Fa0/16, Fa0/17 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10 VLAN0010	active	Fa0/18
20 Engineering	active	
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

Which VLANs are listed? Ignore VLANs 1002 to 1005.

```
VLAN 1, VLAN 10, VLAN 20
```

Lab – Troubleshooting Inter-VLAN Routing

Are there any VLANs numbers or names missing in the output? If so, list them.

VLAN 10 missing name R&D

Are the access ports assigned to the correct VLANs? If not, list the missing or incorrect assignments.

F0/18 needs to be assigned to the VLAN 20 instead of 10

If required, what commands would resolve the VLAN issues?

```
S2(config)# vlan 10
S2(config-vlan)# name R&D
S2(config-vlan)# exit
S2(config)# interface fa0/18
S2(config-if)# switchport access vlan 20
```

- d. On S2, re-issue the **show vlan brief** command to verify any configuration changes.

S2# **show vlan brief**

```
VLAN Name                Status      Ports
-----
1    default                active     Fa0/2, Fa0/3, Fa0/4, Fa0/5
                                           Fa0/6, Fa0/7, Fa0/8, Fa0/9
                                           Fa0/10, Fa0/11, Fa0/12, Fa0/13
                                           Fa0/14, Fa0/15, Fa0/16, Fa0/17
                                           Fa0/19, Fa0/20, Fa0/21, Fa0/22
                                           Fa0/23, Fa0/24, Gi0/1, Gi0/2
10   R&D                    active
20   Engineering            active     Fa0/18
1002 fddi-default          act/unsup
1003 token-ring-default   act/unsup
1004 fddinet-default      act/unsup
1005 trnet-default        act/unsup
```

Step 2: Verify trunking interfaces.

- a. On S1, enter the **show interface trunk** command to view the trunking interfaces.

S1# **show interface trunk**

```
Port      Mode          Encapsulation  Status      Native vlan
Fa0/5     on            802.1q         trunking    1

Port      Vlans allowed on trunk
Fa0/5     1-4094

Port      Vlans allowed and active in management domain
```

Lab – Troubleshooting Inter-VLAN Routing

```
Fa0/5      1,10,20
```

```
Port      Vlans in spanning tree forwarding state and not pruned
Fa0/5     1,10,20
```

Which ports are in trunking mode?

F0/5

Are there any ports missing in the output? If so, list them.

F0/1

If required, what commands would resolve the port trunking issues?

```
S1(config)# interface fa0/1
S1(configs-if)# switchport mode trunk
```

- b. On S1, re-issue the **show interface trunk** command to verify any configuration changes.

```
S1# show interface trunk
```

```
Port      Mode      Encapsulation  Status      Native vlan
Fa0/1     on        802.1q         trunking    1
Fa0/5     on        802.1q         trunking    1
```

```
Port      Vlans allowed on trunk
Fa0/1     1-4094
Fa0/5     1-4094
```

```
Port      Vlans allowed and active in management domain
Fa0/1     1,10,20
Fa0/5     1,10,20
```

```
Port      Vlans in spanning tree forwarding state and not pruned
Fa0/1     none
Fa0/5     1,10,20
```

- c. On S2, enter the **show interface trunk** command to view the trunking interfaces.

```
S2# show interface trunk
```

```
Port      Mode      Encapsulation  Status      Native vlan
Fa0/1     on        802.1q         trunking    1
```

```
Port      Vlans allowed on trunk
Fa0/1     1-4094
```

```
Port      Vlans allowed and active in management domain
Fa0/1     1,10,20
```

Lab – Troubleshooting Inter-VLAN Routing

```
Port          Vlans in spanning tree forwarding state and not pruned
Fa0/1         1,10,20
```

Which ports are in trunking mode?

F0/1

Are there any ports missing in the output? If so, list them.

None

If required, what commands would resolve the port trunking issues?

All trunk ports configured correctly

Part 4: Test Layer 3 Connectivity

- a. Now that you have corrected multiple configuration issues, let's test connectivity.

From PC-A, is it possible to ping the default gateway for VLAN 10? _____ Yes.

From PC-A, is it possible to ping PC-B? _____ Yes.

From PC-A, is it possible to ping Lo0? _____ Yes.

If the answer is **no** to any of these questions, troubleshoot the configurations and correct the error.

Note: It may be necessary to disable the PC firewall for pings between PCs to be successful.

From PC-A, is it possible to ping S1? _____ No.

From PC-A, is it possible to ping S2? _____ No.

List some of the issues that could still be preventing successful pings to the switches.

Incorrect VLAN assignment on router subinterface, incorrect IP address on switch, no default gateway on switch

- b. One way to help resolve where the error is occurring is to do a **tracert** from PC-A to S1.

```
C:\Users\User1> tracert 192.168.1.11
Tracing route to 192.168.1.11 over a maximum of 30 hops
  1  <1 ms  <1 ms  <1 ms  192.168.10.1
  2  *        *        *        Request timed out.
  3  *        *        *        Request timed out.
<output omitted>
```

This output shows that the request from PC-A is reaching the default gateway on R1 g0/1.10, but the packet stops at the router.

- c. You have already verified the routing table entries for R1, now execute the **show run | section interface** command to verify VLAN configuration. List any configuration errors.
-

Interface g0/1.1 is assigned to VLAN 11 instead of VLAN 1

```
R1# show run | section interface
interface Loopback0
  ip address 209.165.200.225 255.255.255.224
interface Embedded-Service-Engine0/0
  no ip address
  shutdown
interface GigabitEthernet0/0
  no ip address
  shutdown
  duplex auto
  speed auto
interface GigabitEthernet0/1
  no ip address
  duplex auto
  speed auto
interface GigabitEthernet0/1.1
  encapsulation dot1Q 11
  ip address 192.168.1.1 255.255.255.0
interface GigabitEthernet0/1.10
  encapsulation dot1Q 10
  ip address 192.168.10.1 255.255.255.0
interface GigabitEthernet0/1.20
  encapsulation dot1Q 20
  ip address 192.168.20.1 255.255.255.0
interface Serial0/0/0
  no ip address
  shutdown
  clock rate 2000000
interface Serial0/0/1
  no ip address
  shutdown
```

What commands would resolve any issues found?

```
R1(config)# interface g0/1.1
R1(config-if)# encapsulation dot1q 1
```

- d. Verify that that pings from PC-A now reach both S1 and S2.
- From PC-A, is it possible to ping S1? _____ Yes.
- From PC-A, is it possible to ping S2? _____ Yes.

Reflection

What are the advantages of viewing the routing table for troubleshooting purposes?

All configured interfaces and subinterfaces are listed and can be easily examined for errors.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Instructor Note: The VLANs configured do not display in the switch running configuration but are stored in the `vlan.dat` file.

Router R1

```
R1# show run
Building configuration...

Current configuration : 1522 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
memory-size iomem 15  
!  
ip cef  
!  
!  
!  
!  
!  
!  
!  
no ip domain lookup  
no ipv6 cef  
multilink bundle-name authenticated  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
interface Loopback0  
ip address 209.165.200.225 255.255.255.224  
!  
interface Embedded-Service-Engine0/0  
no ip address  
shutdown  
!  
interface GigabitEthernet0/0  
no ip address  
shutdown  
duplex auto  
speed auto  
!  
interface GigabitEthernet0/1  
no ip address  
duplex auto  
speed auto  
!  
interface GigabitEthernet0/1.1  
encapsulation dot1Q 1  
ip address 192.168.1.1 255.255.255.0  
!  
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
interface GigabitEthernet0/1.10
 encapsulation dot1Q 10
 ip address 192.168.10.1 255.255.255.0
!
interface GigabitEthernet0/1.20
 encapsulation dot1Q 20
 ip address 192.168.20.1 255.255.255.0
!
interface Serial0/0/0
 no ip address
 shutdown
 clock rate 2000000
!
interface Serial0/0/1
 no ip address
 shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
!
!
control-plane
!
!
!
line con 0
 password cisco
 logging synchronous
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password cisco
 login
 transport input all
!
scheduler allocate 20000 1000
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
end
```

Switch S1

```
S1# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/7, Fa0/8, Fa0/9, Fa0/10 Fa0/11, Fa0/12, Fa0/13, Fa0/14 Fa0/15, Fa0/16, Fa0/17, Fa0/18 Fa0/19, Fa0/20, Fa0/21, Fa0/22 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10 R&D	active	Fa0/6
20 Engineering	active	
1002 fddi-default	act/unsup	
1003 token-ring-default	act/unsup	
1004 fddinet-default	act/unsup	
1005 trnet-default	act/unsup	

```
S1# show run
```

```
Building configuration...
```

```
Current configuration : 1453 bytes
```

```
!  
!  
version 15.0  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname S1  
!  
boot-start-marker  
boot-end-marker  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
system mtu routing 1500  
!  
!  
no ip domain-lookup  
!  
!  
!  
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
!  
!  
!  
spanning-tree mode pvst  
spanning-tree extend system-id  
!  
vlan internal allocation policy ascending  
!  
!  
!  
!  
!  
!  
interface FastEthernet0/1  
  switchport mode trunk  
!  
interface FastEthernet0/2  
!  
interface FastEthernet0/3  
!  
interface FastEthernet0/4  
!  
interface FastEthernet0/5  
  switchport mode trunk  
!  
interface FastEthernet0/6  
  switchport access vlan 10  
  switchport mode access  
!  
interface FastEthernet0/7  
!  
interface FastEthernet0/8  
!  
interface FastEthernet0/9  
!  
interface FastEthernet0/10  
!  
interface FastEthernet0/11  
!  
interface FastEthernet0/12  
!  
interface FastEthernet0/13  
!  
interface FastEthernet0/14  
!  
interface FastEthernet0/15  
!  
interface FastEthernet0/16  
!  
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
interface FastEthernet0/17
!
interface FastEthernet0/18
!
interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
 ip address 192.168.1.11 255.255.255.0
!
 ip default-gateway 192.168.1.1
 ip http server
 ip http secure-server
!
!
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

Switch S2

```
S2# show vlan brief
```

VLAN Name	Status	Ports
1 default	active	Fa0/2, Fa0/3, Fa0/4, Fa0/5 Fa0/6, Fa0/7, Fa0/8, Fa0/9

Lab – Troubleshooting Inter-VLAN Routing

```
Fa0/10, Fa0/11, Fa0/12, Fa0/13
Fa0/14, Fa0/15, Fa0/16, Fa0/17
Fa0/19, Fa0/20, Fa0/21, Fa0/22
Fa0/23, Fa0/24, Gi0/1, Gi0/2
10 R&D active
20 Engineering active Fa0/18
1002 fddi-default act/unsup
1003 token-ring-default act/unsup
1004 fddinet-default act/unsup
1005 trnet-default act/unsup
```

```
S2# show run
```

```
Building configuration...
```

```
Current configuration : 1458 bytes
```

```
!
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGholQM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
!
!
!
!
!
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
!  
!  
!  
!  
interface FastEthernet0/1  
  switchport mode trunk  
!  
interface FastEthernet0/2  
!  
interface FastEthernet0/3  
!  
interface FastEthernet0/4  
!  
interface FastEthernet0/5  
!  
interface FastEthernet0/6  
!  
interface FastEthernet0/7  
!  
interface FastEthernet0/8  
!  
interface FastEthernet0/9  
!  
interface FastEthernet0/10  
!  
interface FastEthernet0/11  
!  
interface FastEthernet0/12  
!  
interface FastEthernet0/13  
!  
interface FastEthernet0/14  
!  
interface FastEthernet0/15  
!  
interface FastEthernet0/16  
!  
interface FastEthernet0/17  
!  
interface FastEthernet0/18  
  switchport access vlan 20  
  switchport mode access  
!  
interface FastEthernet0/19  
!  
interface FastEthernet0/20  
!  
interface FastEthernet0/21  
!
```

Lab – Troubleshooting Inter-VLAN Routing

```
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
 ip address 192.168.1.12 255.255.255.0
!
 ip default-gateway 192.168.1.1
 ip http server
 ip http secure-server
!
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

The Inside Track (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Explain how Layer 3 switches forward data in a small- to medium-sized business LAN.

Students will choose which type of inter-VLAN routing they would prefer if designing a network for local area network communications.

Scenario

Your company has just purchased a three-level building. You are the network administrator and must design the company inter-VLAN routing network scheme to serve a few employees on each floor.

Floor 1 is occupied by the HR Department, Floor 2 is occupied by the IT Department, and Floor 3 is occupied by the Sales Department. All Departments must be able to communicate with each other, but at the same time have their own separate working networks.

You brought three Cisco 2960 switches and a Cisco 1941 series router from the old office location to serve network connectivity in the new building. New equipment is non-negotiable.

Refer to the PDF for this activity for further instructions.

Resources

- Software presentation program

Directions

Work with a partner to complete this activity.

Step 1: Design your topology.

- Use one 2960 switch per floor of your new building.
- Assign one department to each switch.
- Pick one of the switches to connect to the 1941 series router.

Step 2: Plan the VLAN scheme.

- Devise VLAN names and numbers for the HR, IT, and Sales Departments.
- Include a management VLAN, possibly named Management or Native, numbered to your choosing.
- Use either IPv4 or v6 as your addressing scheme for the LANs. If using IPv4, you must also use VLSM.

Step 3: Design a graphic to show your VLAN design and address scheme.

Step 4: Choose your inter-VLAN routing method.

- Legacy (per interface)
- Router-on-a-Stick
- Multilayer switching

Step 5: Create a presentation justifying your inter-VLAN routing method of choice.

- a. No more than eight slides can be created for the presentation.
- b. Present your group's design to the class or to your instructor.
 - 1) Be able to explain the method you chose. What makes it different or more desirable to your business than the other two methods?
 - 2) Be able to show how data moves throughout your network. Verbally explain how the networks are able to communicate using your inter-VLAN method of choice.

Instructor Resource Information

- All students should be able to differentiate between the three inter-VLAN routing methods
- All students should be able to explain how they chose the method of inter-VLAN routing for their business
- All students should be able to explain how data flows on their chosen inter-VLAN routing method

Identify elements of the model that map to IT-related content:

- Legacy or per-interface inter-VLAN routing
- Router-on-a-Stick inter-VLAN routing
- Multi-layer switching inter-VLAN routing

Own or Lease? (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Configure DHCP for IPv4 on a LAN switch.

In preparation of learning DHCP in this chapter, students will visit a Linksys tutorial web site, <http://ui.linksys.com/WRT54GL/4.30.0/Setup.htm>. They will use the simulation on this site to practice how to configure IPv4 on a simple ISR LAN switch.

Scenario

This chapter presents the concept of using the DHCP process in a small- to medium-sized business network. This modeling activity describes how very basic wireless ISR devices work using the DHCP process.

Visit <http://ui.linksys.com/WRT54GL/4.30.0/Setup.htm>, which is a web-based simulator that helps you learn to configure DHCP using a Linksys wireless 54GL router. To the right of the simulator (in the blue description column), you can click **More** to read information about configuring DHCP settings on this particular integrated services router (ISR) simulator.

Practice configuring the ISR's:

- Hostname
- Local IP address with subnet mask
- DHCP (enable and disable)
- Starting IP address
- Maximum number of users to receive an IP DHCP address
- Lease time
- Time zone (use yours or a favorite as an alternative)

When you have completed configuring the settings as listed for this assignment, take a screen shot of your settings by using the **PrtScr** key command. Copy and place your screen shot into a word processing document. Save it and be prepared to discuss your configuration choices with the class.

Required Resources

Internet connectivity

Reflection

1. Why would any network administrator need to save a bank of IP addresses for DHCP **not** to use?

Some IP addresses need to be reserved for important equipment, such as network printers, ports on network routers, and servers.

2. You are designing your small- to medium-sized network and you have a choice as to whether to buy a small, generic ISR for DHCP purposes, or use a DHCP full server. Before you read this chapter, how would you make your decision?

Students will probably mention cost, mobility, ease of use. They may also want to mention security and configuration options as other answers.

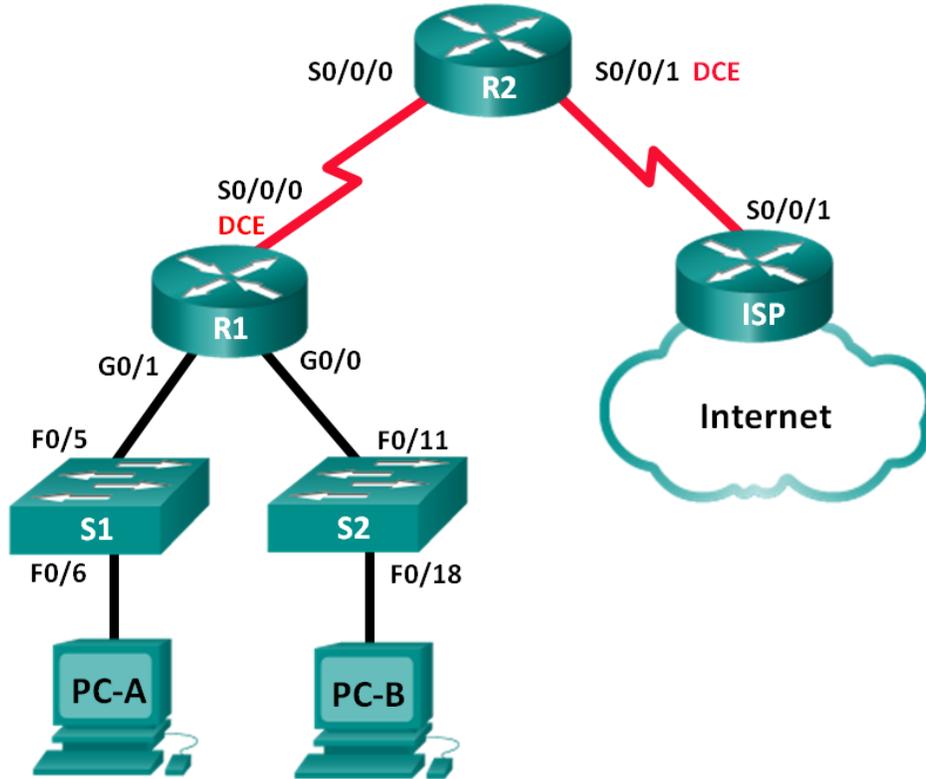
Identify elements of the model that map to IT-related content:

- Wireless routers may be used as DHCP servers.
- Wireless routers can be changed to respect different lease times for IP assignments.
- Some wireless routers function as both routers and switches (ISRs).
- It is good practice to keep a bank of IP addresses within a network for important static end device IP addressing and for specific users.

Lab - Configuring Basic DHCPv4 on a Router (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/0	192.168.0.1	255.255.255.0	N/A
	G0/1	192.168.1.1	255.255.255.0	N/A
	S0/0/0 (DCE)	192.168.2.253	255.255.255.252	N/A
R2	S0/0/0	192.168.2.254	255.255.255.252	N/A
	S0/0/1 (DCE)	209.165.200.226	255.255.255.224	N/A
ISP	S0/0/1	209.165.200.225	255.255.255.224	N/A
PC-A	NIC	DHCP	DHCP	DHCP
PC-B	NIC	DHCP	DHCP	DHCP

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure a DHCPv4 Server and a DHCP Relay Agent

Background / Scenario

The Dynamic Host Configuration Protocol (DHCP) is a network protocol that lets network administrators manage and automate the assignment of IP addresses. Without DHCP, the administrator must manually assign and configure IP addresses, preferred DNS servers, and default gateways. As the network grows in size, this becomes an administrative problem when devices are moved from one internal network to another.

In this scenario, the company has grown in size, and the network administrators can no longer assign IP addresses to devices manually. Your job is to configure the R2 router to assign IPv4 addresses on two different subnets connected to router R1.

Note: This lab provides minimal assistance with the actual commands necessary to configure DHCP. However, the required commands are provided in Appendix A. Test your knowledge by trying to configure the devices without referring to the appendix.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure the routers and switches with basic settings, such as passwords and IP addresses. You will also configure the IP settings for the PCs in the topology.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the routers and switches.

Step 3: Configure basic settings for each router.

- a. Disable DNS lookup.
- b. Configure the device name as shown in the topology.
- c. Assign **class** as the encrypted privileged EXEC mode password.
- d. Assign **cisco** as the console and vty passwords.
- e. Configure **logging synchronous** to prevent console messages from interrupting command entry.
- f. Configure the IP addresses for all the router interfaces according to the Addressing Table.
- g. Configure the serial DCE interface on R1 and R2 with a clock rate of 128000.

- h. Configure EIGRP for R1.

```
R1(config)# router eigrp 1
R1(config-router)# network 192.168.0.0 0.0.0.255
R1(config-router)# network 192.168.1.0 0.0.0.255
R1(config-router)# network 192.168.2.252 0.0.0.3
R1(config-router)# no auto-summary
```

- i. Configure EIGRP and a default route to the ISP on R2.

```
R2(config)# router eigrp 1
R2(config-router)# network 192.168.2.252 0.0.0.3
R2(config-router)# redistribute static
R2(config-router)# exit
R2(config)# ip route 0.0.0.0 0.0.0.0 209.165.200.225
```

- j. Configure a summary static route on ISP to reach the networks on the R1 and R2 routers.

```
ISP(config)# ip route 192.168.0.0 255.255.252.0 209.165.200.226
```

- k. Copy the running configuration to the startup configuration.

Step 4: Verify network connectivity between the routers.

If any pings between routers fail, correct the errors before proceeding to the next step. Use **show ip route** and **show ip interface brief** to locate possible issues.

Step 5: Verify the host PCs are configured for DHCP.

Part 2: Configure a DHCPv4 Server and a DHCP Relay Agent

To automatically assign address information on the network, you will configure R2 as a DHCPv4 server and R1 as a DHCP relay agent.

Step 1: Configure DHCPv4 server settings on router R2.

On R2, you will configure a DHCP address pool for each of the R1 LANs. Use the pool name **R1G0** for the G0/0 LAN and **R1G1** for the G0/1 LAN. You will also configure the addresses to be excluded from the address pools. Best practice dictates that excluded addresses be configured first, to guarantee that they are not accidentally leased to other devices.

Exclude the first 9 addresses in each R1 LAN starting with .1. All other addresses should be available in the DHCP address pool. Make sure that each DHCP address pool includes a default gateway, the domain **ccna-lab.com**, a DNS server (209.165.200.225), and a lease time of 2 days.

On the lines below, write the commands necessary for configuring DHCP services on router R2, including the DHCP-excluded addresses and the DHCP address pools.

Note: The required commands for Part 2 are provided in Appendix A. Test your knowledge by trying to configure DHCP on R1 and R2 without referring to the appendix.

Lab - Configuring Basic DHCPv4 on a Router

```
R1(config-if)# exit
R1(config)# interface g0/1
R1(config-if)# ip helper-address 192.168.2.254
```

Step 3: Record IP settings for PC-A and PC-B.

On PC-A and PC-B, issue the **ipconfig /all** command to verify that the PCs have received IP address information from the DHCP server on R2. Record the IP and MAC address for each PC.

Answers may vary.

Based on the DHCP pool that was configured on R2, what are the first available IP addresses that PC-A and PC-B can lease?

PC-B: 192.168.0.10, and PC-A: 192.168.1.10

Step 4: Verify DHCP services and address leases on R2.

- a. On R2, enter the **show ip dhcp binding** command to view DHCP address leases.

```
R2# show ip dhcp binding
Bindings from all pools not associated with VRF:
IP address          Client-ID/
                   Hardware address/
                   User name
192.168.0.10        011c.c1de.91c3.5d
                   Mar 13 2013 02:07 AM
192.168.1.10        0100.2170.0c05.0c
                   Mar 13 2013 02:09 AM
Type
Automatic
Automatic
```

Along with the IP addresses that were leased, what other piece of useful client identification information is in the output?

The client hardware addresses identify the specific computers that have joined the network.

- b. On R2, enter the **show ip dhcp server statistics** command to view the DHCP pool statistics and message activity.

```
R2# show ip dhcp server statistics
Memory usage      42175
Address pools     2
Database agents   0
Automatic bindings 2
Manual bindings   0
Expired bindings  0
Malformed messages 0
Secure arp entries 0

Message           Received
BOOTREQUEST      0
DHCPDISCOVER     2
DHCPREQUEST      2
DHCPDECLINE      0
DHCPRELEASE      0
```

Lab - Configuring Basic DHCPv4 on a Router

```
DHCPINFORM          2

Message             Sent
BOOTREPLY           0
DHCPOFFER           2
DHCPACK             4
DHCPNAK             0
```

How many types of DHCP messages are listed in the output?

Ten different types of DHCP messages are listed.

- c. On R2, enter the **show ip dhcp pool** command to view the DHCP pool settings.

```
R2# show ip dhcp pool
```

```
Pool R1G1 :
Utilization mark (high/low)    : 100 / 0
Subnet size (first/next)       : 0 / 0
Total addresses                 : 254
Leased addresses                : 1
Pending event                   : none
1 subnet is currently in the pool :
Current index      IP address range      Leased addresses
192.168.1.11      192.168.1.1      - 192.168.1.254    1

Pool R1G0 :
Utilization mark (high/low)    : 100 / 0
Subnet size (first/next)       : 0 / 0
Total addresses                 : 254
Leased addresses                : 1
Pending event                   : none
1 subnet is currently in the pool :
Current index      IP address range      Leased addresses
192.168.0.11      192.168.0.1      - 192.168.0.254    1
```

In the output of the **show ip dhcp pool** command, what does the Current index refer to?

The next available address for leasing

- d. On R2, enter the **show run | section dhcp** command to view the DHCP configuration in the running configuration.

```
R2# show run | section dhcp
ip dhcp excluded-address 192.168.0.1 192.168.0.9
ip dhcp excluded-address 192.168.1.1 192.168.1.9
ip dhcp pool R1G1
 network 192.168.1.0 255.255.255.0
 default-router 192.168.1.1
 domain-name ccna-lab.com
 dns-server 209.165.200.225
 lease 2
```

Lab - Configuring Basic DHCPv4 on a Router

```
ip dhcp pool R1G0
 network 192.168.0.0 255.255.255.0
 default-router 192.168.0.1
 domain-name ccna-lab.com
 dns-server 209.165.200.225
 lease 2
```

- e. On R1, enter the **show run interface** command for interfaces G0/0 and G0/1 to view the DHCP relay configuration in the running configuration.

```
R1# show run interface g0/0
Building configuration...

Current configuration : 132 bytes
!
interface GigabitEthernet0/0
 ip address 192.168.0.1 255.255.255.0
 ip helper-address 192.168.2.254
 duplex auto
 speed auto
end
```

```
R1# show run interface g0/1
Building configuration...

Current configuration : 132 bytes
!
interface GigabitEthernet0/1
 ip address 192.168.1.1 255.255.255.0
 ip helper-address 192.168.2.254
 duplex auto
 speed auto
end
```

Reflection

What do you think is the benefit of using DHCP relay agents instead of multiple routers acting as DHCP servers?

Having a separate router DHCP server for each subnet would add more complexity and decrease centralized management for the network. It would also require that each router work harder to manage its own DHCP addressing, in addition to the primary function of routing traffic. One DHCP server (router or computer) that is dedicated to the job is easier to manage and more centralized.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Appendix A – DHCP Configuration Commands

Router R1

```
R1(config)# interface g0/0
R1(config-if)# ip helper-address 192.168.2.254
R1(config-if)# exit
R1(config-if)# interface g0/1
R1(config-if)# ip helper-address 192.168.2.254
```

Router R2

```
R2(config)# ip dhcp excluded-address 192.168.0.1 192.168.0.9
R2(config)# ip dhcp excluded-address 192.168.1.1 192.168.1.9
R2(config)# ip dhcp pool R1G1
R2(dhcp-config)# network 192.168.1.0 255.255.255.0
R2(dhcp-config)# default-router 192.168.1.1
R2(dhcp-config)# dns-server 209.165.200.225
R2(dhcp-config)# domain-name ccna-lab.com
R2(dhcp-config)# lease 2
R2(dhcp-config)# exit
R2(config)# ip dhcp pool R1G0
R2(dhcp-config)# network 192.168.0.0 255.255.255.0
R2(dhcp-config)# default-router 192.168.0.1
R2(dhcp-config)# dns-server 209.165.200.225
R2(dhcp-config)# domain-name ccna-lab.com
```

Lab - Configuring Basic DHCPv4 on a Router

```
R2(dhcp-config)# lease 2
```

Device Configs

Router R1

```
R1# show run
```

```
Building configuration...
```

```
Current configuration : 1478 bytes
```

```
!  
version 15.2  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname R1  
!  
boot-start-marker  
boot-end-marker  
!  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
!  
!  
!  
!  
!  
!  
!  
no ip domain lookup  
ip cef  
no ipv6 cef  
multilink bundle-name authenticated  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
interface Embedded-Service-Engine0/0  
no ip address  
shutdown
```

Lab - Configuring Basic DHCPv4 on a Router

```
!  
interface GigabitEthernet0/0  
 ip address 192.168.0.1 255.255.255.0  
 ip helper-address 192.168.2.254  
 duplex auto  
 speed auto  
!  
interface GigabitEthernet0/1  
 ip address 192.168.1.1 255.255.255.0  
 ip helper-address 192.168.2.254  
 duplex auto  
 speed auto  
!  
interface Serial0/0/0  
 ip address 192.168.2.253 255.255.255.252  
 clock rate 128000  
!  
interface Serial0/0/1  
 no ip address  
 shutdown!  
!  
router eigrp 1  
 network 192.168.0.0  
 network 192.168.1.0  
 network 192.168.2.252 0.0.0.3  
!  
ip forward-protocol nd  
!  
no ip http server  
no ip http secure-server  
!  
!  
!  
!  
!  
control-plane  
!  
!  
!  
line con 0  
 password cisco  
 logging synchronous  
 login  
line aux 0  
line 2  
 no activation-character  
 no exec  
 transport preferred none  
 transport input all
```

Lab - Configuring Basic DHCPv4 on a Router

```
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R2

```
R2# show run
Building configuration...

Current configuration : 1795 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R2
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
!
!
!
ip dhcp excluded-address 192.168.0.1 192.168.0.9
ip dhcp excluded-address 192.168.1.1 192.168.1.9
!
ip dhcp pool R1G1
network 192.168.1.0 255.255.255.0
default-router 192.168.1.1
domain-name ccna-lab.com
dns-server 209.165.200.225
lease 2
!
ip dhcp pool R1G0
network 192.168.0.0 255.255.255.0
default-router 192.168.0.1
domain-name ccna-lab.com
```

Lab - Configuring Basic DHCPv4 on a Router

```
dns-server 209.165.200.225
lease 2
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
no ip address
shutdown
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
ip address 192.168.2.254 255.255.255.252
!
interface Serial0/0/1
ip address 209.165.200.226 255.255.255.224
clock rate 128000
!
!
router eigrp 1
network 192.168.2.252 0.0.0.3
redistribute static
!
ip forward-protocol nd
```

Lab - Configuring Basic DHCPv4 on a Router

```
!  
no ip http server  
no ip http secure-server  
!  
ip route 0.0.0.0 0.0.0.0 209.165.200.225  
!  
!  
!  
!  
control-plane  
!  
!  
!  
line con 0  
  password cisco  
  logging synchronous  
  login  
line aux 0  
line 2  
  no activation-character  
  no exec  
  transport preferred none  
  transport input all  
  transport output pad telnet rlogin lapb-ta mop udptn v120 ssh  
  stopbits 1  
line vty 0 4  
  password cisco  
  login  
  transport input all  
!  
scheduler allocate 20000 1000  
!  
end
```

Router ISP

```
ISP#show run  
Building configuration...  
  
Current configuration : 1247 bytes  
!  
version 15.2  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname ISP  
!  
boot-start-marker  
boot-end-marker
```

Lab - Configuring Basic DHCPv4 on a Router

```
!  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
memory-size iomem 10  
!  
!  
!  
!  
!  
!  
!  
!  
no ip domain lookup  
ip cef  
no ipv6 cef  
multilink bundle-name authenticated  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
interface Embedded-Service-Engine0/0  
no ip address  
shutdown  
!  
interface GigabitEthernet0/0  
no ip address  
shutdown  
duplex auto  
speed auto  
!  
interface GigabitEthernet0/1  
no ip address  
shutdown  
duplex auto  
speed auto  
!  
interface Serial0/0/0  
no ip address  
shutdown  
clock rate 2000000  
!  
interface Serial0/0/1
```

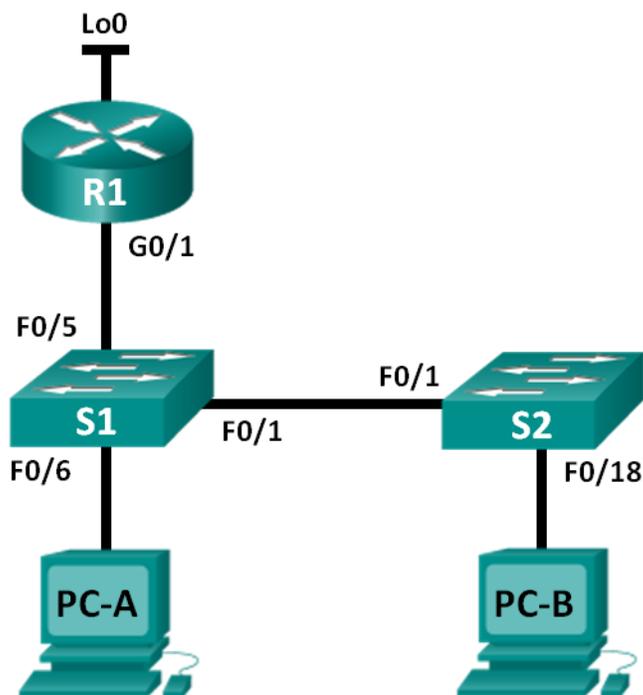
Lab - Configuring Basic DHCPv4 on a Router

```
ip address 209.165.200.225 255.255.255.224
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 192.168.0.0 255.255.252.0 209.165.200.226
!
!
!
!
control-plane
!
!
!
line con 0
  password cisco
  logging synchronous
  login
line aux 0
line 2
  no activation-character
  no exec
  transport preferred none
  transport input all
  transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
  stopbits 1
line vty 0 4
  password cisco
  login
  transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab – Configuring Basic DHCPv4 on a Switch (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask
R1	G0/1	192.168.1.10	255.255.255.0
	Lo0	209.165.200.225	255.255.255.224
S1	VLAN 1	192.168.1.1	255.255.255.0
	VLAN 2	192.168.2.1	255.255.255.0

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Change the SDM Preference

- Set the SDM preference to lanbase-routing on S1.

Part 3: Configure DHCPv4

- Configure DHCPv4 for VLAN 1.
- Verify DHCPv4 and connectivity.

Part 4: Configure DHCP for Multiple VLANs

Lab – Configuring Basic DHCPv4 on a Switch

- Assign ports to VLAN 2.
- Configure DHCPv4 for VLAN 2.
- Verify DHCPv4 and connectivity.

Part 5: Enable IP Routing

- Enable IP routing on the switch.
- Create static routes.

Background / Scenario

A Cisco 2960 switch can function as a DHCPv4 server. The Cisco DHCPv4 server assigns and manages IPv4 addresses from identified address pools that are associated with specific VLANs and switch virtual interfaces (SVIs). The Cisco 2960 switch can also function as a Layer 3 device and route between VLANs and a limited number of static routes. In this lab, you will configure DHCPv4 for both single and multiple VLANs on a Cisco 2960 switch, enable routing on the switch to allow for communication between VLANs, and add static routes to allow for communication between all hosts.

Note: This lab provides minimal assistance with the actual commands necessary to configure DHCP. However, the required commands are provided in Appendix A. Test your knowledge by trying to configure the devices without referring to the appendix.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the router and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the router and switches.

Step 3: Configure basic setting on devices.

- a. Assign device names as shown in the topology.
- b. Disable DNS lookup.
- c. Assign **class** as the enable password and assign **cisco** as the console and vty passwords.

- d. Configure the IP addresses on R1 G0/1 and Lo0 interfaces, according to the Addressing Table.
- e. Configure the IP addresses on S1 VLAN 1 and VLAN 2 interfaces, according to the Addressing Table.
- f. Save the running configuration to the startup configuration file.

Part 2: Change the SDM Preference

The Cisco Switch Database Manager (SDM) provides multiple templates for the Cisco 2960 switch. The templates can be enabled to support specific roles depending on how the switch is used in the network. In this lab, the sdm lanbase-routing template is enabled to allow the switch to route between VLANs and to support static routing.

Step 1: Display the SDM preference on S1.

On S1, issue the **show sdm prefer** command in privileged EXEC mode. If the template has not been changed from the factory default, it should still be the **default** template. The **default** template does not support static routing. If IPv6 addressing has been enabled, the template will be **dual-ipv4-and-ipv6 default**.

```
S1# show sdm prefer
```

```
The current template is "default" template.
The selected template optimizes the resources in
the switch to support this level of features for
0 routed interfaces and 255 VLANs.
```

```
number of unicast mac addresses:          8K
number of IPv4 IGMP groups:              0.25K
number of IPv4/MAC qos aces:            0.125k
number of IPv4/MAC security aces:       0.375k
```

```
S1# show sdm prefer
```

```
The current template is "dual-ipv4-and-ipv6 default" template.
The selected template optimizes the resources in
the switch to support this level of features for
0 routed interfaces and 255 VLANs.
```

```
number of unicast mac addresses:          4K
number of IPv4 IGMP groups + multicast routes: 0.25K
number of IPv4 unicast routes:           0
number of IPv6 multicast groups:         0.375k
number of directly-connected IPv6 addresses: 0
number of indirect IPv6 unicast routes:  0
number of IPv4 policy based routing aces: 0
number of IPv4/MAC qos aces:            0.125k
number of IPv4/MAC security aces:       0.375k
number of IPv6 policy based routing aces: 0
number of IPv6 qos aces:                 0.625k
number of IPv6 security aces:           125
```

```
S1# show sdm prefer
```

```
The current template is "lanbase-routing" template.
The selected template optimizes the resources in
```

Lab – Configuring Basic DHCPv4 on a Switch

the switch to support this level of features for 0 routed interfaces and 255 VLANs.

```
number of unicast mac addresses:          4K
number of IPv4 IGMP groups + multicast routes: 0.25K
number of IPv4 unicast routes:           0.75K
  number of directly-connected IPv4 hosts: 0.75K
  number of indirect IPv4 routes:         16
number of IPv6 multicast groups:         0.375k
number of directly-connected IPv6 addresses: 0.75K
  number of indirect IPv6 unicast routes:  16
number of IPv4 policy based routing aces: 0
number of IPv4/MAC qos aces:             0.125k
number of IPv4/MAC security aces:        0.375k
number of IPv6 policy based routing aces: 0
number of IPv6 qos aces:                 0.375k
number of IPv6 security aces:            127
```

What is the current template?

Answers will vary. "default" or "dual-ipv4-and-ipv6 default" or "lanbase-routing".

Step 2: Change the SDM Preference on S1.

- a. Set the SDM preference to **lanbase-routing**. (If lanbase-routing is the current template, please proceed to Part 3.) From global configuration mode, issue the **sdm prefer lanbase-routing** command.

```
S1(config)# sdm prefer lanbase-routing
```

Changes to the running SDM preferences have been stored, but cannot take effect until the next reload.

Use 'show sdm prefer' to see what SDM preference is currently active.

```
S1# show sdm prefer
```

```
The current template is "default" template.
The selected template optimizes the resources in
the switch to support this level of features for
0 routed interfaces and 255 VLANs.
```

```
number of unicast mac addresses:          8K
number of IPv4 IGMP groups:              0.25K
number of IPv4/MAC qos aces:             0.125k
number of IPv4/MAC security aces:        0.375k
```

On next reload, template will be "lanbase-routing" template.

Which template will be available after reload? _____ **lanbase-routing**

- b. The switch must be reloaded for the template to be enabled.

```
S1# reload
```

```
System configuration has been modified. Save? [yes/no]: no
Proceed with reload? [confirm]
```

Lab – Configuring Basic DHCPv4 on a Switch

Note: The new template will be used after reboot even if the running configuration has not been saved. To save the running configuration, answer **yes** to save the modified system configuration.

Step 3: Verify that lanbase-routing template is loaded.

Issue the **show sdm prefer** command to verify that the lanbase-routing template has been loaded on S1.

```
S1# show sdm prefer
The current template is "lanbase-routing" template.
The selected template optimizes the resources in
the switch to support this level of features for
0 routed interfaces and 255 VLANs.

number of unicast mac addresses:          4K
number of IPv4 IGMP groups + multicast routes: 0.25K
number of IPv4 unicast routes:           0.75K
  number of directly-connected IPv4 hosts: 0.75K
  number of indirect IPv4 routes:         16
number of IPv6 multicast groups:         0.375k
number of directly-connected IPv6 addresses: 0.75K
  number of indirect IPv6 unicast routes: 16
number of IPv4 policy based routing aces: 0
number of IPv4/MAC qos aces:             0.125k
number of IPv4/MAC security aces:        0.375k
number of IPv6 policy based routing aces: 0
number of IPv6 qos aces:                 0.375k
number of IPv6 security aces:            127
```

Part 3: Configure DHCPv4

In Part 3, you will configure DHCPv4 for VLAN 1, check IP settings on host computers to validate DHCP functionality, and verify connectivity for all devices in VLAN 1.

Step 1: Configure DHCP for VLAN 1.

- Exclude the first 10 valid host addresses from network 192.168.1.0/24. Write the command you used in the space provided.

```
S1(config)# ip dhcp excluded-address 192.168.1.1 192.168.1.10
```

- Create a DHCP pool named **DHCP1**. Write the command you used in the space provided.

```
S1(config)# ip dhcp pool DHCP1
```

- Assign the network 192.168.1.0/24 for available addresses. Write the command you used in the space provided.

```
S1(dhcp-config)# network 192.168.1.0 255.255.255.0
```

- Assign the default gateway as 192.168.1.1. Write the command you used in the space provided.
-

Lab – Configuring Basic DHCPv4 on a Switch

```
S1(dhcp-config)# default-router 192.168.1.1
```

- e. Assign the DNS server as 192.168.1.9. Write the command you used in the space provided.

```
S1(dhcp-config)# dns-server 192.168.1.9
```

- f. Assign a lease time of 3 days. Write the command you used in the space provided.

```
S1(dhcp-config)# lease 3
```

- g. Save the running configuration to the startup configuration file.

Step 2: Verify DHCP and connectivity.

- a. On PC-A and PC-B, open the command prompt and issue the **ipconfig** command. If IP information is not present, or if it is incomplete, issue the **ipconfig /release** command, followed by the **ipconfig /renew** command.

For PC-A, list the following:

IP Address: _____ **192.168.1.11**

Subnet Mask: _____ **255.255.255.0**

Default Gateway: _____ **192.168.1.1**

For PC-B, list the following:

IP Address: _____ **192.168.1.12**

Subnet Mask: _____ **255.255.255.0**

Default Gateway: _____ **192.168.1.1**

- b. Test connectivity by pinging from PC-A to the default gateway, PC-B, and R1.

From PC-A, is it possible to ping the VLAN 1 default gateway? _____ **Yes**

From PC-A, is it possible to ping PC-B? _____ **Yes**

From PC-A, is it possible to ping R1 G0/1? _____ **Yes**

If the answer is no to any of these questions, troubleshoot the configurations and correct the error.

Part 4: Configure DHCPv4 for Multiple VLANs

In Part 4, you will assign PC-A to a port accessing VLAN 2, configure DHCPv4 for VLAN 2, renew the IP configuration of PC-A to validate DHCPv4, and verify connectivity within the VLAN.

Step 1: Assign a port to VLAN 2.

Place port F0/6 into VLAN 2. Write the command you used in the space provided.

```
S1(config)# interface f0/6
```

```
S1(config-if)# switchport access vlan 2
```

Step 2: Configure DHCPv4 for VLAN 2

- a. Exclude the first 10 valid host addresses from network 192.168.2.0. Write the command you used in the space provided.

```
S1(config)# ip dhcp excluded-address 192.168.2.1 192.168.2.10
```

- b. Create a DHCP pool named **DHCP2**. Write the command you used in the space provided.

```
S1(config)# ip dhcp pool DHCP2
```

- c. Assign the network 192.168.2.0/24 for available addresses. Write the command you used in the space provided.

```
S1(dhcp-config)# network 192.168.2.0 255.255.255.0
```

- d. Assign the default gateway as 192.168.2.1. Write the command you used in the space provided.

```
S1(dhcp-config)# default-router 192.168.2.1
```

- e. Assign the DNS server as 192.168.2.9. Write the command you used in the space provided.

```
S1(dhcp-config)# dns-server 192.168.2.9
```

- f. Assign a lease time of 3 days. Write the command you used in the space provided.

```
S1(dhcp-config)# lease 3
```

- g. Save the running configuration to the startup configuration file.

Step 3: Verify DHCPv4 and connectivity.

- a. On PC-A, open the command prompt and issue the **ipconfig /release** command, followed by **ipconfig /renew** command.

For PC-A, list the following:

IP Address: _____ 192.168.2.11
Subnet Mask: _____ 255.255.255.0
Default Gateway: _____ 192.168.2.1

- b. Test connectivity by pinging from PC-A to the VLAN 2 default gateway and PC-B.

From PC-A, is it possible to ping the default gateway? _____ Yes

From PC-A, is it possible to ping PC-B? _____ No

Were these pings successful? Why?

Because the default gateway is in the same network as PC-A, PC-A can ping the default gateway. PC-B is in a different network; therefore, the ping from PC-A is not successful.

- c. Issue the **show ip route** command on S1.

```
S1# show ip route
Default gateway is not set
```

```
Host          Gateway          Last Use      Total Uses   Interface
ICMP redirect cache is empty
```

What was the result of this command?

No default gateway has been set and no routing table is present on the switch.

Part 5: Enable IP Routing

In Part 5, you will enable IP routing on the switch, which will allow for inter-VLAN communication. For all networks to communicate, static routes on S1 and R1 must be implemented.

Step 1: Enable IP routing on S1.

- From global configuration mode, use the **ip routing** command to enable routing on S1.

```
S1(config)# ip routing
```

- Verify inter-VLAN connectivity.

From PC-A, is it possible to ping PC-B? _____ **Yes**

What function is the switch performing?

The switch is routing between VLANs.

- View the routing table information for S1.

```
S1# show ip route
```

```
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override
```

```
Gateway of last resort is not set
```

```

  192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.1.0/24 is directly connected, Vlan1
L       192.168.1.1/32 is directly connected, Vlan1
  192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.2.0/24 is directly connected, Vlan2
L       192.168.2.1/32 is directly connected, Vlan2
```

What route information is contained in the output of this command?

The switch exhibits a routing table showing VLANs as directly connected networks 192.168.1.0/24 and 192.168.2.0/24.

- d. View the routing table information for R1.

R1# **show ip route**

```
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override
```

Gateway of last resort is not set

```
          192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C           192.168.1.0/24 is directly connected, GigabitEthernet0/1
L           192.168.1.10/32 is directly connected, GigabitEthernet0/1
          209.165.200.0/27 is variably subnetted, 2 subnets, 2 masks
C           209.165.200.0/27 is directly connected, Loopback0
L           209.165.200.225/32 is directly connected, Loopback0
```

What route information is contained in the output of this command?

The router output shows directly connected networks of 192.168.1.0 and to 209.165.200.224 but has no entry for the 192.168.2.0 network.

- e. From PC-A, is it possible to ping R1? _____ **No**
From PC-A, is it possible to ping Lo0? _____ **No**

Consider the routing table of the two devices, what must be added to communicate between all networks?

In order for communication to occur between all networks, routes must be added to the routing tables.

Step 2: Assign static routes.

Enabling IP routing allows the switch to route between VLANs assigned on the switch. For all VLANs to communicate with the router, static routes must be added to the routing table of both the switch and the router.

- a. On S1, create a default static route to R1. Write the command you used in the space provided.

```
S1(config)# ip route 0.0.0.0 0.0.0.0 192.168.1.10
```

- b. On R1, create a static route to VLAN 2. Write the command you used in the space provided.
-

Lab – Configuring Basic DHCPv4 on a Switch

```
R1(config)# ip route 192.168.2.0 255.255.255.0 g0/1
```

- c. View the routing table information for S1.

```
S1# show ip route
```

```
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override
```

```
Gateway of last resort is 192.168.1.10 to network 0.0.0.0
```

```
S*   0.0.0.0/0 [1/0] via 192.168.1.10
     192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C     192.168.1.0/24 is directly connected, Vlan1
L     192.168.1.1/32 is directly connected, Vlan1
     192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C     192.168.2.0/24 is directly connected, Vlan2
L     192.168.2.1/32 is directly connected, Vlan2
```

How is the default static route represented?

```
Gateway of last resort is 192.168.1.10 to network 0.0.0.0
```

- d. View the routing table information for R1.

```
R1# show ip route
```

```
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override
```

```
Gateway of last resort is not set
```

```
     192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C     192.168.1.0/24 is directly connected, GigabitEthernet0/1
L     192.168.1.10/32 is directly connected, GigabitEthernet0/1
S     192.168.2.0/24 is directly connected, GigabitEthernet0/1
     209.165.200.0/24 is variably subnetted, 2 subnets, 2 masks
C     209.165.200.0/27 is directly connected, Loopback0
L     209.165.200.225/32 is directly connected, Loopback0
```

How is the static route represented?

Lab – Configuring Basic DHCPv4 on a Switch

S 192.168.2.0/24 is directly connected, GigabitEthernet0/1

- e. From PC-A, is it possible to ping R1? _____ **Yes**
From PC-A, is it possible to ping Lo0? _____ **Yes**

Reflection

1. In configuring DHCPv4, why would you exclude the static addresses prior to setting up the DHCPv4 pool?

If the static addresses were excluded after the DHCPv4 pool was created, a window of time exists where the excluded addresses could be given out dynamically to hosts.

2. If multiple DHCPv4 pools are present, how does the switch assign the IP information to hosts?

The switch will assign IP configurations based on the VLAN assignment of the port to which the host is connected.

3. Besides switching, what functions can the Cisco 2960 switch perform?

The switch can function as a DHCP server and can perform static and inter-VLAN routing.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Appendix A: Configuration Commands

Configure DHCPv4

```
S1(config)# ip dhcp excluded-address 192.168.1.1 192.168.1.10
S1(config)# ip dhcp pool DHCP1
S1(dhcp-config)# network 192.168.1.0 255.255.255.0
S1(dhcp-config)# default-router 192.168.1.1
S1(dhcp-config)# dns-server 192.168.1.9
S1(dhcp-config)# lease 3
```

Configure DHCPv4 for Multiple VLANs

```
S1(config)# interface f0/6
S1(config-if)# switchport access vlan 2
S1(config)# ip dhcp excluded-address 192.168.2.1 192.168.2.10
S1(config)# ip dhcp pool DHCP2
S1(dhcp-config)# network 192.168.2.0 255.255.255.0
S1(dhcp-config)# default-router 192.168.2.1
S1(dhcp-config)# dns-server 192.168.2.9
S1(dhcp-config)# lease 3
```

Enable IP Routing

```
S1(config)# ip routing
S1(config)# ip route 0.0.0.0 0.0.0.0 192.168.1.10
R1(config)# ip route 192.168.2.0 255.255.255.0 g0/1
```

Device Configs

Router R1

```
R1#show run
Building configuration...

Current configuration : 1489 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
!
!
!
!
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
interface Loopback0
 ip address 209.165.200.225 255.255.255.0
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
```

Lab – Configuring Basic DHCPv4 on a Switch

```
interface GigabitEthernet0/1
 ip address 192.168.1.10 255.255.255.0
 duplex auto
 speed auto
!
interface Serial0/0/0
 no ip address
 shutdown
 clock rate 2000000
!
interface Serial0/0/1
 no ip address
 shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 192.168.2.0 255.255.255.0 GigabitEthernet0/1
!
!
!
!
control-plane
!
!
!
line con 0
 password cisco
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password cisco
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab – Configuring Basic DHCPv4 on a Switch

Switch S1

```
S1#show run
Building configuration...

Current configuration : 3636 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
ip routing
ip dhcp excluded-address 192.168.1.1 192.168.1.10
ip dhcp excluded-address 192.168.2.1 192.168.2.10
!
ip dhcp pool DHCP1
 network 192.168.1.0 255.255.255.0
 default-router 192.168.1.1
 dns-server 192.168.1.9
 lease 3
!
ip dhcp pool DHCP2
 network 192.168.2.0 255.255.255.0
 default-router 192.168.2.1
 dns-server 192.168.2.9
 lease 3
!
!
no ip domain-lookup
!
!
crypto pki trustpoint TP-self-signed-2531409152
 enrollment selfsigned
 subject-name cn=IOS-Self-Signed-Certificate-2531409152
 revocation-check none
 rsa-keypair TP-self-signed-2531409152
!
!
crypto pki certificate chain TP-self-signed-2531409152
```

Lab – Configuring Basic DHCPv4 on a Switch

```
certificate self-signed 01
 3082022B 30820194 A0030201 02020101 300D0609 2A864886 F70D0101 05050030
 31312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D 43657274
 69666963 6174652D 32353331 34303931 3532301E 170D3933 30333031 30303030
 35365A17 0D323030 31303130 30303030 305A3031 312F302D 06035504 03132649
 4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32 35333134
 30393135 3230819F 300D0609 2A864886 F70D0101 01050003 818D0030 81890281
 8100CA1B 27DE634E CF9FE284 C86127EF 41E7A52F 0A82FA2B 7C5448B7 184EA1AB
 C22510E1 38A742BC D9F416FD 93A52DC6 BA77A928 B317DA75 1B3E2C66 C2D9061B
 806132D9 E3189012 467C7A2C DCAC3EF4 4C419338 790AA98B C7A81D73 8621536C
 4A90659E 267BA2E3 36F801A4 F06BEC65 386A40DA 255D9790 F9412706 9E73A660
 45230203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF 301F0603
 551D2304 18301680 14A7356A D364AE65 E1E9D42F 9B059B27 B69BB9C6 FD301D06
 03551D0E 04160414 A7356AD3 64AE65E1 E9D42F9B 059B27B6 9BB9C6FD 300D0609
 2A864886 F70D0101 05050003 8181002A D78919E7 0D75567C EF60036C 6C4B051A
 2ABC5B9C DA1C1E48 AF33C405 5C64E074 B954C5B5 D825BE61 7340C695 03049797
 D869E516 3936D0EC C871F140 66A1DEB2 BA57AB0D D2AB2706 17674B3A 7423C276
 B96CFB88 DE98A86E 7B539B68 7DEE53BB ED16BFA0 A89A5CA4 79F15F49 59DDF6E5
 E716514A 5CFC7522 8E76778E 029E8F
quit
!
!
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
!
!
!
!
interface FastEthernet0/1
!
interface FastEthernet0/2
!
interface FastEthernet0/3
!
interface FastEthernet0/4
!
interface FastEthernet0/5
!
interface FastEthernet0/6
switchport access vlan 2
!
interface FastEthernet0/7
```

Lab – Configuring Basic DHCPv4 on a Switch

```
!  
interface FastEthernet0/8  
!  
interface FastEthernet0/9  
!  
interface FastEthernet0/10  
!  
interface FastEthernet0/11  
!  
interface FastEthernet0/12  
!  
interface FastEthernet0/13  
!  
interface FastEthernet0/14  
!  
interface FastEthernet0/15  
!  
interface FastEthernet0/16  
!  
interface FastEthernet0/17  
!  
interface FastEthernet0/18  
!  
interface FastEthernet0/19  
!  
interface FastEthernet0/20  
!  
interface FastEthernet0/21  
!  
interface FastEthernet0/22  
!  
interface FastEthernet0/23  
!  
interface FastEthernet0/24  
!  
interface GigabitEthernet0/1  
!  
interface GigabitEthernet0/2  
!  
interface Vlan1  
ip address 192.168.1.1 255.255.255.0  
!  
interface Vlan2  
ip address 192.168.2.1 255.255.255.0  
!  
ip http server  
ip http secure-server  
ip route 0.0.0.0 0.0.0.0 192.168.1.10  
!
```

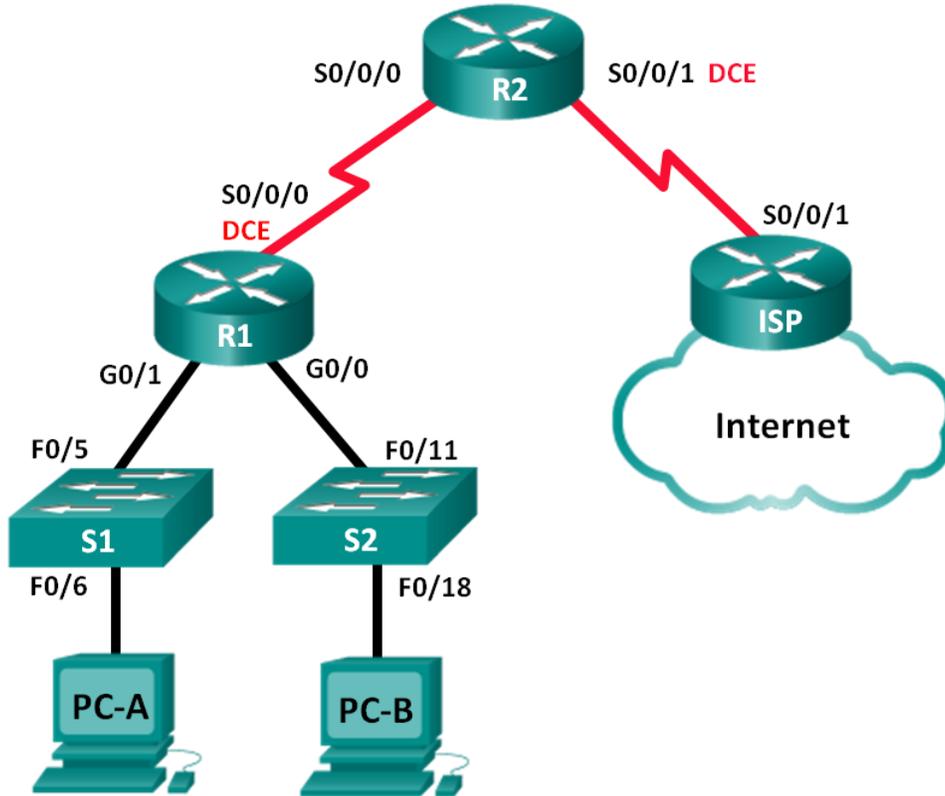
Lab – Configuring Basic DHCPv4 on a Switch

```
!  
!  
line con 0  
  password cisco  
  login  
line vty 0 4  
  password cisco  
  login  
line vty 5 15  
  password cisco  
  login  
!  
end
```

Lab - Troubleshooting DHCPv4 (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/0	192.168.0.1	255.255.255.128	N/A
	G0/1	192.168.1.1	255.255.255.0	N/A
	S0/0/0 (DCE)	192.168.0.253	255.255.255.252	N/A
R2	S0/0/0	192.168.0.254	255.255.255.252	N/A
	S0/0/1 (DCE)	209.165.200.226	255.255.255.252	N/A
ISP	S0/0/1	209.165.200.225	255.255.255.252	N/A
S1	VLAN 1	192.168.1.2	255.255.255.0	192.168.1.1
S2	VLAN 1	192.168.0.2	255.255.255.128	192.168.0.1
PC-A	NIC	DHCP	DHCP	DHCP
PC-B	NIC	DHCP	DHCP	DHCP

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Troubleshoot DHCPv4 Issues

Background / Scenario

The Dynamic Host Configuration Protocol (DHCP) is a network protocol that lets the network administrators manage and automate the assignment of IP addresses. Without DHCP, the administrator must manually assign and configure IP addresses, preferred DNS servers, and the default gateway. As the network grows in size, this becomes an administrative problem when devices are moved from one internal network to another.

In this scenario, the company has grown in size, and the network administrators can no longer assign IP addresses to devices manually. The R2 router has been configured as a DHCP server to assign IP addresses to the host devices on router R1 LANs. Several errors in the configuration have resulted in connectivity issues. You are asked to troubleshoot and correct the configuration errors and document your work.

Ensure that the network supports the following:

- 1) The router R2 should function as the DHCP server for the 192.168.0.0/25 and 192.168.1.0/24 networks connected to R1.
- 2) All PCs connected to S1 and S2 should receive an IP address in the correct network via DHCP.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the routers and switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Instructions for erasing the switches and routers are provided in the Lab Manual.

Required Resources

- 3 Routers (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 2 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 2 PCs (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet and serial cables as shown in the topology

Part 2: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure the routers and switches with basic settings, such as passwords and IP addresses. You will also configure the IP settings for the PCs in the topology.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the routers and switches.

Step 3: Configure basic settings for each router.

- Disable DNS lookup.
- Configure device name as shown in the topology.
- Assign **class** as the privileged EXEC password.
- Assign **cisco** as the console and vty passwords.
- Configure **logging synchronous** to prevent console messages from interrupting command entry.
- Configure the IP addresses for all the router interfaces.
- Set clock rate to **128000** for all DCE router interfaces.
- Configure EIGRP for R1.

```
R1(config)# router eigrp 1
R1(config-router)# network 192.168.0.0 0.0.0.127
R1(config-router)# network 192.168.0.252 0.0.0.3
R1(config-router)# network 192.168.1.0
R1(config-router)# no auto-summary
```

- Configure EIGRP and a static default route on R2.

```
R2(config)# router eigrp 1
R2(config-router)# network 192.168.0.252 0.0.0.3
R2(config-router)# redistribute static
R2(config-router)# exit
R2(config)# ip route 0.0.0.0 0.0.0.0 209.165.200.225
```

- Configure a summary static route on ISP to the networks on R1 and R2 routers.

```
ISP(config)# ip route 192.168.0.0 255.255.254.0 209.165.200.226
```

Step 4: Verify network connectivity between the routers.

If any pings between the routers fail, correct the errors before proceeding to the next step. Use **show ip route** and **show ip interface brief** to locate possible issues.

Step 5: Configure basic settings for each switch.

- Disable DNS lookup.
- Configure device name as shown in the topology.
- Configure the IP address for the VLAN 1 interface and the default gateway for each switch.
- Assign **class** as the privileged EXEC mode password.
- Assign **cisco** as the console and vty passwords.
- Configure **logging synchronous** for the console line.

Step 6: Verify the hosts are configured for DHCP.

Step 7: Load the initial DHCP configuration for R1 and R2.

Router R1

```
!interface GigabitEthernet0/0
! ip helper-address 192.168.0.254
interface GigabitEthernet0/1
 ip helper-address 192.168.0.253
! ip helper-address 192.168.0.254
```

Router R2

```
ip dhcp excluded-address 192.168.11.1 192.168.11.9
!ip dhcp excluded-address 192.168.1.1 192.168.1.9
ip dhcp excluded-address 192.168.0.1 192.168.0.9
ip dhcp pool R1G1
 network 192.168.1.0 255.255.255.0
 default-router 192.168.1.1
ip dhcp pool R1G0
 network 192.168.0.0 255.255.255.128
 default-router 192.168.11.1
!default-router 192.168.0.1
```

Part 3: Troubleshoot DHCPv4 Issues

After configuring routers R1 and R2 with DHCPv4 settings, several errors in the DHCP configurations were introduced and resulted in connectivity issues. R2 is configured as a DHCP server. For both pools of DHCP addresses, the first nine addresses are reserved for the routers and switches. R1 relays the DHCP information to all the R1 LANs. Currently, PC-A and PC-B have no access to the network. Use the **show** and **debug** commands to determine and correct the network connectivity issues.

Step 1: Record IP settings for PC-A and PC-B.

- For PC-A and PC-B, at the command prompt, enter **ipconfig /all** to display the IP and MAC addresses.
- Record the IP and MAC addresses in the table below. The MAC address can be used to determine which PC is involved in the debug message.

	IP Address/Subnet Mask	MAC Address
PC-A	No IP address is assigned by DHCP. (Students may record an APIPA address starting with 169.254.x.x. This is a private local address that Microsoft OS assigns when the host cannot reach a DHCP server to obtain an IP address.)	0050:56BE:768C
PC-B	No IP address is assigned by DHCP. (Students may record an APIPA address starting with 169.254.x.x. This is a private local address that Microsoft OS assigns when the host cannot reach a DHCP server to obtain an IP address.)	0050:56BE:F6DB

Step 2: Troubleshoot DHCP issues for the 192.168.1.0/24 network on router R1.

Router R1 is a DHCP relay agent for all the R1 LANs. In this step, only the DHCP process for the 192.168.1.0/24 network will be examined. The first nine addresses are reserved for other network devices, such as routers, switches, and servers.

- a. Use a DHCP **debug** command to observe the DHCP process on R2 router.

```
R2# debug ip dhcp server events
```

- b. On R1, display the running configuration for the G0/1 interface.

```
R1# show run interface g0/1
interface GigabitEthernet0/1
 ip address 192.168.1.1 255.255.255.0
 ip helper-address 192.168.0.253
 duplex auto
 speed auto
```

If there are any DHCP relay issues, record any commands that are necessary to correct the configurations errors.

DHCP relay was incorrectly configured for G0/1 interface. The command **ip helper-address 192.168.0.254** needs to be added to the R1 router. The incorrect helper address should be removed from the configuration. The issue can be resolved using the following commands:

```
R1(config)# interface g0/1
R1(config-if)## no ip helper-address 192.168.0.253
R1(config-if)# ip helper-address 192.168.0.254
```

- c. In a command prompt on PC-A, type **ipconfig /renew** to receive an address from the DHCP server. Record the configured IP address, subnet mask, and default gateway for PC-A.

IP address: 192.168.1.3, subnet mask: 255.255.255.0, default gateway: 192.168.1.1

- d. Observe the debug messages on R2 router for the DHCP renewal process for PC-A. The DHCP server attempted to assign 192.168.1.1/24 to PC-A. This address is already in use for G0/1 interface on R1. The same issue occurs with IP address 192.168.1.2/24 because this address has been assigned to S1 in the initial configuration. Therefore, an IP address of 192.168.1.3/24 has been assigned to PC-A. The DHCP assignment conflict indicates there may be an issue with the excluded-address statement on the DHCP server configuration on R2.

```
*Mar 5 06:32:16.939: DHCPD: Sending notification of DISCOVER:
*Mar 5 06:32:16.939:   DHCPD: htype 1 chaddr 0050.56be.768c
*Mar 5 06:32:16.939:   DHCPD: circuit id 00000000
*Mar 5 06:32:16.939: DHCPD: Seeing if there is an internally specified pool class:
*Mar 5 06:32:16.939:   DHCPD: htype 1 chaddr 0050.56be.768c
*Mar 5 06:32:16.939:   DHCPD: circuit id 00000000
*Mar 5 06:32:16.943: DHCPD: Allocated binding 2944C764
*Mar 5 06:32:16.943: DHCPD: Adding binding to radix tree (192.168.1.1)
*Mar 5 06:32:16.943: DHCPD: Adding binding to hash tree
*Mar 5 06:32:16.943: DHCPD: assigned IP address 192.168.1.1 to client
0100.5056.be76.8c.
*Mar 5 06:32:16.951: %DHCPD-4-PING_CONFLICT: DHCP address conflict: server pinged
192.168.1.1.
*Mar 5 06:32:16.951: DHCPD: returned 192.168.1.1 to address pool R1G1.
*Mar 5 06:32:16.951: DHCPD: Sending notification of DISCOVER:
*Mar 5 06:32:16.951:   DHCPD: htype 1 chaddr 0050.56be.768c
*Mar 5 06:32:16.951:   DHCPD: circuit id 00000000
*Mar 5 06:32:1
R2#6.951: DHCPD: Seeing if there is an internally specified pool class:
*Mar 5 06:32:16.951:   DHCPD: htype 1 chaddr 0050.56be.768c
*Mar 5 06:32:16.951:   DHCPD: circuit id 00000000
*Mar 5 06:32:16.951: DHCPD: Allocated binding 31DC93C8
*Mar 5 06:32:16.951: DHCPD: Adding binding to radix tree (192.168.1.2)
*Mar 5 06:32:16.951: DHCPD: Adding binding to hash tree
*Mar 5 06:32:16.951: DHCPD: assigned IP address 192.168.1.2 to client
0100.5056.be76.8c.
*Mar 5 06:32:18.383: %DHCPD-4-PING_CONFLICT: DHCP address conflict: server pinged
192.168.1.2.
*Mar 5 06:32:18.383: DHCPD: returned 192.168.1.2 to address pool R1G1.
*Mar 5 06:32:18.383: DHCPD: Sending notification of DISCOVER:
*Mar 5 06:32:18.383:   DHCPD: htype 1 chaddr 0050.56be.6c89
*Mar 5 06:32:18.383:   DHCPD: circuit id 00000000
*Mar 5 06:32:18.383: DHCPD: Seeing if there is an internally specified pool class:
*Mar 5 06:32:18.383:   DHCPD: htype 1 chaddr 0050.56be.6c89
*Mar 5 06:32:18.383:   DHCPD: circuit id 00000000
*Mar 5 06:32:18.383: DHCPD: Allocated binding 2A40E074
*Mar 5 06:32:18.383: DHCPD: Adding binding to radix tree (192.168.1.3)
*Mar 5 06:32:18.383: DHCPD: Adding binding to hash tree
*Mar 5 06:32:18.383: DHCPD: assigned IP address 192.168.1.3 to client
0100.5056.be76.8c.
<output omitted>
```

- e. Display the DHCP server configuration on R2. The first nine addresses for 192.168.1.0/24 network are not excluded from the DHCP pool.

```
R2# show run | section dhcp
```

Lab - Troubleshooting DHCPv4

```
ip dhcp excluded-address 192.168.11.1 192.168.11.9
ip dhcp excluded-address 192.168.0.1 192.168.0.9
ip dhcp pool R1G1
  network 192.168.1.0 255.255.255.0
  default-router 192.168.1.1
ip dhcp pool R1G0
  network 192.168.0.0 255.255.255.128
  default-router 192.168.1.1
```

Record the commands to resolve the issue on R2.

```
R2(config)# no ip dhcp excluded-address 192.168.11.1 192.168.11.9
R2(config)# ip dhcp excluded-address 192.168.1.1 192.168.1.9
```

- f. At the command prompt on PC-A, type **ipconfig /release** to return the 192.168.1.3 address back to the DHCP pool. The process can be observed in the debug message on R2.

```
*Mar  5 06:49:59.563: DHCPD: Sending notification of TERMINATION:
*Mar  5 06:49:59.563:  DHCPD: address 192.168.1.3 mask 255.255.255.0
*Mar  5 06:49:59.563:  DHCPD: reason flags: RELEASE
*Mar  5 06:49:59.563:   DHCPD: htype 1 chaddr 0050.56be.768c
*Mar  5 06:49:59.563:   DHCPD: lease time remaining (secs) = 85340
*Mar  5 06:49:59.563: DHCPD: returned 192.168.1.3 to address pool R1G1.
```

- g. At the command prompt on PC-A, type **ipconfig /renew** to be assigned a new IP address from the DHCP server. Record the assigned IP address and default gateway information.
-

```
IP address/subnet mask: 192.168.1.10/24 Default gateway: 192.168.1.1
```

The process can be observed in the debug message on R2.

```
*Mar  5 06:50:11.863: DHCPD: Sending notification of DISCOVER:
*Mar  5 06:50:11.863:   DHCPD: htype 1 chaddr 0050.56be.768c
*Mar  5 06:50:11.863:   DHCPD: circuit id 00000000
*Mar  5 06:50:11.863: DHCPD: Seeing if there is an internally specified pool class:
*Mar  5 06:50:11.863:   DHCPD: htype 1 chaddr 0050.56be.768c
*Mar  5 06:50:11.863:   DHCPD: circuit id 00000000
*Mar  5 06:50:11.863: DHCPD: requested address 192.168.1.3 has already been assigned.
*Mar  5 06:50:11.863: DHCPD: Allocated binding 3003018C
*Mar  5 06:50:11.863: DHCPD: Adding binding to radix tree (192.168.1.10)
*Mar  5 06:50:11.863: DHCPD: Adding binding to hash tree
*Mar  5 06:50:11.863: DHCPD: assigned IP address 192.168.1.10 to client
0100.5056.be76.8c.
<output omitted>
```

- h. Verify network connectivity.

Can PC-A ping the assigned default gateway? _____ **Yes**

Can PC-A ping the R2 router? _____ **Yes**

Can PC-A ping the ISP router? _____ **Yes**

Step 3: Troubleshoot DHCP issues for 192.168.0.0/25 network on R1.

Router R1 is a DHCP relay agent for all the R1 LANs. In this step, only the DHCP process for the 192.168.0.0/25 network is examined. The first nine addresses are reserved for other network devices.

- a. Use a DHCP **debug** command to observe the DHCP process on R2.

```
R2# debug ip dhcp server events
```

- b. Display the running configuration for the G0/0 interface on R1 to identify possible DHCP issues.

```
R1# show run interface g0/0
interface GigabitEthernet0/0
 ip address 192.168.0.1 255.255.255.128
 duplex auto
 speed auto
```

Record the issues and any commands that are necessary to correct the configurations errors.

DHCP relay was not configured on the R1 G0/0 interface. The issue can be resolved using the following commands:

```
R1(config)# interface g0/0
R1(config-if)# ip helper-address 192.168.0.254
```

- c. From the command prompt on PC-B, type **ipconfig /renew** to receive an address from the DHCP server. Record the configured IP address, subnet mask, and default gateway for PC-B.

IP address: 192.168.0.10, subnet mask: 255.255.255.128, default gateway: 192.168.11.1

- d. Observe the debug messages on R2 router for the renewal process for PC-A. The DHCP server assigned 192.168.0.10/25 to PC-B.

```
*Mar 5 07:15:09.663: DHCPD: Sending notification of DISCOVER:
*Mar 5 07:15:09.663: DHCPD: htype 1 chaddr 0050.56be.f6db
*Mar 5 07:15:09.663: DHCPD: circuit id 00000000
*Mar 5 07:15:09.663: DHCPD: Seeing if there is an internally specified pool class:
*Mar 5 07:15:09.663: DHCPD: htype 1 chaddr 0050.56be.f6db
*Mar 5 07:15:09.663: DHCPD: circuit id 00000000
*Mar 5 07:15:09.707: DHCPD: Sending notification of ASSIGNMENT:
*Mar 5 07:15:09.707: DHCPD: address 192.168.0.10 mask 255.255.255.128
*Mar 5 07:15:09.707: DHCPD: htype 1 chaddr 0050.56be.f6db
*Mar 5 07:15:09.707: DHCPD: lease time remaining (secs) = 86400
```

- e. Verify network connectivity.

Can PC-B ping the DHCP assigned default gateway? _____ **No**

Can PC-B ping its default gateway (192.168.0.1)? _____ **Yes**

Can PC-B ping the R2 router? _____ **Yes**

Can PC-B ping the ISP router? _____ **Yes**

- f. If any issues failed in Step e, record the problems and any commands to resolve the issues.

PC-B is unable to ping the DHCP assigned default gateway. The issue can be resolved using the following commands.

```
R2(config)# ip dhcp pool R1G0
```

```
R2(dhcp-config)# default-router 192.168.0.1
```

- g. Release and renew the IP configurations on PC-B. Repeat Step e to verify network connectivity.
- h. Discontinue the debug process by using the **undebug all** command.

```
R2# undebug all
```

```
All possible debugging has been turned off
```

Reflection

What are the benefits of using DHCP?

Answers will vary. DHCP can prevent address conflicts caused by a previous assigned IP address still in use, supply additional configuration values, such as a DNS server, and can be used with mobile or portable computers.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router R1 (Corrected)

```
R1# show run
Building configuration...

Current configuration : 1419 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
!
```

Lab - Troubleshooting DHCPv4

```
!  
!  
!  
!  
!  
no ip domain lookup  
ip cef  
no ipv6 cef  
multilink bundle-name authenticated  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
interface Embedded-Service-Engine0/0  
no ip address  
shutdown  
!  
interface GigabitEthernet0/0  
ip address 192.168.0.1 255.255.255.128  
ip helper-address 192.168.0.254  
duplex auto  
speed auto  
!  
interface GigabitEthernet0/1  
ip address 192.168.1.1 255.255.255.0  
ip helper-address 192.168.0.254  
duplex auto  
speed auto  
!  
interface Serial0/0/0  
ip address 192.168.0.253 255.255.255.252  
clock rate 128000  
!  
interface Serial0/0/1  
no ip address  
shutdown  
!  
!  
router eigrp 1  
network 192.168.0.0 0.0.0.127  
network 192.168.0.252 0.0.0.3  
network 192.168.1.0
```

Lab - Troubleshooting DHCPv4

```
!  
ip forward-protocol nd  
!  
no ip http server  
no ip http secure-server  
!  
!  
!  
!  
!  
control-plane  
!  
!  
!  
line con 0  
  password cisco  
  logging synchronous  
  login  
line aux 0  
line 2  
  no activation-character  
  no exec  
  transport preferred none  
  transport input all  
  transport output pad telnet rlogin lapb-ta mop udptn v120 ssh  
  stopbits 1  
line vty 0 4  
  password cisco  
  login  
  transport input all  
!  
scheduler allocate 20000 1000  
!  
end
```

Router R2 (Corrected)

```
R2# show run  
Building configuration...  
  
Current configuration : 1552 bytes  
!  
version 15.2  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname R2  
!  
boot-start-marker
```

Lab - Troubleshooting DHCPv4

```
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
!
!
!
!
ip dhcp excluded-address 192.168.0.1 192.168.0.9
ip dhcp excluded-address 192.168.1.1 192.168.1.9
!
ip dhcp pool R1G1
  network 192.168.1.0 255.255.255.0
  default-router 192.168.1.1
!
ip dhcp pool R1G0
  network 192.168.0.0 255.255.255.128
  default-router 192.168.0.1
!
!
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
!
!
license udi pid CISCO1941/K9 sn FTX163283R9
license accept end user agreement
!
!
!
!
!
!
!
!
interface Embedded-Service-Engine0/0
  no ip address
  shutdown
!
interface GigabitEthernet0/0
  no ip address
  shutdown
  duplex auto
```

Lab - Troubleshooting DHCPv4

```
speed auto
!
interface GigabitEthernet0/1
no ip address
shutdown
duplex auto
speed auto
!
interface Serial0/0/0
ip address 192.168.0.254 255.255.255.252
!
interface Serial0/0/1
ip address 209.165.200.226 255.255.255.252
clock rate 128000
!
!
router eigrp 1
network 192.168.0.252 0.0.0.3
redistribute static
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 0.0.0.0 0.0.0.0 209.165.200.225
!
!
!
!
control-plane
!
!
!
line con 0
password cisco
logging synchronous
login
line aux 0
line 2
no activation-character
no exec
transport preferred none
transport input all
transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
stopbits 1
line vty 0 4
password cisco
login
```

Lab - Troubleshooting DHCPv4

```
transport input all
!  
scheduler allocate 20000 1000
!  
end
```

Router ISP

```
ISP#show run
Building configuration...

Current configuration : 1247 bytes
!  
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!  
hostname ISP
!  
boot-start-marker
boot-end-marker
!  
!  
enable secret 4 06YFDUHH6lwAE/kLkDq9BGholQM5EnRtoyr8cHAUg.2
!  
no aaa new-model
memory-size iomem 10
!  
!  
!  
!  
!  
!  
!  
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!  
!  
!  
!  
!  
!  
!  
!  
!  
!  
!
```

Lab - Troubleshooting DHCPv4

```
interface Embedded-Service-Engine0/0
  no ip address
  shutdown
!
interface GigabitEthernet0/0
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface GigabitEthernet0/1
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface Serial0/0/0
  no ip address
  shutdown
  clock rate 2000000
!
interface Serial0/0/1
  ip address 209.165.200.225 255.255.255.252
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 192.168.0.0 255.255.254.0 209.165.200.226
!
!
!
!
control-plane
!
!
!
line con 0
  password cisco
  logging synchronous
  login
line aux 0
line 2
  no activation-character
  no exec
  transport preferred none
  transport input all
  transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
```

Lab - Troubleshooting DHCPv4

```
stopbits 1
line vty 0 4
password cisco
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Lab – Configuring Stateless and Stateful DHCPv6 (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IPv6 Address	Prefix Length	Default Gateway
R1	G0/1	2001:DB8:ACAD:A::1	64	N/A
S1	VLAN 1	Assigned by SLAAC	64	Assigned by SLAAC
PC-A	NIC	Assigned by SLAAC and DHCPv6	64	Assigned by R1

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure the Network for SLAAC

Part 3: Configure the Network for Stateless DHCPv6

Part 4: Configure the Network for Stateful DHCPv6

Background / Scenario

The dynamic assignment of IPv6 global unicast addresses can be configured in three ways:

- Stateless Address Autoconfiguration (SLAAC) only
- Stateless Dynamic Host Configuration Protocol for IPv6 (DHCPv6)
- Stateful DHCPv6

With SLAAC (pronounced slack), a DHCPv6 server is not needed for hosts to acquire IPv6 addresses. It can be used to receive additional information that the host needs, such as the domain name and the domain name server (DNS) address. When SLAAC is used to assign the IPv6 host addresses and DHCPv6 is used to assign other network parameters, it is called Stateless DHCPv6.

With Stateful DHCPv6, the DHCP server assigns all information, including the host IPv6 address.

Determination of how hosts obtain their dynamic IPv6 addressing information is dependent on flag settings contained within the router advertisement (RA) messages.

In this lab, you will initially configure the network to use SLAAC. After connectivity has been verified, you will configure DHCPv6 settings and change the network to use Stateless DHCPv6. After verification that Stateless DHCPv6 is functioning correctly, you will change the configuration on R1 to use Stateful DHCPv6. Wireshark will be used on PC-A to verify all three dynamic network configurations.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the router and switch have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Note: The **default bias** template (used by the Switch Database Manager (SDM)) does not provide IPv6 address capabilities. Verify that SDM is using either the **dual-ipv4-and-ipv6** template or the **lanbase-routing** template. The new template will be used after reboot even if the config is not saved.

```
S1# show sdm prefer
```

Follow these steps to assign the **dual-ipv4-and-ipv6** template as the default SDM template:

```
S1# config t
S1(config)# sdm prefer dual-ipv4-and-ipv6 default
S1(config)# end
S1# reload
```

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 1 PC (Windows 7 or Vista with Wireshark and terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Instructor Note: Wireshark needs to be preinstalled on PC-A.

Note: DHCPv6 client services are disabled on Windows XP. It is recommended to use a Windows 7 host for this lab.

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings, such as device names, passwords and interface IP addresses.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the router and switch as necessary.

Step 3: Configure R1.

- Disable DNS lookup.
- Configure the device name.
- Encrypt plain text passwords.
- Create a MOTD banner warning users that unauthorized access is prohibited.
- Assign **class** as the encrypted privileged EXEC mode password.

- f. Assign **cisco** as the console and vty password and enable login.
- g. Set console logging to synchronous mode.
- h. Save the running configuration to the startup configuration.

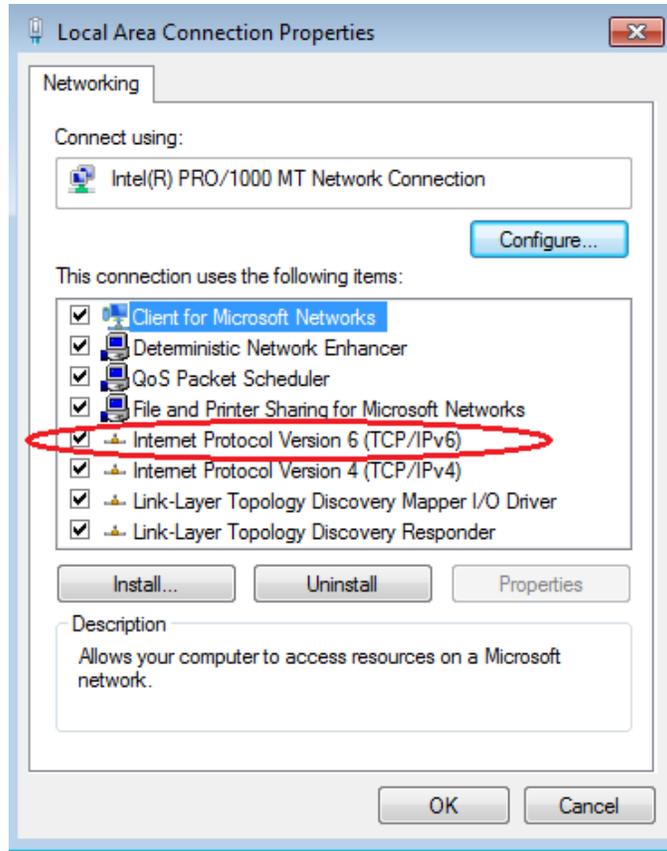
Step 4: Configure S1.

- a. Disable DNS lookup.
- b. Configure the device name.
- c. Encrypt plain text passwords.
- d. Create a MOTD banner warning users that unauthorized access is prohibited.
- e. Assign **class** as the encrypted privileged EXEC mode password.
- f. Assign **cisco** as the console and vty password and enable login.
- g. Set console logging to synchronous mode.
- h. Administratively disable all inactive interfaces.
- i. Save running configuration to the startup configuration.

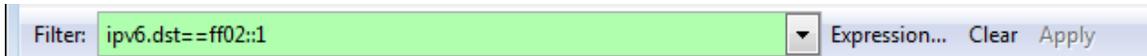
Part 2: Configure the Network for SLAAC

Step 1: Prepare PC-A.

- a. Verify that the IPv6 protocol has been enabled on the Local Area Connection Properties window. If the Internet Protocol Version 6 (TCP/IPv6) check box is not checked, click to enable it.



- b. Start a Wireshark capture of traffic on the NIC.
- c. Filter the data capture to see only RA messages. This can be done by filtering on IPv6 packets with a destination address of FF02::1, which is the all-unicast client group address. The filter entry used with Wireshark is **ipv6.dst==ff02::1**, as shown here.



Step 2: Configure R1.

- a. Enable IPv6 unicast routing.
- b. Assign the IPv6 unicast address to interface G0/1 according to the Addressing Table.
- c. Assign FE80::1 as the IPv6 link-local address for interface G0/1.
- d. Activate interface G0/1.

Step 3: Verify that R1 is part of the all-router multicast group.

Use the **show ipv6 interface g0/1** command to verify that G0/1 is part of the All-router multicast group (FF02::2). RA messages are not sent out G0/1 without that group assignment.

```
R1# show ipv6 interface g0/1
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::1
  No Virtual link-local address(es):
  Global unicast address(es):
```

```
2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64
Joined group address(es):
  FF02::1
  FF02::2
  FF02::1:FF00:1
MTU is 1500 bytes
ICMP error messages limited to one every 100 milliseconds
ICMP redirects are enabled
ICMP unreachable are sent
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds (using 30000)
ND advertised reachable time is 0 (unspecified)
ND advertised retransmit interval is 0 (unspecified)
ND router advertisements are sent every 200 seconds
ND router advertisements live for 1800 seconds
ND advertised default router preference is Medium
Hosts use stateless autoconfig for addresses.
```

Step 4: Configure S1.

Use the **ipv6 address autoconfig** command on VLAN 1 to obtain an IPv6 address through SLAAC.

```
S1(config)# interface vlan 1
S1(config-if)# ipv6 address autoconfig
S1(config-if)# end
```

Step 5: Verify that SLAAC provided a unicast address to S1.

Use the **show ipv6 interface** command to verify that SLAAC provided a unicast address to VLAN1 on S1.

```
S1# show ipv6 interface
Vlan1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::ED9:96FF:FEE8:8A40
  No Virtual link-local address(es):
  Stateless address autoconfig enabled
  Global unicast address(es):
    2001:DB8:ACAD:A:ED9:96FF:FEE8:8A40, subnet is 2001:DB8:ACAD:A::/64 [EUI/CAL/PRE]
      valid lifetime 2591988 preferred lifetime 604788
  Joined group address(es):
    FF02::1
    FF02::1:FFE8:8A40
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachable are sent
  Output features: Check hwidb
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds (using 30000)
  ND NS retransmit interval is 1000 milliseconds
  Default router is FE80::1 on Vlan1
```

Step 6: Verify that SLAAC provided IPv6 address information on PC-A.

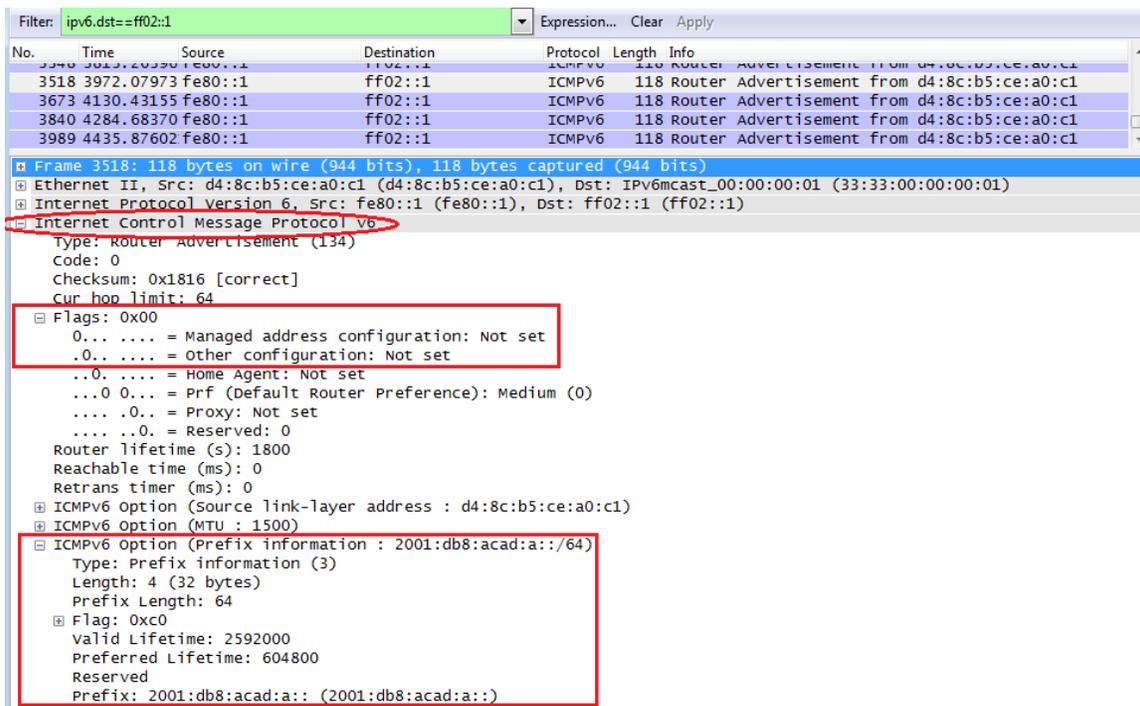
- a. From a command prompt on PC-A, issue the `ipconfig /all` command. Verify that PC-A is showing an IPv6 address with the `2001:db8:acad:a::/64` prefix. The Default Gateway should have the `FE80::1` address.

```

Ethernet adapter Local Area Connection:

Connection-specific DNS Suffix . : 
Description . . . . . : Intel(R) PRO/1000 MT Network Connection
Physical Address. . . . . : 00-50-56-BE-76-8C
DHCP Enabled. . . . . : Yes
Autoconfiguration Enabled . . . . : Yes
IPv6 Address. . . . . : 2001:db8:acad:a:24ba:a0a0:9f0:ff88 (Preferred)
Temporary IPv6 Address. . . . . : 2001:db8:acad:a:c05b:d3f7:31be:100e (Preferred)
Link-local IPv6 Address . . . . . : fe80::24ba:a0a0:9f0:ff88%11 (Preferred)
Autoconfiguration IPv4 Address. . . : 169.254.255.136 (Preferred)
Subnet Mask . . . . . : 255.255.0.0
Default Gateway . . . . . : fe80::1%11
DNS Servers . . . . . : fec0:0:0:ffff::1%1
                       fec0:0:0:ffff::2%1
                       fec0:0:0:ffff::3%1
NetBIOS over Tcpi. . . . . : Enabled
    
```

- b. From Wireshark, look at one of the RA messages that were captured. Expand the Internet Control Message Protocol v6 layer to view the Flags and Prefix information. The first two flags control DHCPv6 usage and are not set if DHCPv6 is not configured. The prefix information is also contained within this RA message.



Part 3: Configure the Network for Stateless DHCPv6

Step 1: Configure an IPv6 DHCP server on R1.

- a. Create an IPv6 DHCP pool.

```
R1(config)# ipv6 dhcp pool IPV6POOL-A
```

Lab – Configuring Stateless and Stateful DHCPv6

- b. Assign a domain name to the pool.

```
R1(config-dhcpv6)# domain-name ccna-statelessDHCPv6.com
```

- c. Assign a DNS server address.

```
R1(config-dhcpv6)# dns-server 2001:db8:acad:a::abcd
R1(config-dhcpv6)# exit
```

- d. Assign the DHCPv6 pool to the interface.

```
R1(config)# interface g0/1
R1(config-if)# ipv6 dhcp server IPV6POOL-A
```

- e. Set the DHCPv6 network discovery (ND) other-config-flag.

```
R1(config-if)# ipv6 nd other-config-flag
R1(config-if)# end
```

Step 2: Verify DHCPv6 settings on interface G0/1 on R1.

Use the **show ipv6 interface g0/1** command to verify that the interface is now part of the IPv6 multicast all-DHCPv6-servers group (FF02::1:2). The last line of the output from this **show** command verifies that the other-config-flag has been set.

```
R1# show ipv6 interface g0/1
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::1
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:2
    FF02::1:FF00:1
    FF05::1:3
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds (using 30000)
  ND advertised reachable time is 0 (unspecified)
  ND advertised retransmit interval is 0 (unspecified)
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  ND advertised default router preference is Medium
  Hosts use stateless autoconfig for addresses.
  Hosts use DHCP to obtain other configuration.
```

Step 3: View network changes to PC-A.

Use the **ipconfig /all** command to review the network changes. Notice that additional information, including the domain name and DNS server information, has been retrieved from the DHCPv6 server. However, the IPv6 global unicast and link-local addresses were obtained previously from SLAAC.

```

Ethernet adapter Local Area Connection:
    Connection-specific DNS Suffix . : ccna-statelessDHCPv6.com
    Description . . . . . : Intel(R) PRO/1000 MT Network Connection
    Physical Address. . . . . : 00-50-56-BE-76-8C
    DHCP Enabled. . . . . : Yes
    Autoconfiguration Enabled . . . . : Yes
    IPv6 Address. . . . . : 2001:db8:acad:a:24ba:a0a0:9f0:ff88<Preferred>
    Temporary IPv6 Address. . . . . : 2001:db8:acad:a:103a:4344:4b5e:ab1d<Preferred>
    Link-local IPv6 Address . . . . . : fe80::24ba:a0a0:9f0:ff88%11<Preferred>
    Autoconfiguration IPv4 Address. . : 169.254.255.136<Preferred>
    Subnet Mask . . . . . : 255.255.0.0
    Default Gateway . . . . . : fe80::1%11
    DHCPv6 IAID . . . . . : 234884137
    DHCPv6 Client DUID. . . . . : 00-01-00-01-17-F6-72-3D-00-0C-29-8D-54-44

    DNS Servers . . . . . : 2001:db8:acad:a::abcd
    NetBIOS over TCP/IP . . . . . : Enabled
    Connection-specific DNS Suffix Search List :
        ccna-statelessDHCPv6.com

Tunnel adapter isatap.{E2FC1866-B195-460A-BF40-F04F42A38FFE}:
    Media State . . . . . : Media disconnected
    Connection-specific DNS Suffix . : ccna-statelessDHCPv6.com
    Description . . . . . : Microsoft ISATAP Adapter
    Physical Address. . . . . : 00-00-00-00-00-00-00-E0
    DHCP Enabled. . . . . : No
    Autoconfiguration Enabled . . . . : Yes
    
```

Step 4: View the RA messages in Wireshark.

Scroll down to the last RA message that is displayed in Wireshark and expand it to view the ICMPv6 flag settings. Notice that the other configuration flag is set to 1.

```

Filter: ipv6.dst==ff02:1
Expression... Clear Apply
No. Time Source Destination Protocol Length Info
191 190.005980 fe80::1 ff02::1 ICMPv6 118 Router Advertisement from d4:8c:b5:ce:a0:c1
422 383.803033 fe80::1 ff02::1 ICMPv6 118 Router Advertisement from d4:8c:b5:ce:a0:c1
696 581.355847 fe80::1 ff02::1 ICMPv6 118 Router Advertisement from d4:8c:b5:ce:a0:c1
877 776.644829 fe80::1 ff02::1 ICMPv6 118 Router Advertisement from d4:8c:b5:ce:a0:c1

Frame 877: 118 bytes on wire (944 bits), 118 bytes captured (944 bits)
Ethernet II, Src: d4:8c:b5:ce:a0:c1 (d4:8c:b5:ce:a0:c1), Dst: IPv6mcast_00:00:00:01 (33:33:00:00:00:01)
Internet Protocol Version 6, Src: fe80::1 (fe80::1), Dst: ff02::1 (ff02::1)
Internet Control Message Protocol v6
  Type: Router Advertisement (134)
  Code: 0
  Checksum: 0x17d6 [correct]
  Cur hop limit: 64
  Flags: 0x40
    0... .. = Managed address configuration: Not set
    .1.. .. = Other configuration: Set
    ..0. .. = Home Agent: Not set
    ...0 0.. = Prf (Default Router Preference): Medium (0)
    ....0.. = Proxy: Not set
    ....0.. = Reserved: 0
  Router lifetime (s): 1800
  Reachable time (ms): 0
  Retrans timer (ms): 0
  ICMPv6 Option (Source link-layer address : d4:8c:b5:ce:a0:c1)
  ICMPv6 Option (MTU : 1500)
  ICMPv6 Option (Prefix information : 2001:db8:acad:a::/64)
    
```

Step 5: Verify that PC-A did not obtain its IPv6 address from a DHCPv6 server.

Use the **show ipv6 dhcp binding** and **show ipv6 dhcp pool** commands to verify that PC-A did not obtain an IPv6 address from the DHCPv6 pool.

```

R1# show ipv6 dhcp binding
R1# show ipv6 dhcp pool
DHCPv6 pool: IPV6POOL-A
    
```

```
DNS server: 2001:DB8:ACAD:A::ABCD
Domain name: ccna-statelessDHCPv6.com
Active clients: 0
```

Step 6: Reset PC-A IPv6 network settings.

- a. Shut down interface F0/6 on S1.

Note: Shutting down the interface F0/6 prevents PC-A from receiving a new IPv6 address before you reconfigure R1 for Stateful DHCPv6 in Part 4.

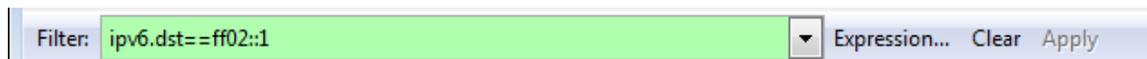
```
S1(config)# interface f0/6
S1(config-if)# shutdown
```

- b. Stop Wireshark capture of traffic on the PC-A NIC.
- c. Reset the IPv6 settings on PC-A to remove the Stateless DHCPv6 settings.
 - 1) Open the Local Area Connection Properties window, deselect the **Internet Protocol Version 6 (TCP/IPv6)** check box, and click **OK** to accept the change.
 - 2) Open the Local Area Connection Properties window again, click to enable the **Internet Protocol Version 6 (TCP/IPv6)** check box, and then click **OK** to accept the change.

Part 4: Configure the Network for Stateful DHCPv6

Step 1: Prepare PC-A.

- a. Start a Wireshark capture of traffic on the NIC.
- b. Filter the data capture to see only RA messages. This can be done by filtering on IPv6 packets with a destination address of FF02::1, which is the all-unicast client group address.



Step 2: Change the DHCPv6 pool on R1.

- a. Add the network prefix to the pool.

```
R1(config)# ipv6 dhcp pool IPV6POOL-A
R1(config-dhcpv6)# address prefix 2001:db8:acad:a::/64
```

- b. Change the domain name to **ccna-statefulDHCPv6.com**.

Note: You must remove the old domain name. It is not replaced by the **domain-name** command.

```
R1(config-dhcpv6)# no domain-name ccna-statelessDHCPv6.com
R1(config-dhcpv6)# domain-name ccna-StatefulDHCPv6.com
R1(config-dhcpv6)# end
```

- c. Verify DHCPv6 pool settings.

```
R1# show ipv6 dhcp pool
DHCPv6 pool: IPV6POOL-A
  Address allocation prefix: 2001:DB8:ACAD:A::/64 valid 172800 preferred 86400 (0 in
  use, 0 conflicts)
  DNS server: 2001:DB8:ACAD:A::ABCD
  Domain name: ccna-StatefulDHCPv6.com
  Active clients: 0
```

- d. Enter debug mode to verify the Stateful DHCPv6 address assignment.

```
R1# debug ipv6 dhcp detail
      IPv6 DHCP debugging is on (detailed)
```

Step 3: Set the flag on G0/1 for Stateful DHCPv6.

Note: Shutting down the G0/1 interface before making changes ensures that an RA message is sent when the interface is activated.

```
R1(config)# interface g0/1
R1(config-if)# shutdown
R1(config-if)# ipv6 nd managed-config-flag
R1(config-if)# no shutdown
R1(config-if)# end
```

Step 4: Enable interface F0/6 on S1.

Now that R1 has been configured for Stateful DHCPv6, you can reconnect PC-A to the network by activating interface F0/6 on S1.

```
S1(config)# interface f0/6
S1(config-if)# no shutdown
S1(config-if)# end
```

Step 5: Verify Stateful DHCPv6 settings on R1.

- a. Issue the **show ipv6 interface g0/1** command to verify that the interface is in Stateful DHCPv6 mode.

```
R1# show ipv6 interface g0/1
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::1
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:2
    FF02::1:FF00:1
    FF05::1:3
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachable are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds (using 30000)
  ND advertised reachable time is 0 (unspecified)
  ND advertised retransmit interval is 0 (unspecified)
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  ND advertised default router preference is Medium
  Hosts use DHCP to obtain routable addresses.
```

Lab – Configuring Stateless and Stateful DHCPv6

Hosts use DHCP to obtain other configuration.

- b. In a command prompt on PC-A, type **ipconfig /release6** to release the currently assigned IPv6 address. Then type **ipconfig /renew6** to request an IPv6 address from the DHCPv6 server.
- c. Issue the **show ipv6 dhcp pool** command to verify the number of active clients.

```
R1# show ipv6 dhcp pool
```

```
DHCPv6 pool: IPV6POOL-A
```

```
Address allocation prefix: 2001:DB8:ACAD:A::/64 valid 172800 preferred 86400 (1 in use, 0 conflicts)
```

```
DNS server: 2001:DB8:ACAD:A::ABCD
```

```
Domain name: ccna-StatefulDHCPv6.com
```

```
Active clients: 1
```

- d. Issue the **show ipv6 dhcp binding** command to verify that PC-A received its IPv6 unicast address from the DHCP pool. Compare the client address to the link-local IPv6 address on PC-A using the **ipconfig /all** command. Compare the address provided by the **show** command to the IPv6 address listed with the **ipconfig /all** command on PC-A.

```
R1# show ipv6 dhcp binding
```

```
Client: FE80::D428:7DE2:997C:B05A
```

```
DUID: 0001000117F6723D000C298D5444
```

```
Username : unassigned
```

```
IA NA: IA ID 0x0E000C29, T1 43200, T2 69120
```

```
Address: 2001:DB8:ACAD:A:B55C:8519:8915:57CE
```

```
preferred lifetime 86400, valid lifetime 172800
```

```
expires at Mar 07 2013 04:09 PM (171595 seconds)
```

```
Ethernet adapter Local Area Connection:
Connection-specific DNS Suffix . : ccna-StatefulDHCPv6.com
Description . . . . . : Intel(R) PRO/1000 MT Network Connection
Physical Address. . . . . : 00-50-56-BE-6C-89
DHCP Enabled. . . . . : Yes
Autoconfiguration Enabled . . . . : Yes
IPv6 Address. . . . . : 2001:db8:acad:a:b55c:8519:8915:57ce (Preferred)
Lease Obtained. . . . . : Tuesday, March 05, 2013 11:53:11 AM
Lease Expires . . . . . : Thursday, March 07, 2013 11:53:11 AM
IPv6 Address. . . . . : 2001:db8:acad:a:d428:7de2:997c:b05a (Preferred)
Temporary IPv6 Address. . . . . : 2001:db8:acad:a:dd37:1e42:948c:225b (Preferred)
Link-local IPv6 Address . . . . . : fe80::d428:7de2:997c:b05a:11 (Preferred)
Autoconfiguration IPv4 Address. . . . : 169.254.176.28 (Preferred)
Subnet Mask . . . . . : 255.255.0.0
Default Gateway . . . . . : fe80::1%11
DHCPv6 IAID . . . . . : 234884137
DHCPv6 Client DUID. . . . . : 00-01-00-01-17-F6-72-3D-00-0C-29-8D-54-44
DNS Servers . . . . . : 2001:db8:acad:a::abcd
NetBIOS over Tcpip. . . . . : Enabled
Connection-specific DNS Suffix Search List :
ccna-StatefulDHCPv6.com
```

- e. Issue the **undebg all** command on R1 to stop debugging DHCPv6.

Note: Typing **u all** is the shortest form of this command and is useful to know if you are trying to stop debug messages from continually scrolling down your terminal session screen. If multiple debugs are in process, the **undebg all** command stops all of them.

```
R1# u all
```

```
All possible debugging has been turned off
```

f. Review the debug messages that appeared on your R1 terminal screen.

1) Examine the solicit message from PC-A requesting network information.

```
*Mar  5 16:42:39.775: IPv6 DHCP: Received SOLICIT from FE80::D428:7DE2:997C:B05A on GigabitEthernet0/1
*Mar  5 16:42:39.775: IPv6 DHCP: detailed packet contents
*Mar  5 16:42:39.775:   src FE80::D428:7DE2:997C:B05A (GigabitEthernet0/1)
*Mar  5 16:42:39.775:   dst FF02::1:2
*Mar  5 16:42:39.775:   type SOLICIT(1), xid 1039238
*Mar  5 16:42:39.775:   option ELAPSED-TIME(8), len 2
*Mar  5 16:42:39.775:     elapsed-time 6300
*Mar  5 16:42:39.775:   option CLIENTID(1), len 14
```

2) Examine the reply message sent back to PC-A with the DHCP network information.

```
*Mar  5 16:42:39.779: IPv6 DHCP: Sending REPLY to FE80::D428:7DE2:997C:B05A on GigabitEthernet0/1
*Mar  5 16:42:39.779: IPv6 DHCP: detailed packet contents
*Mar  5 16:42:39.779:   src FE80::1
*Mar  5 16:42:39.779:   dst FE80::D428:7DE2:997C:B05A (GigabitEthernet0/1)
*Mar  5 16:42:39.779:   type REPLY(7), xid 1039238
*Mar  5 16:42:39.779:   option SERVERID(2), len 10
*Mar  5 16:42:39.779:     00030001FC994775C3E0
*Mar  5 16:42:39.779:   option CLIENTID(1), len 14
*Mar  5 16:42:39.779:     00010001
R1#17F6723D000C298D5444
*Mar  5 16:42:39.779:   option IA-NA(3), len 40
*Mar  5 16:42:39.779:     IAID 0x0E000C29, T1 43200, T2 69120
*Mar  5 16:42:39.779:   option IAADDR(5), len 24
*Mar  5 16:42:39.779:     IPv6 address 2001:DB8:ACAD:A:B55C:8519:8915:57CE
*Mar  5 16:42:39.779:     preferred 86400, valid 172800
*Mar  5 16:42:39.779:   option DNS-SERVERS(23), len 16
*Mar  5 16:42:39.779:     2001:DB8:ACAD:A::ABCD
*Mar  5 16:42:39.779:   option DOMAIN-LIST(24), len 26
*Mar  5 16:42:39.779:     ccna-StatefulDHCPv6.com
```

Step 6: Verify Stateful DHCPv6 on PC-A

- Stop the Wireshark capture on PC-A.
- Expand the most recent RA message listed in Wireshark. Verify that the **Managed address configuration** flag has been set.

Lab – Configuring Stateless and Stateful DHCPv6

Filter: `ipv6.dst==ff02::1` Expression... Clear Apply

No.	Time	Source	Destination	Protocol	Length	Info
36	54.582255	fe80::1	ff02::1	ICMPv6	118	Router Advertisement from fc:99:47:75:c3:e1
265	215.309226	fe80::1	ff02::1	ICMPv6	118	Router Advertisement from fc:99:47:75:c3:e1
425	373.272435	fe80::1	ff02::1	ICMPv6	118	Router Advertisement from fc:99:47:75:c3:e1
553	554.893786	fe80::1	ff02::1	ICMPv6	118	Router Advertisement from fc:99:47:75:c3:e1
664	730.139576	fe80::1	ff02::1	ICMPv6	118	Router Advertisement from fc:99:47:75:c3:e1
775	922.720109	fe80::1	ff02::1	ICMPv6	118	Router Advertisement from fc:99:47:75:c3:e1

Frame 775: 118 bytes on wire (944 bits), 118 bytes captured (944 bits)

- Ethernet II, Src: fc:99:47:75:c3:e1 (fc:99:47:75:c3:e1), Dst: IPv6mcast_00:00:00:01 (33:33:00:00:00:01)
- Internet Protocol Version 6, Src: fe80::1 (fe80::1), Dst: ff02::1 (ff02::1)
- Internet Control Message Protocol v6
 - Type: Router Advertisement (134)
 - Code: 0
 - Checksum: 0x3a82 [correct]
 - Cur hop limit: 64
 - Flags: 0xc0
 - 1... .. = Managed address configuration: Set
 - .1... .. = Other configuration: Set
 - ..0... .. = Home Agent: Not set
 - ...0 0... = Prf (Default Router Preference): Medium (0)
 -0.. = Proxy: Not set
 -0. = Reserved: 0
 - Router lifetime (<): 1800

- c. Change the filter in Wireshark to view **DHCPv6** packets only by typing **dhcpv6**, and then **Apply** the filter. Highlight the last DHCPv6 reply listed and expand the DHCPv6 information. Examine the DHCPv6 network information that is contained in this packet.

Filter: `dhcpv6` Expression... Clear Apply

No.	Time	Source	Destination	Protocol	Length	Info
250	443.078236	fe80::d428:7de2:997:ff02::1:2	ff02::1:2	DHCPv6	146	Solicit XID: 0x2b2a8e CID: 0001000117f6723d000c2f
267	475.083284	fe80::d428:7de2:997:ff02::1:2	ff02::1:2	DHCPv6	146	Solicit XID: 0x2b2a8e CID: 0001000117f6723d000c2f
425	656.281211	fe80::d428:7de2:997:ff02::1:2	ff02::1:2	DHCPv6	146	Solicit XID: 0xc86c32 CID: 0001000117f6723d000c2f
429	656.282249	fe80::1	fe80::d428:7de2:997:ff02::1:2	DHCPv6	191	Advertise XID: 0xc86c32 CID: 0001000117f6723d000c2f
460	657.292018	fe80::d428:7de2:997:ff02::1:2	ff02::1:2	DHCPv6	188	Request XID: 0xc86c32 CID: 0001000117f6723d000c2f
462	657.292638	fe80::1	fe80::d428:7de2:997:ff02::1:2	DHCPv6	191	Reply XID: 0xc86c32 CID: 0001000117f6723d000c298

Ethernet II, Src: fc:99:47:75:c3:e1 (fc:99:47:75:c3:e1), Dst: Vmware_be:6c:89 (00:50:56:be:6c:89)

- Internet Protocol Version 6, Src: fe80::1 (fe80::1), Dst: fe80::d428:7de2:997c:b05a (fe80::d428:7de2:997c:b05a)
- User Datagram Protocol, Src Port: dhcpv6-server (547), Dst Port: dhcpv6-client (546)
- DHCPv6
 - Message type: Reply (7)
 - Transaction ID: 0xc86c32
 - Server Identifier: 00030001fc994775c3e0
 - Client Identifier: 0001000117f6723d000c298d5444
 - Identity Association for Non-temporary Address
 - Option: Identity Association for Non-temporary Address (3)
 - Length: 40
 - Value: 0e000c290000a8c000010e000005001820010db8acad000a...
 - IAID: 0e000c29
 - T1: 43200
 - T2: 69120
 - IA Address: 2001:db8:acad:a:b55c:8519:8915:57ce
 - DNS recursive name server
 - Option: DNS recursive name server (23)
 - Length: 16
 - Value: 20010db8acad000a000000000000abcd
 - DNS servers address: 2001:db8:acad:a:abcd
 - Domain Search List
 - Option: Domain Search List (24)
 - Length: 25
 - Value: 1363636e612d537461746566756c44484350763603636f6d...
 - DNS Domain Search List
 - Domain: ccna-statefulDHCPv6.com

Reflection

1. What IPv6 addressing method uses more memory resources on the router configured as a DHCPv6 server, Stateless DHCPv6 or Stateful DHCPv6? Why?

Lab – Configuring Stateless and Stateful DHCPv6

Stateful DHCPv6 uses more memory resources. Answers will vary, but Stateful DHCPv6 requires the router to store dynamic state information about the DHCPv6 clients. Stateless DHCPv6 clients do not use the DHCP server to obtain address information, so this information does not need to be stored.

2. Which type of dynamic IPv6 address assignment is recommended by Cisco, Stateless DHCPv6 or Stateful DHCPv6?

Cisco recommends Stateless DHCPv6 when implementing and deploying IPv6 networks without a Cisco Network Registrar (CNR).

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs - Part 1 and 2 combined for R1 and S1

Router R1 (After parts 1 and 2 of this lab)

```
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
memory-size iomem 15
```

Lab – Configuring Stateless and Stateful DHCPv6

```
!  
no ip domain lookup  
ip cef  
no ipv6 cef  
multilink bundle-name authenticated  
!  
interface Embedded-Service-Engine0/0  
no ip address  
shutdown  
!  
interface GigabitEthernet0/0  
no ip address  
shutdown  
duplex auto  
speed auto  
!  
interface GigabitEthernet0/1  
no ip address  
shutdown  
duplex auto  
speed auto  
!  
interface Serial0/0/0  
no ip address  
shutdown  
clock rate 2000000  
!  
interface Serial0/0/1  
no ip address  
shutdown  
!  
ip forward-protocol nd  
!  
no ip http server  
no ip http secure-server  
!  
control-plane  
!  
banner motd ^C  
Unauthorized Access is Prohibited!  
^C  
!  
line con 0  
password 7 070C285F4D06  
logging synchronous  
login  
line aux 0  
!  
line vty 0 4
```

Lab – Configuring Stateless and Stateful DHCPv6

```
password 7 13061E010803
login
transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1 (After parts 1 and 2 of this lab)

```
service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 shutdown
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 shutdown
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
!
interface FastEthernet0/6
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
```

Lab – Configuring Stateless and Stateful DHCPv6

```
shutdown
!  
interface FastEthernet0/9  
shutdown  
!  
interface FastEthernet0/10  
shutdown  
!  
interface FastEthernet0/11  
shutdown  
!  
interface FastEthernet0/12  
shutdown  
!  
interface FastEthernet0/13  
shutdown  
!  
interface FastEthernet0/14  
shutdown  
!  
interface FastEthernet0/15  
shutdown  
!  
interface FastEthernet0/16  
shutdown  
!  
interface FastEthernet0/17  
shutdown  
!  
interface FastEthernet0/18  
shutdown  
!  
interface FastEthernet0/19  
shutdown  
!  
interface FastEthernet0/20  
shutdown  
!  
interface FastEthernet0/21  
shutdown  
!  
interface FastEthernet0/22  
shutdown  
!  
interface FastEthernet0/23  
shutdown  
!  
interface FastEthernet0/24  
shutdown
```

Lab – Configuring Stateless and Stateful DHCPv6

```
!  
interface GigabitEthernet0/1  
 shutdown  
!  
interface GigabitEthernet0/2  
 shutdown  
!  
interface Vlan1  
 no ip address  
 shutdown  
!  
ip http server  
ip http secure-server  
!  
banner motd ^C  
  Unauthorized Access is Prohibited!  
^C  
!  
line con 0  
 password 7 05080F1C2243  
 logging synchronous  
 login  
line vty 0 4  
 password 7 02050D480809  
 login  
line vty 5 15  
 password 7 02050D480809  
 login  
!  
end
```

Router R1 (Final)

```
service password-encryption  
!  
hostname R1  
!  
boot-start-marker  
boot-end-marker  
!  
!  
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2  
!  
no aaa new-model  
memory-size iomem 15  
!  
no ip domain lookup  
ip cef  
ipv6 unicast-routing  
ipv6 dhcp pool IPV6POOL-A
```

Lab – Configuring Stateless and Stateful DHCPv6

```
address prefix 2001:DB8:ACAD:A::/64
dns-server 2001:DB8:ACAD:A::ABCD
domain-name ccna-StatelfulDHCPv6.com
!
ipv6 cef
multilink bundle-name authenticated
!
interface GigabitEthernet0/0
no ip address
shutdown
duplex auto
speed auto
!
interface GigabitEthernet0/1
no ip address
duplex auto
speed auto
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:A::1/64
ipv6 nd managed-config-flag
ipv6 nd other-config-flag
ipv6 dhcp server IPV6POOL-A
!
interface Serial0/0/0
no ip address
shutdown
clock rate 2000000
!
interface Serial0/0/1
no ip address
shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
control-plane
!
!
banner motd ^C
  Unauthorized Access is Prohibited!
^C
!
line con 0
password 7 070C285F4D06
logging synchronous
login
line aux 0
```

Lab – Configuring Stateless and Stateful DHCPv6

```
!  
line vty 0 4  
  password 7 13061E010803  
  login  
  transport input all  
!  
scheduler allocate 20000 1000  
!  
end
```

Lab - Troubleshooting DHCPv6 (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Addressing Table

Device	Interface	IPv6 Address	Prefix Length	Default Gateway
R1	G0/1	2001:DB8:ACAD:A::1	64	N/A
S1	VLAN 1	Assigned by SLAAC	64	Assigned by SLAAC
PC-A	NIC	Assigned by SLAAC and DHCPv6	64	Assigned by SLAAC

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Troubleshoot IPv6 Connectivity

Part 3: Troubleshoot Stateless DHCPv6

Background / Scenario

The ability to troubleshoot network issues is a very useful skill for network administrators. It is important to understand IPv6 address groups and how they are used when troubleshooting a network. Knowing what commands to use to extract IPv6 network information is necessary to effectively troubleshoot.

In this lab, you will load configurations on R1 and S1. These configurations will contain issues that prevent Stateless DHCPv6 from functioning on the network. You will troubleshoot R1 and S1 to resolve these issues.

Note: The routers used with CCNA hands-on labs are Cisco 1941 Integrated Services Routers (ISRs) with Cisco IOS Release 15.2(4)M3 (universalk9 image). The switches used are Cisco Catalyst 2960s with Cisco IOS Release 15.0(2) (lanbasek9 image). Other routers, switches and Cisco IOS versions can be used. Depending on the model and Cisco IOS version, the commands available and output produced might vary from what is shown in the labs. Refer to the Router Interface Summary Table at the end of this lab for the correct interface identifiers.

Note: Make sure that the router and switch have been erased and have no startup configurations. If you are unsure, contact your instructor.

Instructor Note: Refer to the Instructor Lab Manual for the procedures to initialize and reload devices.

Note: The default bias template used by the Switch Database Manager (SDM) does not provide IPv6 address capabilities. Verify that SDM is using either the **dual-ipv4-and-ipv6** template or the **lanbase-routing** template. The new template will be used after reboot even if the configuration is not saved.

```
S1# show sdm prefer
```

Follow this configuration to assign the **dual-ipv4-and-ipv6** template as the default SDM template:

```
S1# config t
```

```
S1(config)# sdm prefer dual-ipv4-and-ipv6 default
S1(config)# end
S1# reload
```

Required Resources

- 1 Router (Cisco 1941 with Cisco IOS Release 15.2(4)M3 universal image or comparable)
- 1 Switch (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 1 PC (Windows 7, Vista, or XP with terminal emulation program, such as Tera Term)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and clear any configurations if necessary. You will configure basic settings on the router and switch. Then you will load the provided IPv6 configurations before you start troubleshooting.

Step 1: Cable the network as shown in the topology.

Step 2: Initialize and reload the router and the switch.

Step 3: Configure basic settings on the router and switch.

- Disable DNS lookup.
- Configure device names as shown in the topology.
- Encrypt plain text passwords.
- Create a MOTD banner warning users that unauthorized access is prohibited.
- Assign **class** as the encrypted privileged EXEC mode password.
- Assign **cisco** as the console and vty passwords and enable login.
- Configure **logging synchronous** to prevent console messages from interrupting command entry.

Step 4: Load the IPv6 configuration to R1.

```
ip domain name ccna-lab.com
! ipv6 unicast-routing
ipv6 dhcp pool IPV6POOL-A
  dns-server 2001:DB8:ACAD:CAFE::A
  domain-name ccna-lab.com
interface g0/0
  no ip address
  shutdown
  duplex auto
  speed auto
interface g0/1
  no ip address
  duplex auto
```

```
speed auto
ipv6 address FE80::1 link-local
ipv6 address 2001:DB8:ACAD:A::11/64
! no ipv6 address 2001:db8:acad:a::11/64
! ipv6 address 2001:db8:acad:a::1/64
! ipv6 nd other-config-flag
! ipv6 dhcp server IPV6POOL-A
! no shutdown
end
```

Step 5: Load the IPv6 configuration to S1.

```
interface range f0/1-24
shutdown
!interface range f0/5-6
! no shutdown
interface range g0/1-2
shutdown
interface Vlan1
shutdown
! ipv6 address autoconfig
! no shutdown
end
```

Step 6: Save the running configurations on R1 and S1.

Step 7: Verify that IPv6 is enabled on PC-A.

Verify that IPv6 has been enabled in the Local Area Connection Properties window on PC-A.

Part 2: Troubleshoot IPv6 Connectivity

In Part 2, you will test and verify Layer 3 IPv6 connectivity on the network. Continue troubleshooting the network until Layer 3 connectivity has been established on all devices. Do not continue to Part 3 until you have successfully completed Part 2.

Step 1: Troubleshoot IPv6 interfaces on R1.

- According to the topology, which interface must be active on R1 for network connectivity to be established? Record any commands used to identify which interfaces are active.

G0/1

R1# **show ip interface brief**

- If necessary, take the steps required to bring up the interface. Record the commands used to correct the configuration errors and verify that the interface is active.

R1(config)# **interface g0/1**

```
R1(config-if)# no shutdown
```

- c. Identify the IPv6 addresses configured on R1. Record the addresses found and the commands used to view the IPv6 addresses.

```
2001:DB8:ACAD:A::11/64
```

```
show ipv6 interface or show ipv6 interface g0/1. Show run interface g0/1 can also be used.
```

- d. Determine if a configuration error has been made. If any errors are identified, record all the commands used to correct the configuration.

```
R1(config)# interface g0/1
```

```
R1(config-if)# no ipv6 address 2001:db8:acad:a::11/64
```

```
R1(config-if)# ipv6 address 2001:db8:acad:a::1/64
```

- e. On R1, what multicast group is needed for SLAAC to function?

```
All-routers multicast group (FF02::2)
```

- f. What command is used to verify that R1 is a member of that group?

```
show ipv6 interface or show ipv6 interface g0/1
```

```
R1# show ipv6 interface
```

```
GigabitEthernet0/1 is down, line protocol is down
  IPv6 is tentative, link-local address is FE80::1 [TEN]
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64 [TEN]
  Joined group address(es):
    FF02::1
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds (using 30000)
  ND advertised reachable time is 0 (unspecified)
  ND advertised retransmit interval is 0 (unspecified)
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  ND advertised default router preference is Medium
  Hosts use stateless autoconfig for addresses.
```

Lab – Troubleshooting DHCPv6

- g. If R1 is not a member of the multicast group that is needed for SLAAC to function correctly, make the necessary changes to the configuration so that it joins the group. Record any commands necessary to correct the configurations errors.

```
R1(config)# ipv6 unicast-routing
```

- h. Re-issue the command to verify that interface G0/1 has joined the all-routers multicast group (FF02::2).

Note: If you are unable to join the all-routers multicast group, you may need to save your current configuration and reload the router.

Step 2: Troubleshoot S1.

- a. Are the interfaces needed for network connectivity active on S1? _____ **No**

Record any commands that are used to activate necessary interfaces on S1.

```
S1(config)# interface range f0/5-6
```

```
S1(config-if)# no shutdown
```

```
S1(config-if)# interface vlan 1
```

```
S1(config-if)# no shutdown
```

- b. What command could you use to determine if an IPv6 unicast address has been assigned to S1?

Issue the **show ipv6 interface** or **show ipv6 interface vlan1** command.

- c. Does S1 have an IPv6 unicast address configured? If so, what is it?

No IPv6 address has been assigned.

- d. If S1 is not receiving a SLAAC address, make the necessary configuration changes to allow it to receive one. Record the commands used.

```
S1(config)# interface vlan 1
```

```
S1(config-if)# ipv6 address autoconfig
```

- e. Re-issue the command that verifies that the interface now receives a SLAAC address.
f. Can S1 ping the IPv6 unicast address assigned to the G0/1 interface assigned to R1?

Yes, S1 should be able to ping the 2001:db8:acad:a::1 IPv6 address.

Step 3: Troubleshoot PC-A.

- a. Issue the command used on PC-A to verify the IPv6 address assigned. Record the command.

ipconfig /all

- b. What is the IPv6 unicast address SLAAC is providing to PC-A?

If all the changes were made to R1 and S1, PC-A should receive an IPv6 address with the 2001:db8:acad:a::/64 prefix.

- c. Can PC-A ping the default gateway address that was assigned by SLAAC?

Yes, PC-A should be able to ping the FE80::1 address.

- d. Can PC-A ping the management interface on S1?

Yes, PC-A should be able to ping the IPv6 address assigned to VLAN 1. This address can be found by issuing the **show ipv6 interface vlan1** command on S1 and then looking for the IPv6 address with a prefix of 2001:db8:acad:a::/64.

Note: Continue troubleshooting until you can ping R1 and S1 from PC-A.

Part 3: Troubleshoot Stateless DHCPv6

In Part 3, you will test and verify that Stateless DHCPv6 is working correctly on the network. You will need to use the correct IPv6 CLI commands on the router to determine if Stateless DHCPv6 is working. You may want to use debug to help determine if the DHCP server is being solicited.

Step 1: Determine if Stateless DHCPv6 is functioning correctly.

- a. What is the name of the IPv6 DHCP pool? How did you determine this?

IPv6POOL-A. Issue the **show ipv6 dhcp pool** command to determine the name of the DHCPv6 Server pool. You can also issue the **show run | section ipv6 dhcp** command to see this information.

```
R1# show ipv6 dhcp pool
DHCPv6 pool: IPV6POOL-A
  DNS server: 2001:DB8:ACAD:CAFE::A
  Domain name: ccna-lab.com
  Active clients: 0
```

- b. What network information is listed in the DHCPv6 pool?

A DNS server is listed with a 2001:DB8:ACAD:CAFE::A, and a domain name is listed as ccna-lab.com.

- c. Was the DHCPv6 information assigned to PC-A? How did you determine this?

No, this can be determined by issuing an **ipconfig /all** command at the command prompt on PC-A.

Step 2: Troubleshoot R1.

- a. What commands can be used to determine if R1 is configured for Stateless DHCPv6?

The **show ipv6 interface** command can be used to determine if an interface has the Stateless DHCPv6 flag set. The **show run** command can also be used to view the configuration on the interface.

```
R1# show ipv6 interface
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::1
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:1
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachable are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds (using 30000)
  ND advertised reachable time is 0 (unspecified)
  ND advertised retransmit interval is 0 (unspecified)
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  ND advertised default router preference is Medium
  Hosts use stateless autoconfig for addresses.
```

- b. Is the G0/1 interface on R1 in Stateless DHCPv6 mode?

No. The interface is not part of the all-DHCPv6 Servers group because the FF02::1:2 group address is not listed. It also does not mention the state of the DHCP server at the bottom of the output.

- c. What command can be used to have R1 join the all-DHCPv6 server group?

Issue the command **ipv6 dhcp server IPV6POOL-A** on interface G0/1.

```
R1(config)# interface g0/1
R1(config-if)# ipv6 dhcp server IPV6POOL-A
```

- d. Verify that the all-DHCPv6 server group is configured for interface G0/1.

```
R1# show ipv6 interface
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::1
```

```
No Virtual link-local address(es):
Global unicast address(es):
  2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64
Joined group address(es):
  FF02::1
  FF02::2
  FF02::1:2
  FF02::1:FF00:1
  FF05::1:3
MTU is 1500 bytes
ICMP error messages limited to one every 100 milliseconds
ICMP redirects are enabled
ICMP unreachable are sent
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds (using 30000)
ND advertised reachable time is 0 (unspecified)
ND advertised retransmit interval is 0 (unspecified)
ND router advertisements are sent every 200 seconds
ND router advertisements live for 1800 seconds
ND advertised default router preference is Medium
Hosts use stateless autoconfig for addresses.
```

- e. Will PC-A receive the DHCP information now? Explain?

No, the **show ipv6 interface** command is still not showing that hosts are going to use DHCP to obtain other configuration information. This can be verified by issuing an **ipconfig /all** on PC-A.

- f. What is missing from the configuration of G0/1 that causes hosts to use the DHCP server to retrieve other network information?

The **ipv6 nd other-config-flag** command is needed to tell hosts to use the DHCP server to retrieve other network information.

```
R1(config)# interface g0/1
R1(config-if)# ipv6 nd other-config-flag
R1# show ipv6 interface
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::1
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:A::1, subnet is 2001:DB8:ACAD:A::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:2
    FF02::1:FF00:1
    FF05::1:3
  MTU is 1500 bytes
```

```
ICMP error messages limited to one every 100 milliseconds
ICMP redirects are enabled
ICMP unreachable are sent
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds (using 30000)
ND advertised reachable time is 0 (unspecified)
ND advertised retransmit interval is 0 (unspecified)
ND router advertisements are sent every 200 seconds
ND router advertisements live for 1800 seconds
ND advertised default router preference is Medium
Hosts use stateless autoconfig for addresses.
Hosts use DHCP to obtain other configuration.
```

- g. Reset the IPv6 settings on PC-A.
 - 1) Open the Local Area Connection Properties window, deselect the Internet Protocol Version 6 (TCP/IPv6) check box, and then click **OK** to accept the change.
 - 2) Open the Local Area Connection Properties window again, click the Internet Protocol Version 6 (TCP/IPv6) check box, and then click **OK** to accept the change.
- h. Issue the command to verify changes have been made on PC-A.

Note: Continue troubleshooting until PC-A receives the additional DHCP information from R1.

Reflection

- 1. What command is needed in the DHCPv6 pool for Stateful DHCPv6 that is not needed for Stateless DHCPv6? Why?

The **address prefix <ipv6 prefix address>** command is needed for Stateful DHCPv6. Hosts receive their IPv6 unicast addresses from the DHCP server so this command is needed to provide the IPv6 prefix to use for the network.

- 2. What command is needed on the interface to change the network to use Stateful DHCPv6 instead of Stateless DHCPv6?

The **ipv6 nd managed-config-flag** command is used to set the Stateful DHCPv6 flag. This is transmitted to all hosts on the network through the router advertisement messages sent by R1.

Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2801	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/1/0 (S0/1/0)	Serial 0/1/1 (S0/1/1)
2811	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. There is no way to effectively list all the combinations of configurations for each router class. This table includes identifiers for the possible combinations of Ethernet and Serial interfaces in the device. The table does not include any other type of interface, even though a specific router may contain one. An example of this might be an ISDN BRI interface. The string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Device Configs

Router R1 (Final)

```
R1#sh run
Building configuration...

Current configuration : 1829 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
memory-size iomem 10
!
ipv6 unicast-routing
```

Lab – Troubleshooting DHCPv6

```
ipv6 dhcp pool IPV6POOL-A
 dns-server 2001:DB8:ACAD:CAFE::A
 domain-name ccna-lab.com
!
ipv6 cef
!
no ip domain lookup
ip domain name ccna-lab.com
ip cef
!
multilink bundle-name authenticated
!
crypto pki token default removal timeout 0
!
redundancy
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
 ipv6 address FE80::1 link-local
 ipv6 address 2001:DB8:ACAD:A::1/64
 ipv6 nd other-config-flag
 ipv6 dhcp server IPV6POOL-A
!
interface Serial0/0/0
 no ip address
 shutdown
 clock rate 2000000
!
interface Serial0/0/1
 no ip address
 shutdown
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
```

Lab – Troubleshooting DHCPv6

```
control-plane
!
banner motd ^CC
  Unauthorized Access is Prohibited!
^C
!
line con 0
  exec-timeout 0 0
  password 7 0205085A1815
  logging synchronous
  login
line aux 0
line 2
  no activation-character
  no exec
  transport preferred none
  transport input all
  transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
  stopbits 1
line vty 0 4
  password 7 104D05181604
  login
  transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1 (Final)

```
S1#sh run
Building configuration...

Current configuration : 3365 bytes
!
version 12.2
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
```

Lab – Troubleshooting DHCPv6

```
ip subnet-zero
!
!
no ip domain-lookup
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 shutdown
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 shutdown
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
!
interface FastEthernet0/6
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
!
interface FastEthernet0/11
 shutdown
!
interface FastEthernet0/12
 shutdown
!
interface FastEthernet0/13
 shutdown
!
```

Lab – Troubleshooting DHCPv6

```
interface FastEthernet0/14
shutdown
!
interface FastEthernet0/15
shutdown
!
interface FastEthernet0/16
shutdown
!
interface FastEthernet0/17
shutdown
!
interface FastEthernet0/18
shutdown
!
interface FastEthernet0/19
shutdown
!
interface FastEthernet0/20
shutdown
!
interface FastEthernet0/21
shutdown
!
interface FastEthernet0/22
shutdown
!
interface FastEthernet0/23
shutdown
!
interface FastEthernet0/24
shutdown
!
interface GigabitEthernet0/1
shutdown
!
interface GigabitEthernet0/2
shutdown
!
interface Vlan1
no ip address
ipv6 address autoconfig
!
ip http server
ip http secure-server
!
control-plane
!
banner motd ^C
```

Lab – Troubleshooting DHCPv6

```
Unauthorized Access is Prohibited!  
^C  
!  
line con 0  
password 7 104D000A0618  
logging synchronous  
login  
line vty 0 4  
password 7 104D000A0618  
login  
line vty 5 15  
password 7 104D000A0618  
login  
!  
end
```

IoE and DHCP (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Configure DHCP for IPv4 or IPv6 on a Cisco 1941 router.

At the end of this chapter, students should be able to configure a Cisco 1941 router for IPv4 and IPv6 DHCP end-device addressing. In this activity, students will use Packet Tracer to configure DHCP addressing for end devices in a home environment.

Scenario

This chapter presents the concept of using the DHCP process in a small- to medium-sized business network; however, DHCP also has other uses!

With the advent of the Internet of Everything (IoE), any device in your home capable of wired or wireless connectivity to a network will be able to be accessed from just about anywhere.

Using Packet Tracer for this modeling activity, perform the following tasks:

- Configure a Cisco 1941 router (or DHCP-server-capable ISR device) for IPv4 or IPv6 DHCP addressing.
- Think of five devices in your home you would like to receive IP addresses from the router's DHCP service. Set the end devices to claim DHCP addresses from the DHCP server.
- Show output validating that each end device secures an IP address from the server. Save your output information via a screen capture program or use the **PrtScrn** key command.
- Present your findings to a fellow classmate or to the class.

Required Resources

Packet Tracer software

Reflection

1. Why would a user want to use a Cisco 1941 router to configure DHCP on his home network? Wouldn't a smaller ISR be good enough to use as a DHCP server?

Answers will vary. The 1941 routers are more expensive than smaller ISRs, but they offer more options to implement security plans and are more robust in processing/bandwidth power.

2. How do you think small- medium-sized businesses are able to use DHCP IP address allocation in the IoE and IPv6 network world? Brainstorm and record five possible answers.

Small landscaping firms may be able to turn on sprinkler systems for customers when they go on vacation, based on the landscaping firm's DHCP server IP address allocations.

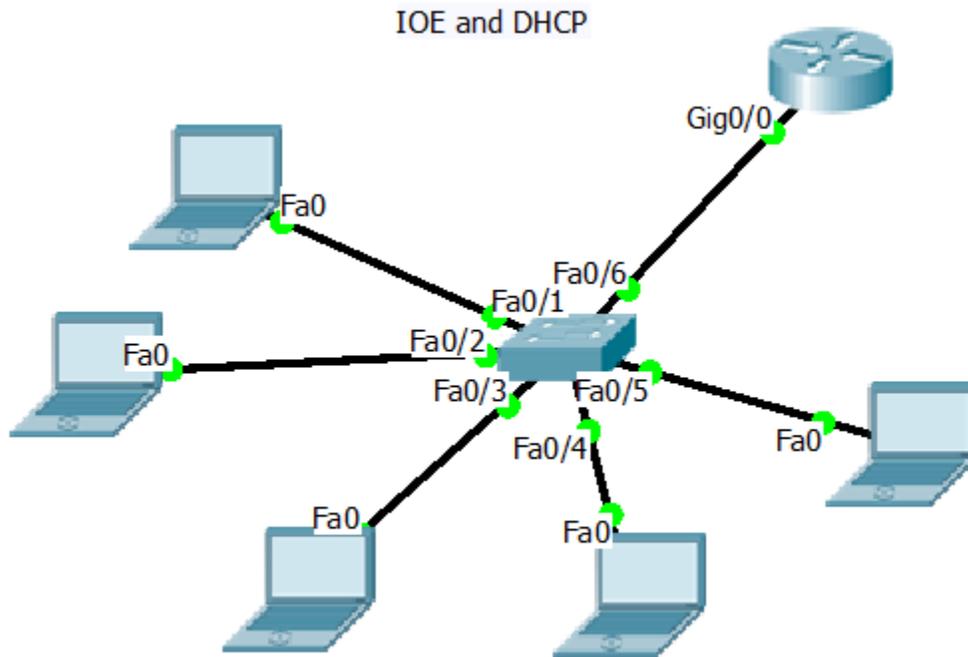
Small electric companies may be able to check error codes on any device with an IP address to evaluate the end-device for repair by using their own DHCP servers' IP address allocations.

Small automotive businesses may be able to provide estimates for repair based on DHCP IP addressing of automobiles with auto addresses linked to the business' DHCP server.

A homeowner may be able to start the washer or dryer from any location, based upon a DNS server location and their own DHCP server address.

Televisions may be controlled to turn off, turn on, select stations to record, record programs, and more using a DNS server and personal DHCP server.

Instructor Activity Representative Topology and Output



```
Router# show run
(output omitted)

hostname Router

ip dhcp excluded-address 192.168.1.1 192.168.1.10
!
ip dhcp pool HOME-ADDRESSES
 network 192.168.1.0 255.255.255.0
 default-router 192.168.1.1
!
(output omitted)

spanning-tree mode pvst
!
interface GigabitEthernet0/0
 ip address 192.168.1.1 255.255.255.0
 duplex auto
 speed auto
```

```
Router# show ip dhcp binding
IP address      Client-ID/
                Hardware address
192.168.1.11    0090.0CC1.A57B      --      Automatic
192.168.1.14    0060.3E80.2074      --      Automatic
192.168.1.13    0001.C9B3.382D      --      Automatic
192.168.1.12    000A.F345.487C      --      Automatic
192.168.1.15    00E0.F995.0C3B      --      Automatic
```

Identify elements of the model that map to IT-related content:

- DHCP servers can allocate IP addresses to any network-capable device.
- DHCP servers can provide small- to medium-sized businesses with functionality that is not provided with static addressing.
- Network administrators, who configure network DHCP servers, such as routers, switches or dedicated servers, can save time in implementing an IP addressing scheme.

Make Mine Wireless (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Explain how wireless LAN components are deployed in a small- to medium-sized business.

Instructor Notes: This activity can be completed individually, in small groups, or as a class.

Scenario

As the network administrator for your small- to medium-sized business, you realize that your wireless network needs updating, both inside and outside of your building. Therefore, you decide to research how other businesses and educational and community groups set up their WLANs for better access to their employees and clients.

To research this topic, you visit the [Customer Case Studies and Research](#) website to see how other businesses use wireless technology. After viewing a few of the videos, or reading some of the case study PDFs, you decide to select two to show to your CEO to support upgrading to a more robust wireless solution for your company.

To complete this class modeling activity, open the accompanying PDF for further instructions on how to proceed.

Resources

Internet access to the WWW

Step 1: Open your browser and the URL specified for this activity.

- a. Choose two case studies about wireless LAN upgrades from the list to read, located on the [Customer Case Studies and Research](#) website.
- b. As you view the media or read the PDFs, write notes for the following categories:
 - 1) The WLAN **challenge** that the company sought to mitigate
 - 2) The **solution** that was found to the challenge
 - 3) The **results** that were gained by WLAN updates

Step 2: Share your findings.

- a. Share your findings with the class or a classmate.
- b. Play the media or show the PDF for one of the case studies you chose from the URL page.
- c. In your own words, explain the challenge, solution, and results learned from the media or PDF.
- d. Explain how the results you found could be applied to improve your company's network.

Instructor Suggested Example

Barrick Gold Corporation

Challenge

Provide continuous access and updates to the Caterpillar Minestar software for fleet management, drilling and blasting, loading, hauling, dozing, and truck management.

Solutions

Created an outdoor mesh wireless network, deployed on solar-powered trailers across the mine and inside the mining pit.

Results

- Closely monitored dispatch process and managed operational efficiency.
- Improved productivity and safety.
- Cut costs by implementing single network for communications and data sharing of new applications.

Identify elements of the model that map to IT-related content:

- Wireless topologies
- Inside-building wireless solutions
- Outside-building wireless solutions
- Wireless LAN devices
- Wireless LAN communication

Lab – Investigating Wireless Implementations (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objectives

Part 1: Explore Integrated Wireless Routers

Part 2: Explore Wireless Access Points

Background / Scenario

The number of mobile devices, such as smart phones, tablets, and laptops, continues to increase. These mobile devices can connect via integrated wireless routers or wireless access points (WAPs) to access the Internet and other network resources. Wireless routers are typically employed in home and small business networks. WAPs are more common in larger, more complex networks.

In this lab, you will explore some integrated wireless routers and Cisco WAPs. You will access online emulators for some of Linksys routers and Cisco WAPs. The emulators imitate the configuration screens for the Linksys routers and Cisco WAPs.

Required Resources

Device with Internet access

Part 1: Explore Integrated Wireless Routers

Integrated wireless routers usually perform the functions of the following devices:

- a switch by connecting wired devices
- an access point by connecting wireless devices
- a router/gateway by providing access to the Internet through a modem to the ISP

Currently there are many different broadcast standards for wireless routers:

- 802.11b
- 802.11g
- 802.11n
- 802.11ac

The differences between these standards are speed and signal strength. In addition to the standards, each integrated wireless router may have features that meet your network requirement, such as content filtering, QoS, IPv6 support, and wireless security.

In Part 1, you will search the Internet for three different wireless routers and create a list of the important router feature by recording them in the following table. During your search, you can also record additional features that are important to you in the **Other Features** column in the table.

To explore emulators for some of the Linksys routers, go to <http://ui.linksys.com/files/>.

Note: The Linksys emulators may not provide the most current version of the firmware.

Lab – Investigating Wireless Implementations

Brand/Model	Price	IPv6-Enabled	Wireless Security	Band	Other Features
Linksys/EA4500	\$129.99 USD	Yes	WPA2	Dual-band N (2.4 GHz and 5 GHz)	Separate Guest Network, 4 Gigabit Ethernet Ports, QoS, remote administration from mobile devices, such as smart phones

After you have completed the table above, determine which integrated wireless router you would choose for your home. Explain your choice.

Answer will vary. Some of the reasons can include ease of configuration, parental control, and QoS.

Part 2: Explore Wireless Access Points

Unlike integrated wireless routers, a WAP does not have integrated switch and router functions. A WAP only allows users to access the network wirelessly using mobile devices and provides a connection to the main wired network infrastructure. With the correct user credentials, wireless users can access resources on the network.

In this part, you will explore two Cisco WAPs, WAP321 and AP541N. Cisco's website (<http://www.cisco.com>) can provide you with technical specifications regarding these WAPs. Furthermore, online emulators are also available at the following links:

To access an online WAP321 emulator, go to https://www.cisco.com/assets/sol/sb/WAP321_Emulators/WAP321_Emulator_v1.0.2.3/main.html.

To access an online AP541N emulator, go to http://www.cisco.com/assets/sol/sb/AP541N_Emulators/AP541N_Emulator_v1.9.2/Getting_Started.htm.

Lab – Investigating Wireless Implementations

Model	Security	Band	Other Features / Comments
WAP321			
AP541N			

Reflection

What features on the wireless routers or WAPs are important for your network? Why?

Answer will vary. For example, wireless security is important because unauthorized wireless access to the network can have devastating consequences, such as loss of confidential company information.

Lab – Configuring a Wireless Router and Client (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Topology



Linksys Router Settings

Network Name (SSID)	CCNA-Net
Network Password	cisconet
Router Password	cisco123

Objectives

Part 1: Configure Basic Settings on a Linksys EA Series Router

Part 2: Secure the Wireless Network

Part 3: Review Additional Features on a Linksys EA Series Router

Part 4: Connect a Wireless Client

Background / Scenario

Surfing the web from anywhere in the home or office has become common. Without wireless connectivity, users would be limited to connect only where there is a wired connection. Users have embraced the flexibility that wireless routers provide for accessing the network and the Internet.

In this lab, you will configure a Linksys Smart Wi-Fi router, which includes applying WPA2 security settings and activating DHCP services. You will review some added features available on these routers, such as USB storage, parental controls, and time restrictions. You will also configure a wireless PC client.

Required Resources

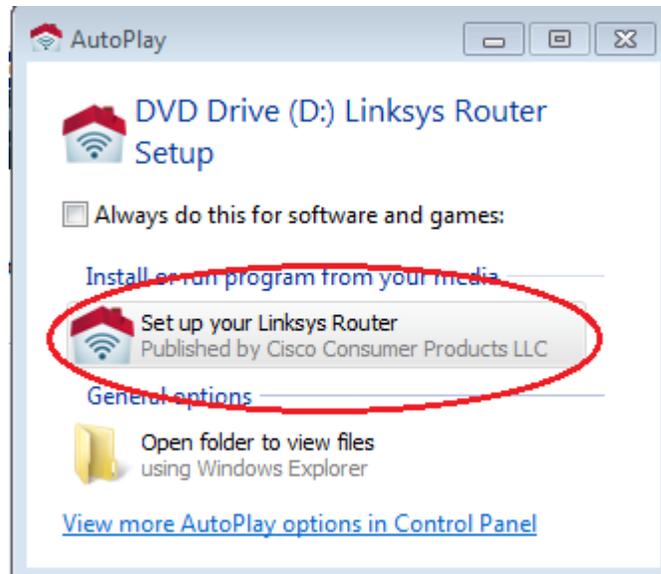
- 1 Linksys EA Series Router (EA4500 with firmware version 2.1.39.145204 or comparable)
- 1 Cable or DSL modem (Optional - needed for Internet service and normally supplied by ISP)
- 1 PC with a Wireless NIC (Windows 7, Vista, or XP)
- Ethernet cables as shown in the topology

Part 1: Configure Basic Settings on a Linksys EA Series Router

The most efficient way to configure basic settings on an EA Series router is to run the Linksys EA Series Setup CD that came with the router. If the Setup CD is unavailable, download the Setup program from <http://Linksys.com/support>.

Step 1: Insert the Linksys EA-Series Setup CD into the PC.

When prompted, select **Set up your Linksys Router**. You will be asked to read and accept the License Terms for using the software. Click **Next >** after accepting the license terms.



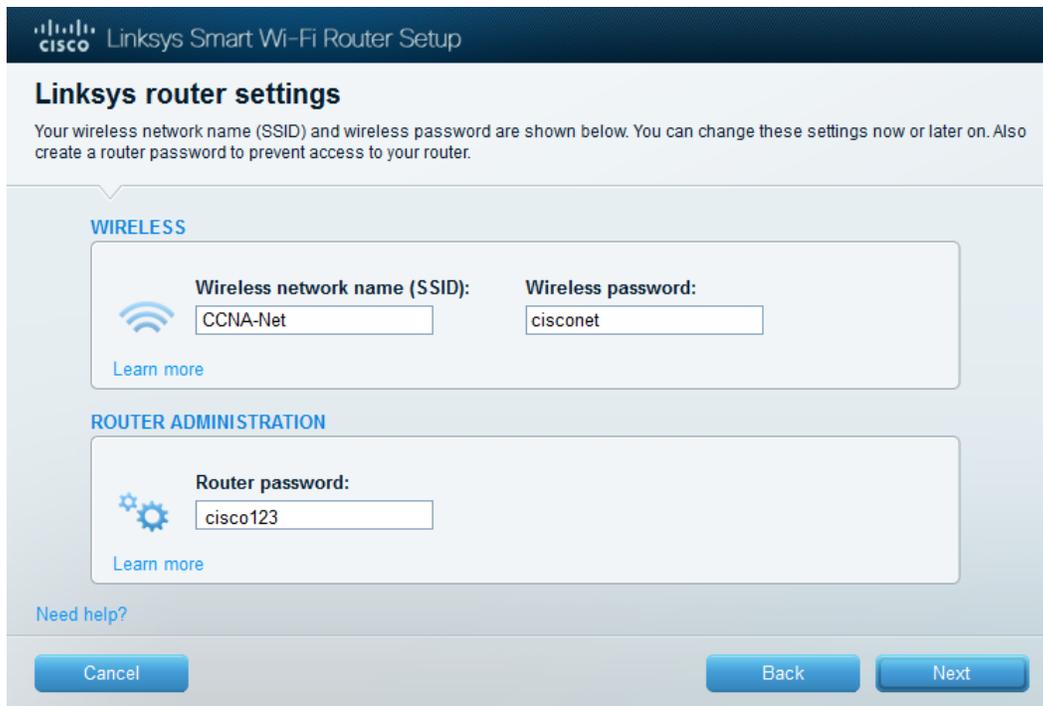
Step 2: Cable the network as shown in the topology.

Follow the directions in the next window for connecting the power cable and Ethernet cable from your cable modem or DSL modem. You may connect the PC to one of the four unused Ethernet ports on the back of the router. After you have connected everything, click **Next >**.



Step 3: Configure Linksys router settings.

- a. Allow time for the **Linksys router settings** window to display. Use the **Linksys Router Settings** table at the beginning of this lab to fill in the fields in this window. Click **Next** to display the summary router settings screen. Click **Next**.



- b. The **Create your Linksys Smart Wi-Fi account** window displays. A Linksys Smart Wi-Fi account associates your router to the account, allowing you to remotely manage the router using a browser or

Lab – Configuring a Wireless Router and Client

mobile device running the Smart Wi-Fi app. For this lab, bypass the account setup process. Click the **No thanks** box and press **Continue**.

Note: An account can be setup by browsing to www.linksyssmartwifi.com.



Linksys Smart Wi-Fi Router Setup

Create your Linksys Smart Wi-Fi account

Create your free Smart Wi-Fi account to experience and access your connected home from anywhere at any time. The account is optional and takes only a few minutes to set up.

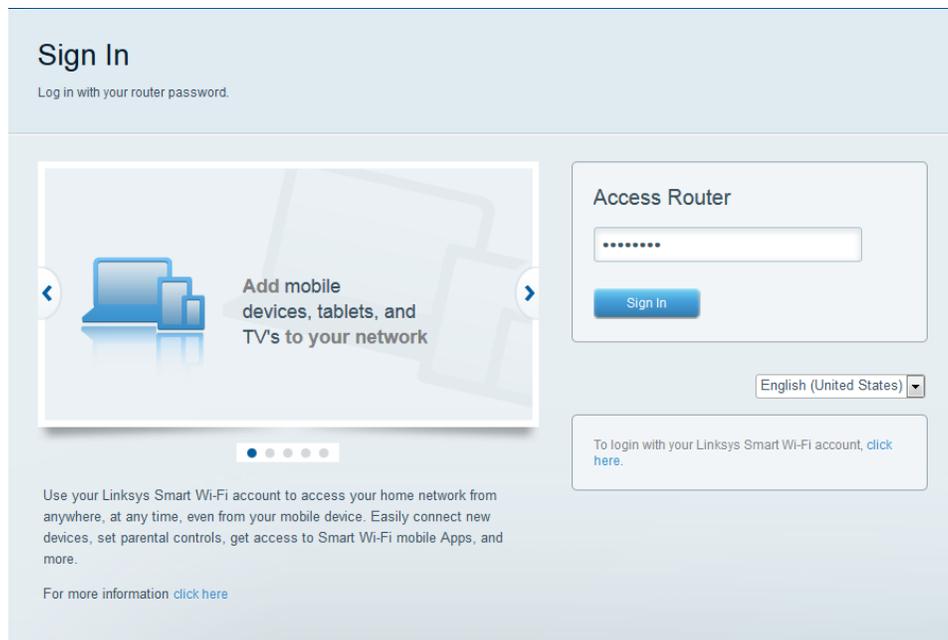
Why a Linksys Smart Wi-Fi account?

- Get anytime, anywhere access to your home network
- Access new and exciting Apps
- Use intelligent media prioritization for HD video and gaming
- Control kids' content even when you're away from home

No thanks

Continue

c. A **Sign In** window displays. In the **Access Router** field, enter **cisco123**, and click **Sign In**.



Sign In

Log in with your router password.

Add mobile devices, tablets, and TV's to your network

Access Router

.....

Sign In

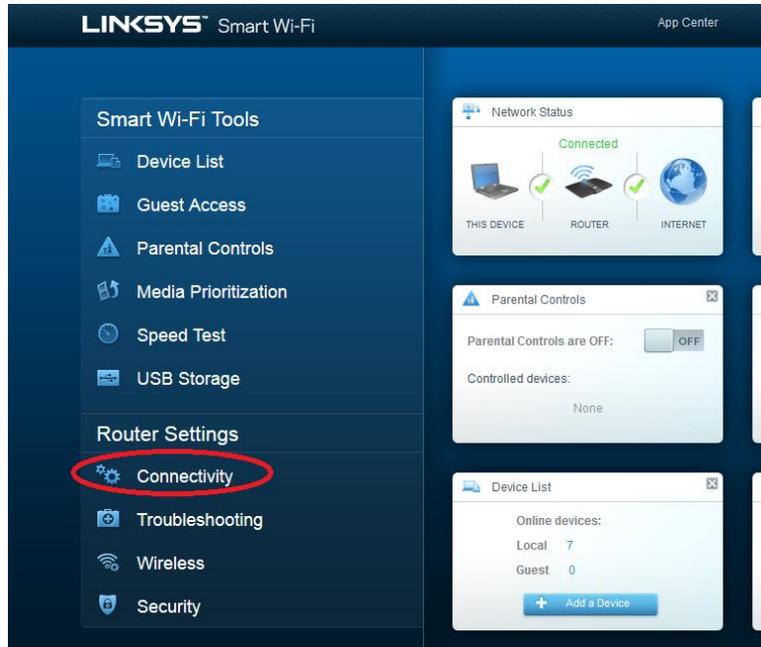
English (United States)

To login with your Linksys Smart Wi-Fi account, [click here](#).

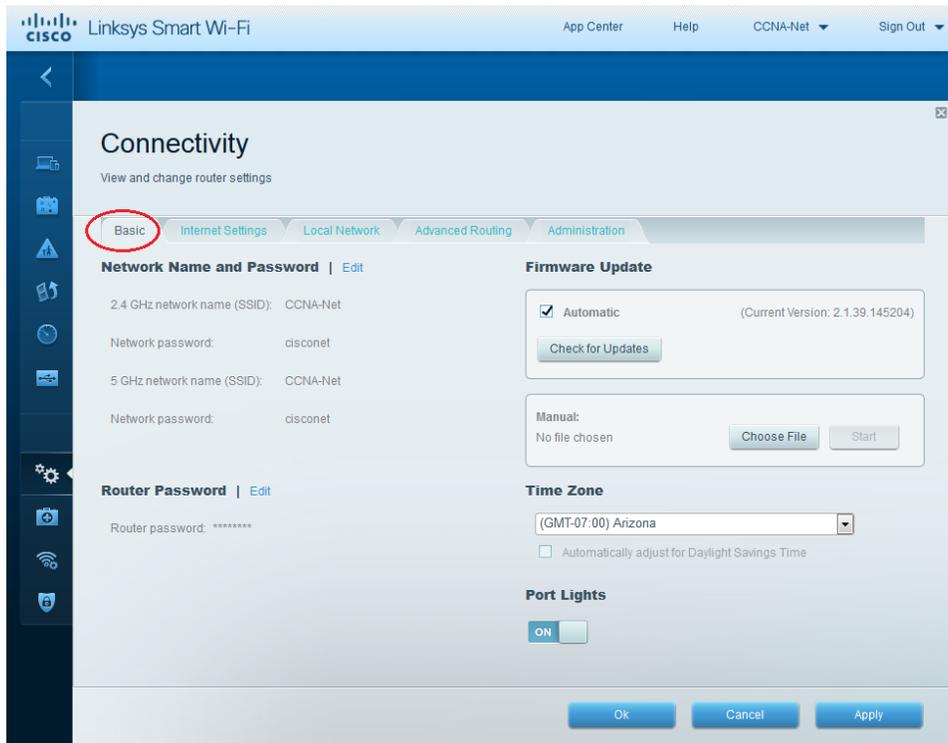
For more information [click here](#)

d. On the Linksys Smart Wi-Fi home page, click **Connectivity** to view and change basic router settings.

Lab – Configuring a Wireless Router and Client

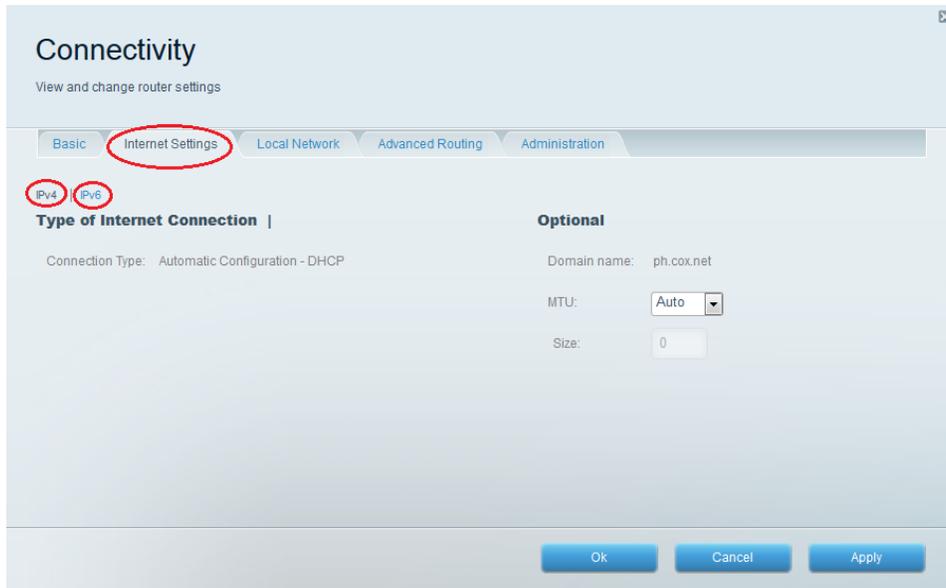


- e. On the **Basic** tab, you can edit the SSID name and password, change the router password, perform firmware updates, and set the time zone for your router. (The router password and SSID information was set in Step 3a.) Select the correct time zone for your router from the drop-down box and click **Apply**.



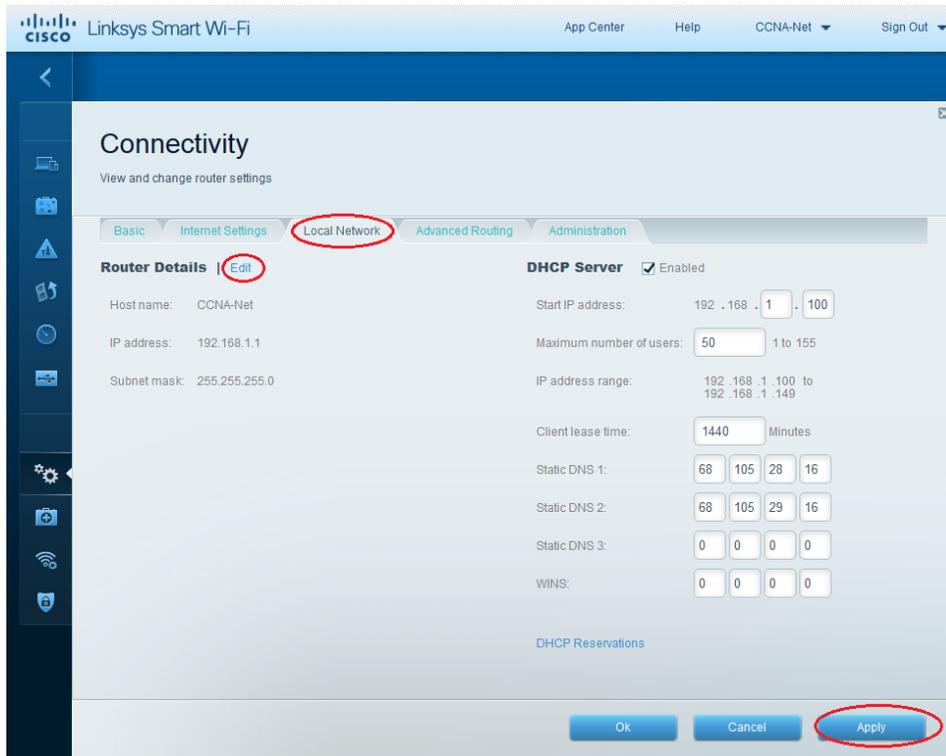
- f. The **Internet Settings** tab provides information about the Internet connection. In the example, the router automatically configured the connection for DHCP. Both IPv4 and IPv6 information can be displayed from this screen.

Lab – Configuring a Wireless Router and Client



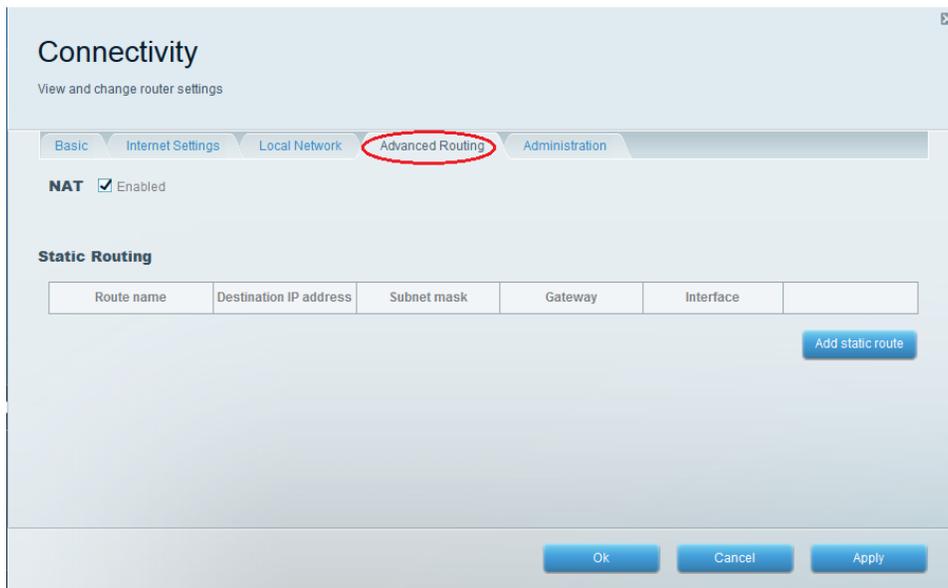
- g. The **Local Network** tab controls the local DHCP server settings. The default local network settings specify the 192.168.1.0/24 network and the local IP address of the default router is 192.168.1.1. This can be changed by clicking **Edit** next to **Router Details**. DHCP Server settings can be changed on this screen. You can set the DHCP starting address, maximum number of DHCP users, client lease time, and static DNS servers. Click **Apply** to accept all changes made on this screen.

Note: If DHCP is used to obtain ISP connection information, these DNS addresses will most likely be populated with the ISP's DNS server information.

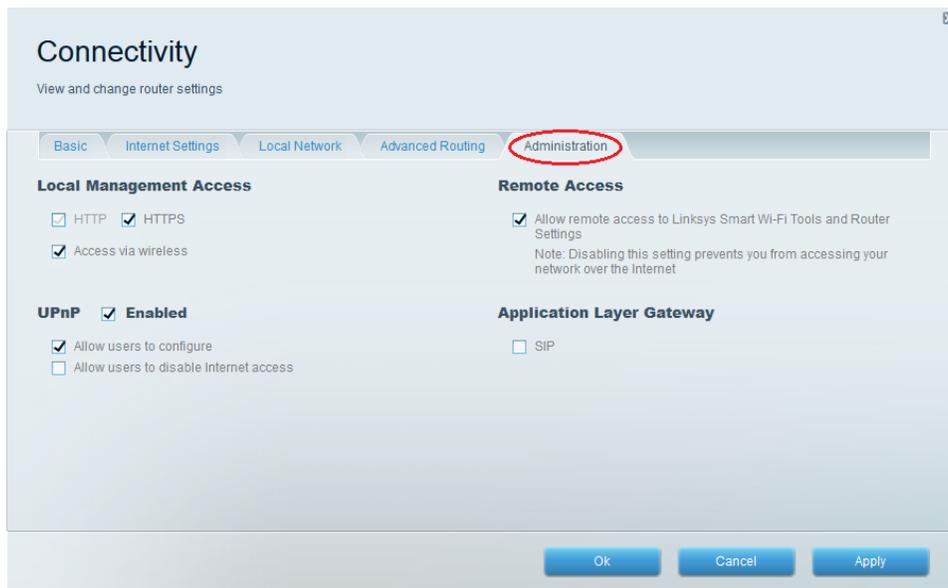


Lab – Configuring a Wireless Router and Client

- h. The **Advanced Routing** tab allows you to disable Network Address translation (NAT), which is enabled by default. This screen also allows you to add static routes. Click **Apply** to accept any desired changes made on this screen.



- i. The **Administration** tab provides controls for the management of the Smart Wi-Fi software. By checking the appropriate box, you can activate remote management access to the router. You can also activate HTTPS access and restrict wireless management. Universal Plug and Play (UPnP) and Application Layer Gateway controls are also available on this screen. Click **Apply** to accept any desired changes made on this screen.

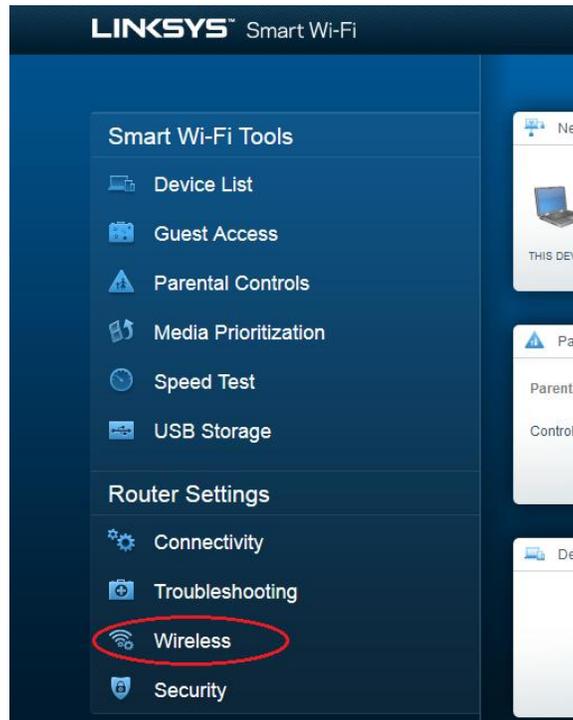


Part 2: Secure the Wireless Network

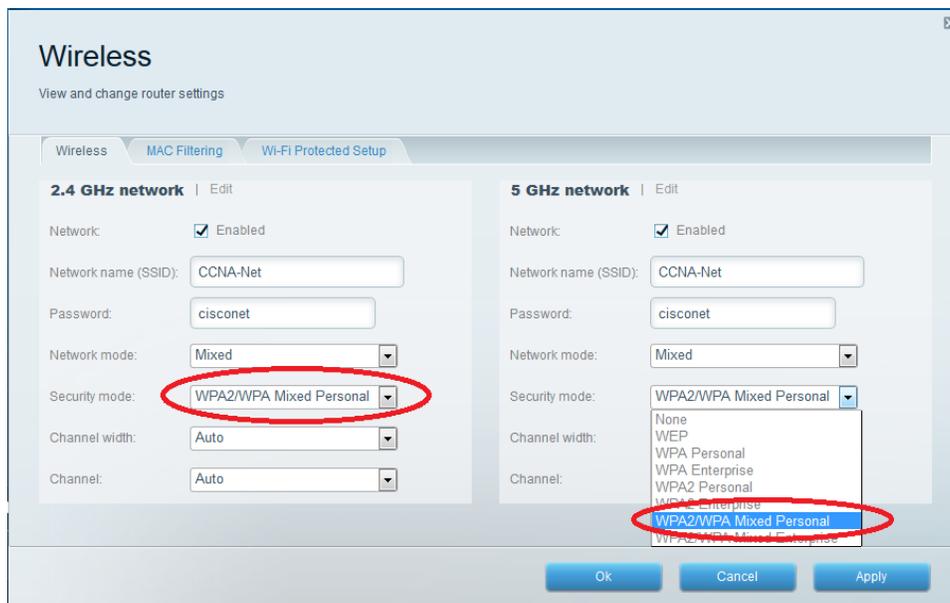
In Part 2, you will secure the Linksys EA series router wireless network and review firewall and port forwarding options on a Linksys Smart Wi-Fi router.

Step 1: Add WPA security on the wireless routers.

- a. From the Linksys Smart Wi-Fi home page, click **Wireless**.



- b. The **Wireless** window displays the settings for both the 2.4 and 5 GHz radios. Use the **Edit** button next to each column to modify the security setting on each wireless frequency range. (The SSID and password were previously set in Part 1.) Click the **Security mode** drop-down list to select the **WPA2/WPA Mixed Personal** option for each range. Click **Apply** to save your settings, and then click **OK**.

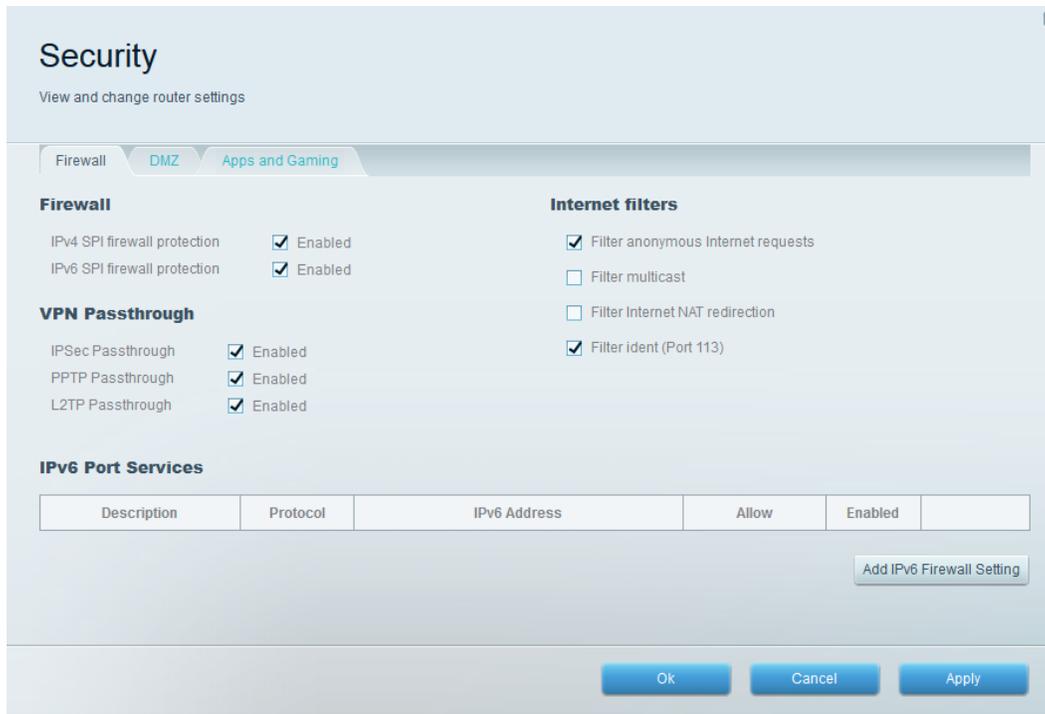


Step 2: Apply firewall and port forwarding settings.

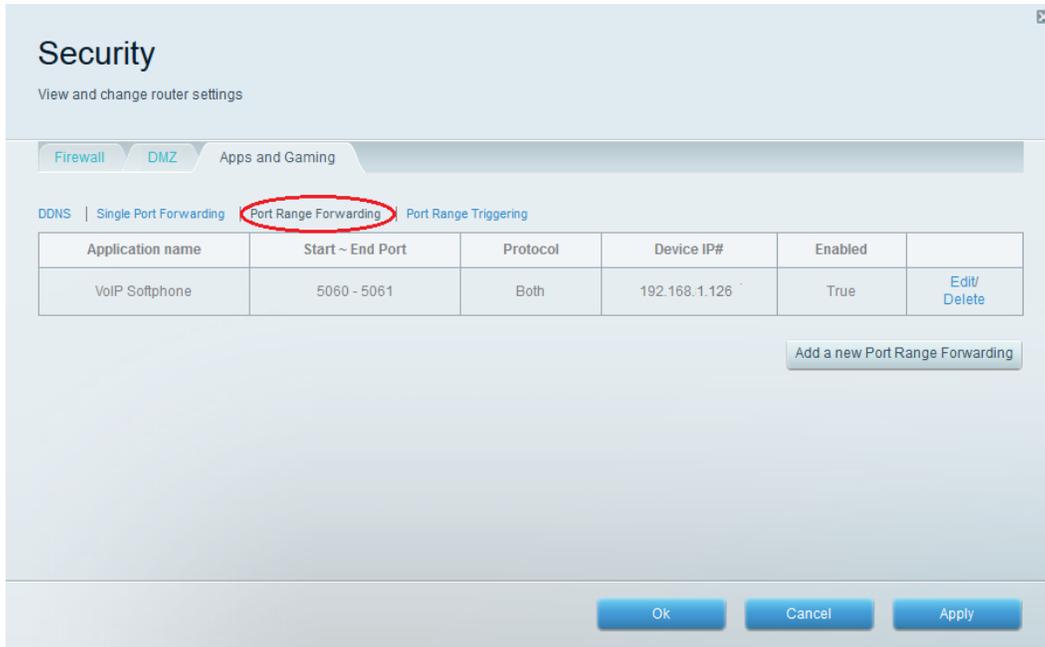
- a. From the Linksys Smart Wi-Fi home page, click **Security**. In the **Security** windows, the **Firewall**, **DMZ**, and **Apps and Gaming** tabs are available to view and change router security settings.



- b. The **Firewall** tab displays firewall settings, where you can enable or disable IPv4 and IPv6 Stateful Packet Inspection (SPI) firewall protection, Virtual Private Network (VPN) Passthrough options, and Internet filters. Click **Apply** to accept any desired changes made on this screen.



- c. The **Apps and Gaming** tab provides port forwarding capabilities. In the example, ports 5060 and 5061 have been opened for a VoIP Softphone application running on a local device at IP address 192.168.1.126. Click **Apply** to accept any desired changes made on this screen.



Part 3: Review Additional Features on a Linksys EA Series Router

In Part 3, you will review some of the additional features available on the Linksys EA series router.

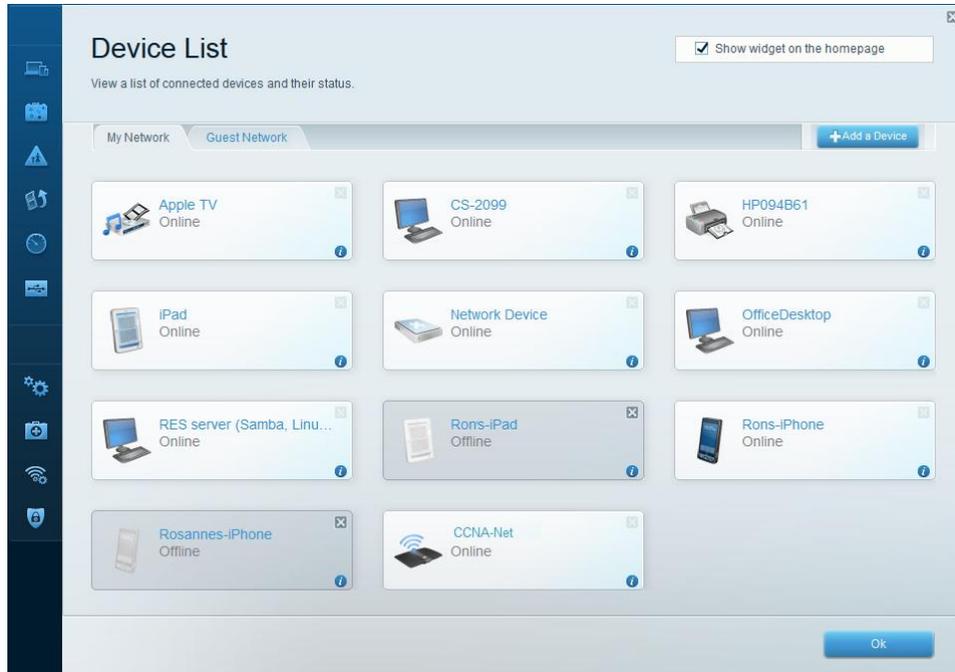
Step 1: Review Smart Wi-Fi Tools.

- a. From the Linksys Smart Wi-Fi home page, click **Device List**.



The **Device List** window displays the list of clients on the local network. Notice that there is a tab for the **Guest Network**. If the Guest network was activated, clients on that network would be displayed in the **Guest Network** tab.

Lab – Configuring a Wireless Router and Client

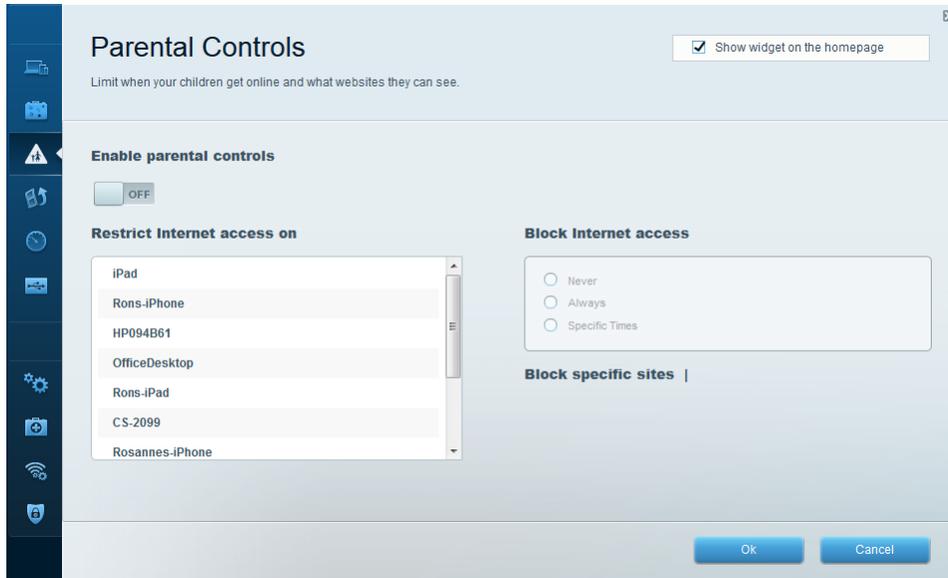


- b. From the Linksys Smart Wi-Fi home page, click **Guest Access**. Clients on the guest network only have access to the Internet and are unable to access other clients on the local network. To allow guest access, click on the **Allow guest access** toggle button. Click **Edit** link (next to the Guest network name and password) to change the Guest network password and click **OK** to accept the changes.

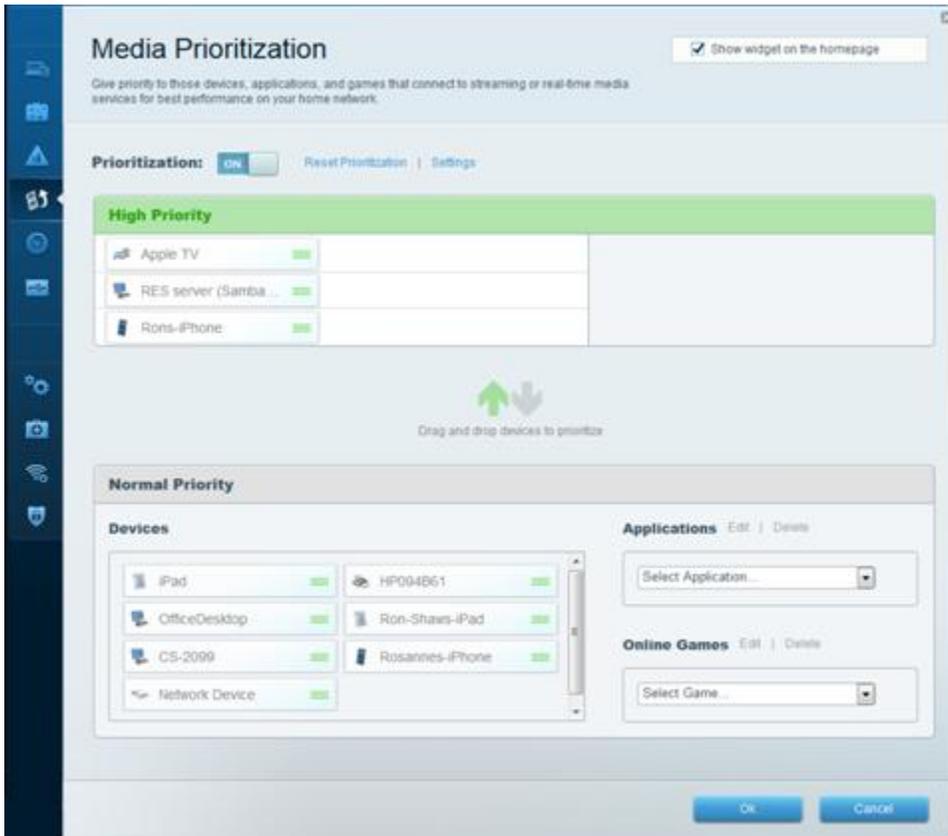


- c. From the Linksys Smart Wi-Fi home page, click **Parental Controls**. Use these settings to restrict Internet access on selected devices and to restrict time and websites. Click **OK** to save the settings.

Lab – Configuring a Wireless Router and Client



- d. From the Linksys Smart Wi-Fi home page, click on **Media Prioritization**. These settings allows you to assign network bandwidth prioritization to selected devices on the local network. In the example, the device labeled Apple TV has been given the highest priority for network resources. To make prioritization changes, just drag and drop the listed devices, and click **OK** to save your settings.

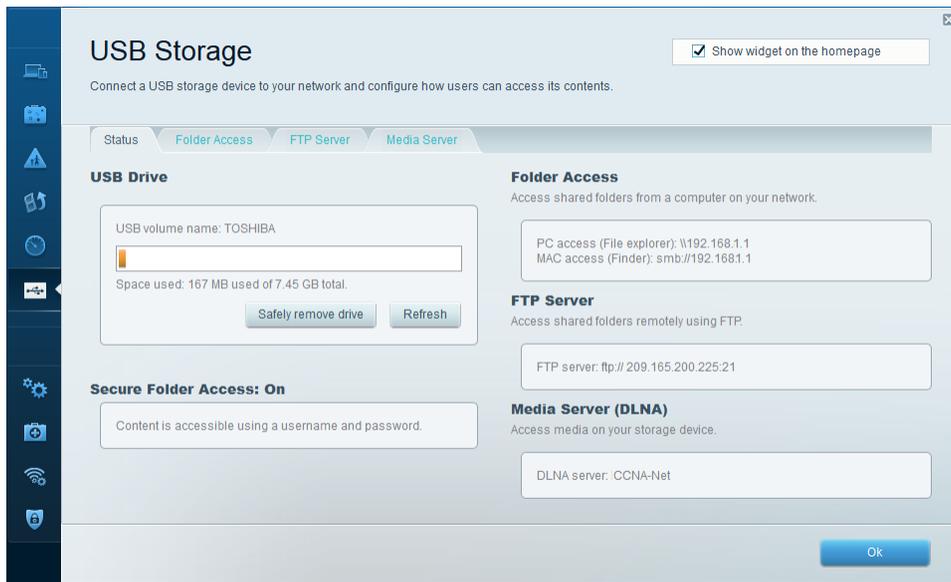


Lab – Configuring a Wireless Router and Client

- e. From the Linksys Smart Wi-Fi home page, click **Speed Test**. Use this utility to test your Internet access speeds. The example shows the results of the speed test. The router stores the results of each speed tests and allows you to display that history.



- f. From the Linksys Smart Wi-Fi home page, click **USB Storage**. Use this screen to review your USB drive settings. From here, you can click on the appropriate tab to set up FTP and Media Servers. You can also set up individual user accounts for access to these servers by clicking the tabs at the top of this screen. A USB storage device is plugged into the back of the router to use this option. Click **OK** to save any desired changes.

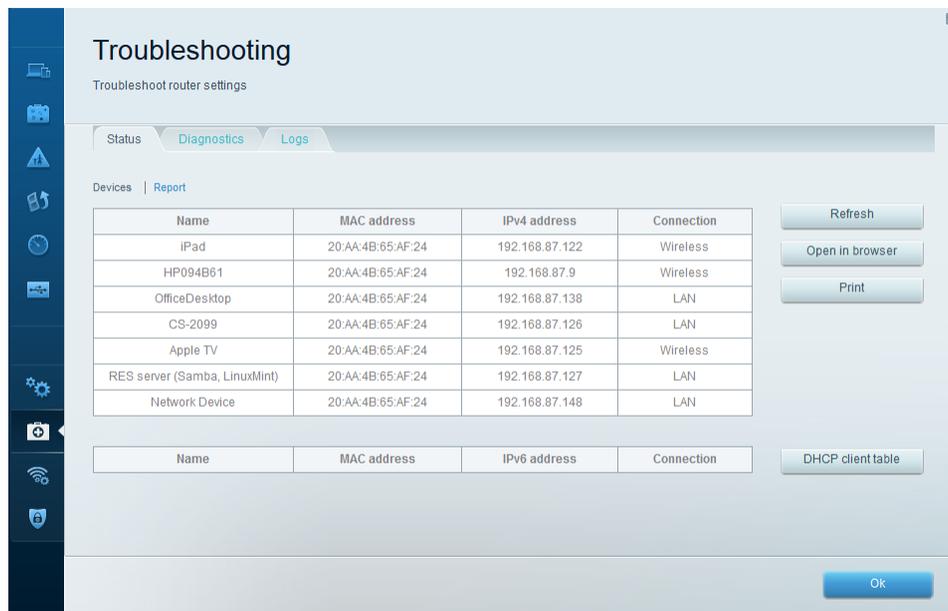


Step 2: Troubleshoot the router.

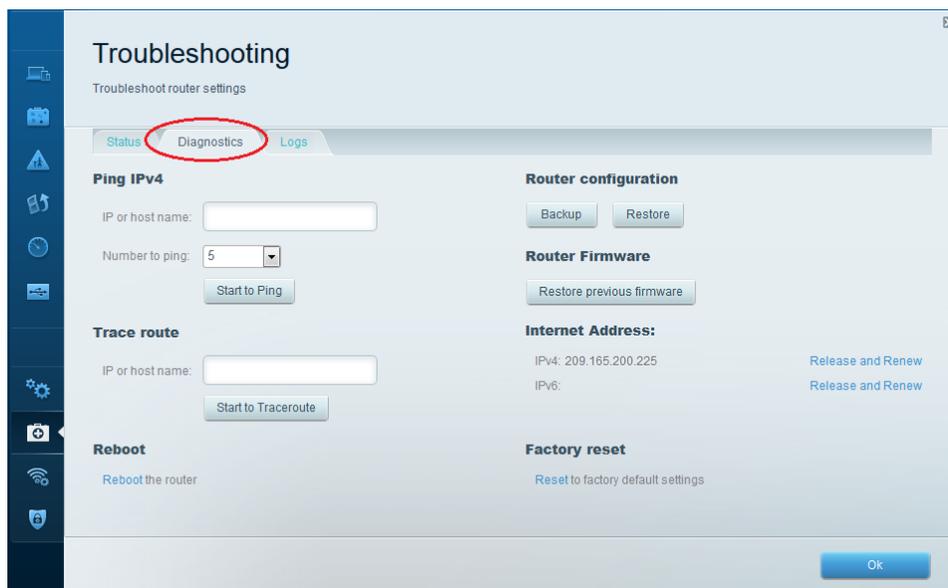
From the Linksys Smart Wi-Fi home page, click **Troubleshooting**.

- a. The **Status** tab provides a list of clients on the local network along with their NIC MAC and IP addresses. It also displays how they are connected to the network. Click **OK** to save any desired changes.

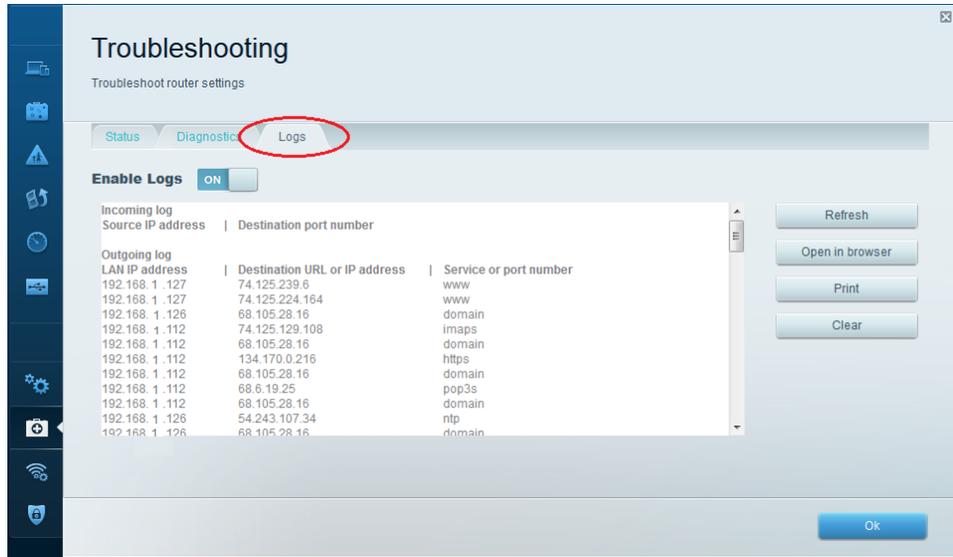
Lab – Configuring a Wireless Router and Client



- b. The **Diagnostics** tab provides the ping and traceroute utilities. It also allows you to reboot the router, backup and restore the router configuration, restore a previous firmware version, release and renew the Internet addresses on your router, and reset to factory default settings. Click **OK** to save any desired changes.



- c. The **Logs** tab provides Incoming and Outgoing, Security, and DHCP logs. You can print and clear these logs from this screen. Click **OK** to save any desired changes.



Part 4: Connect a Wireless Client

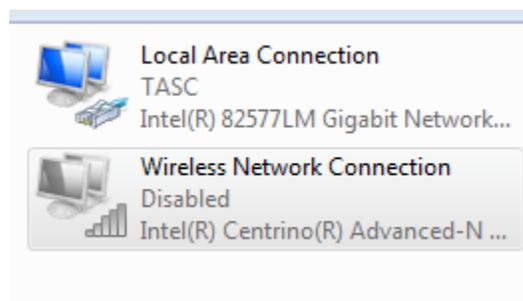
In Part 4, you will configure the PC's wireless NIC to connect to the Linksys EA Series Router.

Note: This lab was performed using a PC running the Windows 7 operating system. You should be able to perform the lab with other Windows operating systems listed; however, menu selections and screens may vary.

Step 1: Use the Network and Sharing Center.

- Open the **Network and Sharing Center** by clicking the Windows **Start** button > **Control Panel** > **View network status and tasks** under Network and Internet heading in the Category View.
- In the left pane, click the **Change adapter settings** link.

The **Network Connections** window provides the list of NICs available on this PC. Look for your **Local Area Connection** and **Wireless Network Connection** adapters in this window.

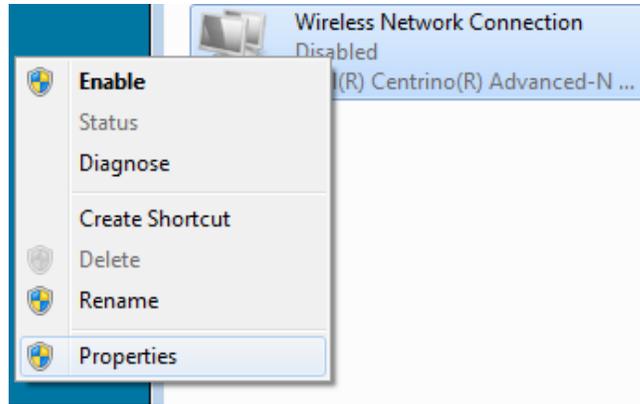


Note: VPN adapters and other types of network connections may also be displayed in this window.

Step 2: Work with your wireless NIC.

- Select and right-click the **Wireless Network Connection** option to display a drop-down list. If your wireless NIC is disabled, you must **Enable** it.

Lab – Configuring a Wireless Router and Client



- b. Right-click the **Wireless Network Connection**, and then click **Connect/Disconnect**. This displays a list of SSIDs in range of your wireless NIC. Select **CCNA-Net**, then click the **Connect**.



- c. When prompted, enter **cisconet** to supply the network security key, and then click **OK**.



- d. The wireless icon should display in your taskbar when you have a wireless connection. Click this icon to display the list of SSIDs in range of your PC.



- e. The SSID **CCNA-Net** should now show that you are connected to the CCNA-Net wireless network.



Reflection

Why would you not want to use WEP security for your wireless network?

WEP uses RC4 encryption, which can be easily hacked. WPA2 use Advanced Encryption Standard (AES), which is considered the strongest encryption protocol.

Inside and Outside Control (Instructor Version)

Instructor Note: Red font color or Gray highlights indicate text that appears in the instructor copy only.

Objective

Explain how wireless LAN components are deployed in a small- to medium-sized business.

Instructor Notes: This activity can be completed individually, in small groups, or as a class.

Scenario

An assessment has been completed to validate the need for an upgrade to your small- to medium-sized wireless network. Approved for purchase are indoor and outdoor access points and one wireless controller. You must compare equipment models and their specifications before you purchase.

Therefore, you visit the [Wireless Compare Products and Services](#) web site and see a features chart for indoor and outdoor wireless access points and controller devices. After reviewing the chart, you note there is some terminology with which you are unfamiliar:

- Federal Information Processing Standard (FIPS)
- MIMO
- Cisco CleanAir Technology
- Cisco FlexConnect
- Band Select

Research the above terms. Prepare your own chart with your company's most important requirements listed for purchasing the indoor and outdoor wireless access points and wireless controller. This chart will assist in validating your purchase order to your accounting manager and CEO.

Resources

Internet access to the World Wide Web

Part 1: Secure Background Knowledge of Wireless Terminology

Step 1: Define unfamiliar wireless terms.

- a. FIPS
- b. MIMO
- c. Cisco CleanAir Technology
- d. Cisco FlexConnect
- e. Band Select

Step 2: Visit the [Wireless Compare Products and Services](#) web site.

- a. Compare the devices in each category based on their feature sets.
- b. Choose one model from each category: indoor, outdoor, and controller categories for the upgrades for your business.

Step 3: Create a chart for each device chosen in Step 2b to include:

- a. The main type of selected device (indoor access point, outdoor access point, or controller).

- b. A graphic of each selected device.
- c. Five of the most beneficial features that the selected models would provide your business.

Step 4: After research is complete, explain, and justify your choices with another student, class group, or entire class.

Suggested Activity Completion Examples

Part 1:

Wireless device features definitions

FIPS	FIPS is the Federal Information Processing Standard regarding security for wireless devices.
MIMO	Unlike SISO (Single Input, Single Output), MIMO technology uses multiple radio bands and paths to transfer network data through multiple signals. Multiple antennas are used to send multiple spatial streams at the same time allowing for higher data transmission speeds and data delivery payloads.
Cisco CleanAir Technology	CleanAir Technology allows Cisco devices to: <ul style="list-style-type: none">• provide continual, system-wide wireless network discovery without wireless performance impact• identify source, location and interference of wireless signals• take automatic steps to avoid current and future wireless interference while recording what steps were taken to do so
Cisco FlexConnect	FlexConnect (previously known as Hybrid Remote Edge Access Point or H-REAP) is a wireless solution which enables network administrators to configure and control access points located at remote locations. This is performed by using a local wireless controller through a WAN connection.
Band Select	Band Select is a Cisco-selected frequency range technology based upon the ISM (industrial, scientific, and medical) unlicensed usage. These include: <ul style="list-style-type: none">• 900 MHz• 2.4 GHz (802.11b, g, and n standards) – better range but lower data rates• 5 GHz (802.11a, n, and ac standards) – less range but higher data rates

Part 2:

Cisco 2600 Series Indoor Access Point



Wi-Fi Standards	802.11 a, b, g, n (supports Dual paths/radio rates of 2.4 and 5 GHz) Data rate capabilities of 450 Mbps
FIPS	In process
CleanAir Technology	Yes
FlexConnect	Yes
Antennas	Internal and external

Cisco 1552I Series Outdoor Access Point



Wi-Fi Standards	802.11 a, b, g, n (supports Dual paths/radio rates of 2.4 and 5 GHz) Data rate capabilities of 300 Mbps downstream with 10/100/1000 Mbps upstream
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FIPS	In process
CleanAir Technology	Yes
FlexConnect	Yes
Antennas	Internal

Cisco Wireless Controller Module for ISR G2



Data Throughput	500 Mbps
Wireless Guest Services	Yes (up to 500 clients supported by 50 APs) 16 WLANs supported with 16 maximum VLANs allowed
CleanAir Technology	Yes
FlexConnect	Yes
Access Control Lists (ACLs for security)	Yes

Identify elements of the model that map to IT-related content:

- Wireless terminology
- Inside and outside wireless access points
- Wireless controllers
- Wireless device capabilities