Labs & Study Guide

Scaling Networks

Version 6

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CHAPTER 1

LAN Design

As a business grows, so does its networking requirements. To keep pace with a business's expansion and new emerging technologies, a network must be designed to scale. A network that scales well is not only one that can handle growing traffic demands, but also one designed to expand as needed. This short chapter sets the stage for the rest of the course. This chapter covers the campus wired LAN designs and appropriate device selections that you can use to systematically design a highly functional network.

Study Guide

Campus Wired LAN Designs

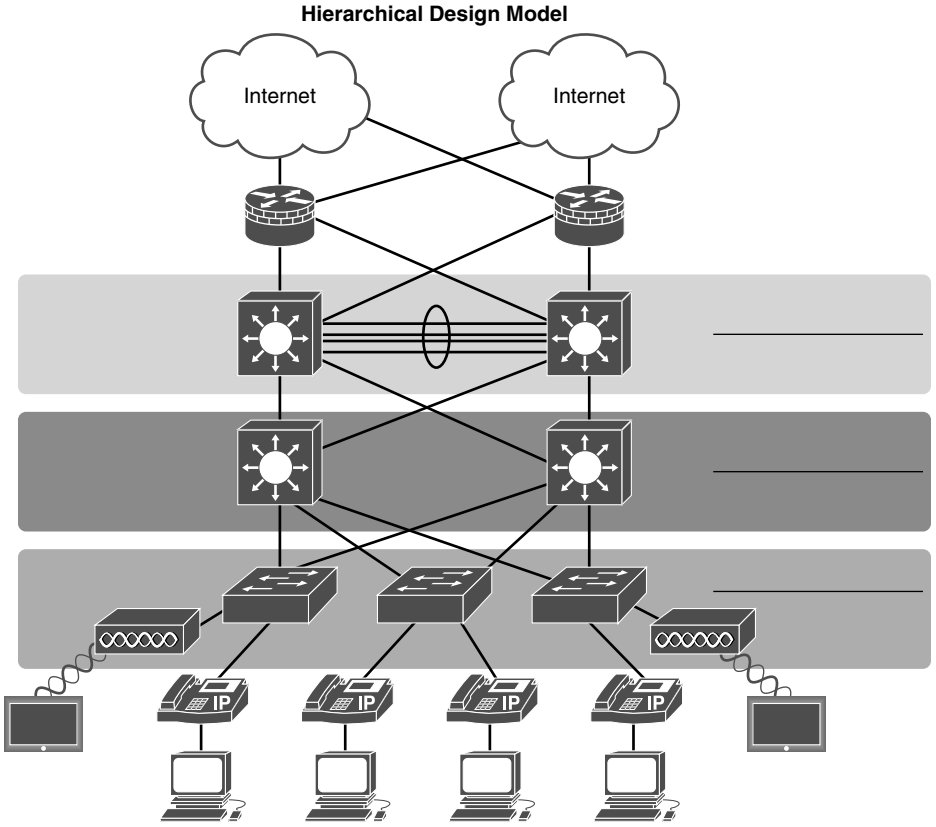
An enterprise network must be designed to support the exchange of various types of network traffic, including data files, email, IP telephony, and video applications for multiple business units.

Hierarchical Network Design

Enterprise networks are large multilocation networks that often span the globe. They must be able to support a variety of critical applications, converge different network traffic types, address diverse business needs, and provide centralized management control. The basic building block for enterprise networks is the LAN. The LAN is the networking infrastructure that provides access to network services for end users. LANs can be wired or wireless. Over a small geographic area, an enterprise interconnects these LANs into a campus network.

The campus wired LAN uses a hierarchical design model to break up the design into three layers. Designing a network using the three-layer hierarchical design model helps optimize the network. In Figure 1-1, label the three layers of the hierarchical design model.

Figure 1-1 Hierarchical Design Model



Briefly describe each layer of the hierarchical design model.

_____

_____

_____

_____

Identify Scalability Terminology

Match the definition on the left with the term on the right. This is a one-to-one matching exercise.

Definition

___ Isolates routing updates and minimizes the size of routing tables

___ Cisco proprietary distance vector routing protocol

___ Allows for redundant paths by eliminating switching loops

___ Technique for aggregating multiple links between equipment to increase bandwidth

___ Minimizes the possibility of a single point of failure

___ Supports new features and devices without requiring major equipment upgrades

___ Link-state routing protocol with a two-layer hierarchical design

___ Increases flexibility, reduces costs, and provides mobility to users

Terms

a. Modular equipment
b. OSPF
c. EIGRP
d. Wireless LANs
e. Redundancy
f. Spanning Tree Protocol
g. Scalable Routing Protocol
h. EtherChannel

Selecting Network Devices

When designing a network, it is important to select the proper hardware to meet current network requirements and to allow for network growth. Within an enterprise network, both switches and routers play a critical role in network communication.

Selecting Switch Hardware

Match the business consideration on the left with the switch feature on the right. This is a one-to-one matching exercise.

Business Consideration

___ Should provide continuous access to the network
___ Daisy-chain switches with high-bandwidth throughput
___ Refers to a switch's ability to support the appropriate number of devices on the network
___ Ability to adjust to growth of network users
___ How fast the interfaces will process network data
___ Important consideration in a network where there may be congested ports to servers or other areas of the network
___ Provides electrical current to other device and supports redundant power supplies
___ Switches with preset features or options
___ Depends on the number and speed of the interfaces, supported features, and expansion capability
___ Switches with insertable switching line/port cards

Switch Feature

a. Reliability
b. Modular
c. Uninterruptible power supply
d. Stackable
e. Frame buffers
f. Cost
g. Fixed configuration
h. Scalability
i. Port speed
j. Port density

Selecting Router Hardware

In Table 1-1, select the router category that applies to each description.

Table 1-1 Identify Router Category Features

Router Description	Branch Routers	Network Edge Routers	Service Provider Routers
Fast performance with high security for data centers, campus, and branch networks			
Simple network configuration and management for LANs and WANs			
Optimizes services on a single platform			
End-to-end delivery of subscriber services			
Delivers next-generation Internet experiences across all devices and locations			
High capacity and scalability with hierarchical quality of service			
Maximizes local services and ensures 24/7/365 uptime			
Unites campus, data center, and branch networks			

Managing Devices

A basic router or switch configuration includes the hostname for identification, passwords for security, and assignment of IP addresses to interfaces for connectivity and management. A router configuration also includes basic routing.

In addition to configuration commands, router and switch verification commands are used to verify the operational status of the router or switch and related network functionality. Use the address scheme in Table 1-2 in the following exercises that review the most common router and switch configuration and verification commands.

Table 1-2 Router and Switch Addressing Table

Device	Interface	IPv4 Address	Subnet Mask	Default Gateway
R1	G0/0	192.168.1.1	255.255.255.0	N/A
	S0/0/0	172.16.3.1	255.255.255.252	N/A
	S0/0/1	192.168.10.5	255.255.255.252	N/A
S1	VLAN 1	192.168.1.5	255.255.255.0	192.168.1.1

Basic Router Configuration Review

Using Table 1-2 and the following requirements, record the commands, including the router prompt, to implement a basic router configuration:

- Hostname is **R1**.
- Console and Telnet line's password is **cisco**.
- Privileged EXEC password is **class**.
- Banner message-of-the-day.
- Interface addressing.
- RIPv2 routing.
- Save the configuration.

```
Router(config)# _____
```

Basic Router Verification Review

In Table 1-3, record the verification command that will generate the described output.

Table 1-3 Router Verification Commands

Command	Command Output
	Displays the routing table for known networks, including administrative distance, metric, and outbound interface
	Displays information about routing protocols, including process ID, router ID, and neighbors
	Displays information about directly connected Cisco devices
	Displays all interfaces in an abbreviated format, including IP address and status
	Displays one or all interfaces, including status, bandwidth, and duplex type

Basic Switch Configuration Review

Using Table 1-2 and the following requirements, record the commands, including the switch prompt, to implement a basic switch configuration:

- Hostname is **S1**.
- Console and Telnet line's password is **cisco**.

- Privileged EXEC password is **class**.
- Banner message-of-the-day.
- VLAN 1 interface addressing.
- Save the configuration.

```
Switch(config)# _____
```

Basic Switch Verification Review

In Table 1-4, record the verification command that will generate the described output.

Table 1-4 Switch Verification Commands

Command	Command Output
	Displays information about directly connected Cisco devices
	Displays all secure MAC addresses
	Displays a table of learned MAC addresses, including the port number and VLAN assigned to the port
	Displays one or all interfaces, including status, bandwidth, and duplex type
	Displays information about maximum MAC addresses allowed, current counts, security violation count, and action to be taken

Packet Tracer Activity

Packet Tracer Exercise 1-1: Basic Device Configuration

Now you are ready to use Packet Tracer to apply your documented configuration. Download and open the file LSG03-0101.pka found at the companion website for this book. Refer to the Introduction of this book for specifics on accessing files.

Note: The following instructions are also contained within the Packet Tracer Exercise.

In this Packet Tracer activity, you will configure a router and a switch with basic settings and verify connectivity. Use the commands you documented in the section "Managing Devices." You will then verify that other routers can ping PC1.

Requirements

Configure the routers with the following settings:

- Name the router **R1** and the switch **S1**.
- The privileged EXEC password is **class**.
- The line password is **cisco**.
- All plaintext passwords should be encrypted.
- Users must login to the console and vty lines.
- The message-of-the-day is **Authorized Access Only!**
- Configure and activate all interfaces according to Table 1-2.
- Save the configurations.
- Verify connectivity from R2 and R3 to PC1.

Your completion percentage should be 100%. All the connectivity tests should show a status of "successful." If not, click **Check Results** to see which required components are not yet completed.

Labs and Activities

Command Reference

In Table 1-5, record the command, including the correct router or switch prompt, that fits the description. Fill in any blanks with the appropriate missing information.

Table 1-5 Commands for Chapter 1, LAN Design

Command	Description
	Enter privileged EXEC mode.
	Exit privileged EXEC mode.
	Enter global configuration mode.
	Configure R1 as the hostname for the router.
	Enter line configuration mode for the console.
	Configure the console password to be "cisco123".
	Require a password for user EXEC mode.
	Configure "Authorized Access Only" as the message of the day. Use $ as the delimiting character.
	Enter interface configuration mode for g0/0.
	Configure the IPv4 address 172.16.1.1 255.255.255.0 on interface g0/0.
	Activate the interface.
	Enter router configuration mode for RIP.
	Configure RIP version 2.
	Configure RIP to advertise 172.16.0.0.
	On switch S1, enter interface configuration mode for VLAN 1.
	Configure interface VLAN 1 with the IP address 172.16.1.5/24.
	Configure S1 with the default gateway address 172.16.1.1.

1.0.1.2 Class Activity–Network by Design

Objective

Explain the need to design a hierarchical network that is scalable.

Scenario

Your employer is opening a new branch office.

You have been reassigned to the site as the network administrator where your job will be to design and maintain the new branch network.

The network administrators at the other branches used the Cisco, three-layer, hierarchical approach when designing their networks. You decide to use the same approach.

To get an idea of what using the hierarchical model can do to enhance the design process, you research the topic.

Resources

- Internet access
- Word processing software

Directions

Step 1. Use the Internet to find information and take notes about the Cisco, three-layered hierarchical model. The site should include information about the:

- **a.** Access layer
- **b.** Distribution layer
- **c.** Core layer

Step 2. In your research, make sure to include:

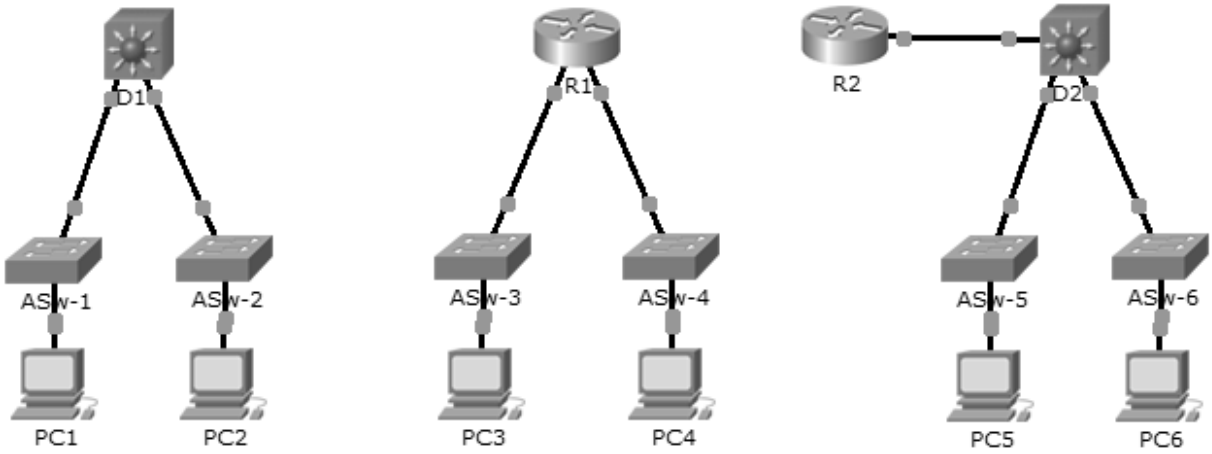
- **a.** A simple definition of each hierarchical layer
- **b.** Three concise facts about each layer
- **c.** Network device capabilities needed at each layer
- **d.** A detailed graphic that shows a full, three-layer hierarchical model design

Step 3. Create a simple table to organize and share your research with another student, group, the class, or instructor.

Packet Tracer
Activity

1.2.1.7 Packet Tracer–Compare 2960 and 3560 Switches

Topology



Objective

Part 1: Compare Layer 2 and Layer 3 Switches

Part 2: Compare a Layer 3 Switch and a Router

Background

In this activity, you will use various commands to examine three different switching topologies and compare the similarities and differences between the 2960 and 3560 switches. You will also compare the routing table of a 1941 router with a 3560 switch.

Part 1: Compare Layer 2 and Layer 3 Switches

a. Examine the physical aspects of **D1** and **ASw-1**.

Each individual switch has how many physical interfaces? _____

How many Fast Ethernet and Gigabit Ethernet interfaces does each switch have?

_____

List the transmission speed of the Fast Ethernet and Gigabit Ethernet interfaces on each switch.

_____

Are either of the two switches modular in design? _____

b. The interface of a 3560 switch can be configured as a Layer 3 interface by entering the **no switchport** command in interface configuration mode. This allows technicians to assign an IP address and subnet mask to the interface the same way it is configured on a router's interface.

What is the difference between a Layer 2 switch and a Layer 3 switch?

_____

_____

_____

What is the difference between a switch's physical interface and the VLAN interface?

_____

_____

_____

On which layers do 2960 and 3560 switches operate?

_____

Issue the **show run** command to examine the configurations of the **D1** and **ASw-1** switches. Do you notice any differences between them?

_____

_____

Display the routing table on both switches using the **show ip route** command. Why do you think the command does not work on **ASW-1**, but works on **D1**?

_____

_____

_____

Part 2: Compare a Layer 3 Switch and a Router

a. Up until recently, switches and routers have been separate and distinct devices. The term switch was set aside for hardware devices that function at Layer 2. Routers, on the other hand, are devices that make forwarding decisions based on Layer 3 information. They use routing protocols to share routing information and to communicate with other routers. Layer 3 switches, such as the 3560, can be configured to forward Layer 3 packets. Entering the **ip routing** command in global configuration mode allows Layer 3 switches to be configured with routing protocols, thereby possessing some of the same capabilities as a router. Although similar in some forms, switches are different in many other aspects.

Open the Physical tab on D1 and R1. Do you notice any similarities between the two? Do you notice any differences between the two?

_____

_____

_____

Issue the **show run** command and examine the configurations of R1 and D1. What differences do you see between the two?

Which command allows D1 to configure an IP address on one of its physical interfaces?

Use the **show ip route** command on both devices. Do you see any similarities or differences between the two tables?

Now, analyze the routing table of R2 and D2. What is evident now that was not in the configuration of R1 and D1?

b. Verify that each topology has full connectivity by completing the following tests.

- Ping from **PC1** to **PC2**
- Ping from **PC3** to **PC4**
- Ping from **PC5** to **PC6**

In all three examples, each PC is on a different network. Which device is used to provide communication between networks?

Why were we able to ping across networks without there being a router?

Suggested Scoring Rubric

Activity Section	Question Location	Possible Points	Earned Points
Part 1: Compare Layer 2 and Layer 3 Switches	a	20	
	b	40	
	Part 1 Total	**60**	
Part 2: Compare a Layer 3 Switch and a Router	a	30	
	b	10	
	Part 2 Total	**40**	
	Total Score	**100**	

1.3.1.1 Class Activity–Layered Network Design Simulation

Objectives

Explain the need to design a hierarchical network that is scalable.

Scenario

As the network administrator for a very small network, you want to prepare a simulated-network presentation for your branch manager to explain how the network currently operates.

The small network includes the following equipment:

- One Cisco 2911 series router
- One Cisco 3560 switch
- One Cisco 2960 switch
- Four user workstations (PCs or laptops)
- One printer

Resources

- Packet Tracer software

Directions

Step 1. Create a simple network topology using Packet Tracer software. Place the devices at the appropriate levels of the Cisco three-layer hierarchical model design, including:

a. One Cisco 2911 series router

b. One Cisco 3560 switch

c. One Cisco 2960 switch

d. Four user workstations (PCs or laptops)

e. One printer

Step 2. Using Packet Tracer's drawing tool, indicate the hierarchical layers with different color coding and labels:

a. Access layer

b. Distribution layer

c. Core layer

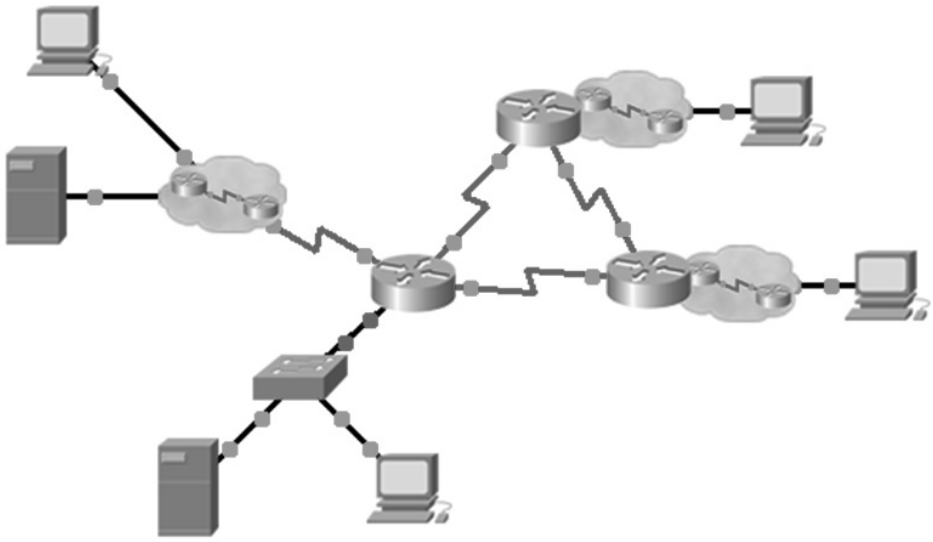
Step 3. Configure the network and user devices. Check for end-to-end connectivity.

Step 4. Share your configuration and hierarchical network design Packet Tracer file with another student, group, the class, or the instructor.

Packet Tracer
Activity

1.3.1.3 Packet Tracer–Skills Integration Challenge

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
[[R1Name]]	G0/0.15	[[R1G0sub15Add]]	[[R1G0sub15SM]]	N/A
	G0/0.30	[[R1G0sub30Add]]	[[R1G0sub30SM]]	N/A
	G0/0.45	[[R1G0sub45Add]]	[[R1G0sub45SM]]	N/A
	G0/0.60	[[R1G0sub60Add]]	[[R1G0sub60SM]]	N/A
	S0/0/0	[[R1S000Add]]	255.255.255.252	N/A
	S0/0/1	[[R1S001Add]]	255.255.255.252	N/A
	S0/1/0	[[R1S010Add]]	255.255.255.252	N/A
[[R2Name]]	G0/0	[[R2G00Add]]	[[R2R3LanSM]]	N/A
	S0/0/0	[[R2S000Add]]	255.255.255.252	N/A
	S0/0/1	[[R2S001Add]]	255.255.255.252	N/A
[[R3Name]]	G0/0	[[R3G00Add]]	[[R2R3LanSM]]	N/A
	S0/0/0	[[R3S000Add]]	255.255.255.252	N/A
	S0/0/1	[[R3S001Add]]	255.255.255.252	N/A
[[S1Name]]	VLAN 60	[[S1VLAN60Add]]		
[[PC1Name]]	NIC	DHCP Assigned	DHCP Assigned	DHCP Assigned

VLANs and Port Assignments Table

VLAN Number - Name	Port assignment	Network
15 - Servers	F0/11 - F0/20	
30 - PCs	F0/1 - F0/10	
45 - Native	G0/1	
60 - Management	VLAN 60	

Scenario

This activity includes many of the skills that you have acquired during your CCNA studies. First, you will complete the documentation for the network. Make sure you have a printed version of the instructions. During implementation, you will configure VLANs, trunking, port security, and SSH remote access on a switch. Then, you will implement inter-VLAN routing and NAT on a router. Finally, you will use your documentation to verify your implementation by testing end-to-end connectivity.

Documentation

You are required to fully document the network. You will need a print out of this instruction set, which will include an unlabeled topology diagram:

- Label all the device names, network addresses, and other important information that Packet Tracer generated.
- Complete the Addressing Table and VLANs and Port Assignments Table.
- Fill in any blanks in the **Implementation** and **Verification** steps. The information is supplied when you launch the Packet Tracer activity.

Implementation

Note: All devices in the topology except [[R1Name]], [[S1Name]], and [[PC1Name]] are fully configured. You do not have access to the other routers. You can access all the servers and PCs for testing purposes.

Implement the following requirements using your documentation:

[[S1Name]]

- Configure remote management access including IP addressing and SSH:
  - Domain is cisco.com
  - Enable secret ciscoenpass
  - User **[[UserText]]** with password **[[UserPass]]**
  - Crypto key length of 1024
  - SSH version 2, limited to 2 authentication attempts and a 60 second timeout
  - Plaintext passwords should be encrypted.
- Configure, name, and assign VLANs. Ports should be manually configured as access ports.
- Configure trunking.

- Implement port security:
  - On F0/1, allow 2 MAC addresses that are automatically added to the configuration file when detected. The port should not be disabled, but a syslog message should be captured if a violation occurs.
  - Disable all other unused ports.

[[R1Name]]

- Configure inter-VLAN routing.
- Configure DHCP services for VLAN 30. Use **LAN** as the case-sensitive name for the pool.
- Implement routing:
  - Use RIPv2.
  - Configure one network statement for the entire **[[DisplayNet]]** address space.
  - Disable interfaces that should not send RIPv2 messages.
  - Configure a default route to the Internet.
- Implement NAT:
  - Configure a standard, one statement ACL number 1. All IP addresses belonging to the **[[DisplayNet]]** address space are allowed.
  - Refer to your documentation and configure static NAT for the File Server.
  - Configure dynamic NAT with PAT using a pool name of your choice, a /30 mask, and these two public addresses:

    [[NATPoolText]]

    [[PC1Name]]
- Verify **[[PC1Name]]** has received full addressing information from **[[R1Name]]**.

Verification

All devices should now be able to ping all other devices. If not, troubleshoot your configurations to isolate and solve problems. A few tests include:

- Verify remote access to **[[S1Name]]** by using SSH from a PC.
- Verify VLANs are assigned to appropriate ports and port security is in force.
- Verify a complete routing table.
- Verify NAT translations and statistics.
  - **Outside Host** should be able to access **File Server** at the public address.
  - Inside PCs should be able to access **Web Server**.
- Document any problems you encountered and the solutions in the **Troubleshooting Documentation** table below.

Troubleshooting Documentation

Problem	Solution

Suggested Scoring Rubric

Packet Tracer scores 75 points. Documentation is worth 25 points.

CHAPTER 2

Scaling VLANs

Several tools allow you to scale your VLANs. VLAN Trunking Protocol (VTP) reduces administration in a switched network. Using an extended VLAN range you can increase the number of VLANs you can configure. The Dynamic Trunking Protocol (DTP) provides the capability for ports to automatically negotiate trunking between switches. Layer 3 switches allow you to consolidate Layer 2 switch and Layer 3 router functionality in one device. This chapter reviews VTP, extended VLANs, DTP, and Layer 3 switching. It also describes issues encountered when implementing VTP, DTP, and inter-VLAN routing.

Study Guide

VTP, Extended VLANs, and DTP

VTP, extended VLANs, and DTP are tools you can use to scale your network.

VTP Concepts and Operation

As the number of switches increases on a small or medium-sized business network, the overall administration required to manage VLANs and trunks in a network becomes a challenge. Cisco engineers invented the VLAN Trunking Protocol (VTP), a technology that helps network administrators automate some of the tasks related to VLAN creation, deletion, and synchronization.

Match the definition on the left with a term on the right. All definitions and terms are used exactly one time.

Definition

___ Switches share VLAN information; boundary is defined by a Layer 3 device.

___ Can only create, delete, and modify local VLANs.

___ Advertises VLAN configuration information; can create, delete, and modify VLANs.

___ By default, this is disabled.

___ Stores VLAN information only in RAM.

___ Carries VLAN configuration information.

Terms

a. VTP advertisements

b. VTP client

c. VTP domain

d. VTP pruning

e. VTP server

f. VTP transparent

VTP Modes

Finish Table 2-1 by first indicating the VTP mode and then answering Yes or No for each of the features listed.

Table 2-1 VTP Mode Comparisons

Feature	_____ Mode	_____ Mode	_____ Mode
Source VTP messages			
Listen to VTP messages			
Create VLANs	Yes	No	Yes*
Remember VLANs			

*Locally significant only

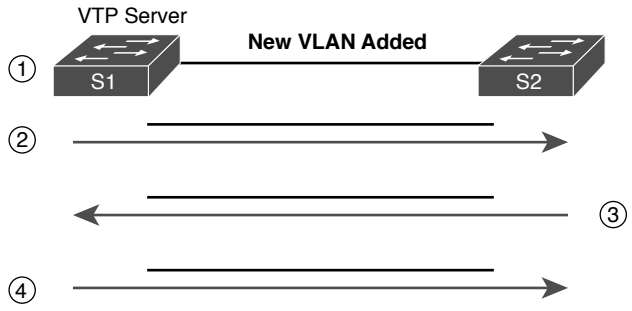
VTP Advertisements

Refer to Figure 2-1. When a network administrator adds a new VLAN in a VTP domain, the following process takes place:

1. The new VLAN is added to the VTP server S1.
2. S1 informs other switches in the same VTP domain that the revision number has changed.
3. S2 has a lower revision number, so it asks for more information.
4. S1 replies with the changes to the VLAN database.

In Figure 2-1, label the correct name for these VTP advertisements.

Figure 2-1 VTP Advertisements



Default VTP Configuration

Fill in the default VTP settings for a Cisco 2960 switch.

- VTP Version: _____
- VTP Domain Name: _____
- VTP Pruning Mode: _____
- VTP Traps Generation: _____
- VTP Mode: _____
- Configuration Revision Number: _____

VTP Caveats

Assuming a new switch was configured with the correct domain name, what would happen if you added a VTP client or server switch with a higher configuration revision number to the network?

_____

_____

_____

_____

_____

_____

List two ways to reset the configuration revision number on a switch.

_____

_____

VTP Configuration

VTP configuration is straightforward, so this exercise uses a rather large topology, shown in Figure 2-2, to give you extra practice. Table 2-2 shows the addressing scheme used for this exercise.

Figure 2-2 VTP Configuration Topology

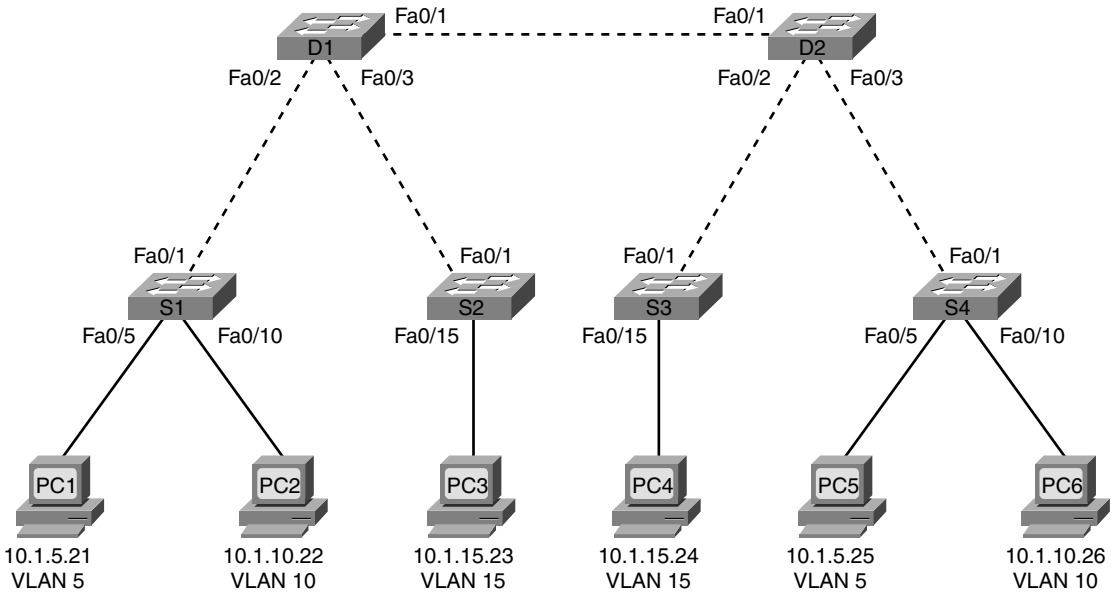


Table 2-2 Addressing Table for VTP Configuration Exercise

Device	Interface	IP Address	Subnet Mask	Default Gateway
D1	VLAN 99	10.1.1.1	255.255.255.0	N/A
D2	VLAN 99	10.1.1.2	255.255.255.0	N/A
S1	VLAN 99	10.1.1.11	255.255.255.0	N/A
S2	VLAN 99	10.1.1.12	255.255.255.0	N/A
S3	VLAN 99	10.1.1.13	255.255.255.0	N/A
S4	VLAN 99	10.1.1.14	255.255.255.0	N/A
PC1	NIC	10.1.5.21	255.255.255.0	10.1.5.1
PC2	NIC	10.1.10.22	255.255.255.0	10.1.10.1
PC3	NIC	10.1.15.23	255.255.255.0	10.1.15.1
PC4	NIC	10.1.15.24	255.255.255.0	10.1.15.1
PC5	NIC	10.1.5.25	255.255.255.0	10.1.5.1
PC6	NIC	10.1.10.26	255.255.255.0	10.1.10.1

Specifications for configuring VLANs and VTP are as follows:

- **D1** is responsible for sending VLAN configuration information to all other switches.
- The other switches are clients.
- The domain is **CCNA**.
- The password is **cisco**.
- The VLANs are as follows:
  - VLAN 5: Engineering
  - VLAN 10: Sales
  - VLAN 15: Administration
  - VLAN 99: Management

Enter the commands, including the switch prompt, to configure D1 as the VTP server:

Enter the commands, including the switch prompt, to configure the remaining switches as VTP clients. You need to list the commands only once.

What command displays the following output? Also, indicate which switch this output is from.

```
VTP Version                     : 2
Configuration Revision          : 8
Maximum VLANs supported locally : 64
Number of existing VLANs        : 9
VTP Operating Mode              : Server
VTP Domain Name                 : CCNA
VTP Pruning Mode                : Disabled
VTP V2 Mode                     : Disabled
```

```
VTP Traps Generation            : Disabled
MD5 digest                      : 0xA0 0xA3 0xB8 0xC9 0x49 0xE2 0x44 0xA6
Configuration last modified by 0.0.0.0 at 3-1-93 00:12:32
Local updater ID is 10.1.1.1 on interface Vl99 (lowest numbered VLAN interface found)
```

You need to configure another switch for the CCNA domain and you forgot the VTP password. How would you find out what the password is?

_____

_____

_____

_____

Packet Tracer ☐ Activity

Packet Tracer Exercise 2-1: VTP Configuration

Now you are ready to use Packet Tracer to apply your documented configuration. Download and open the file LSG03-0201.pka found at the companion website for this book. Refer to the Introduction of this book for specifics on accessing files.

Note: The following instructions are also contained within the Packet Tracer Exercise.

In this Packet Tracer activity, you will configure a router and a switch with basic settings and verify connectivity. Use the commands you documented in the section "VTP Configuration." You will then verify that switches can ping each other and PCs in the same VLAN can ping each other.

Requirements

Configure the switches with the following settings:

- Configure VTP on the switches.
- Configure VLANs on the VTP server.
- Configure trunking between the switches. Assign VLAN 99 as the native VLAN.
- After the network converges, use **show vtp status** and **show vlan brief** to verify that:
  - D1 is the VTP server.
  - The remaining switches are VTP clients.
  - The remaining switches have all VLANs from D1.
- Configure access ports and assign VLANs for the PCs.
- All switches should now be able to ping each other. PCs belonging to the same VLAN should be able to ping each other.

Your completion percentage should be 100%. All the connectivity tests should show a status of "successful." If not, click **Check Results** to see which required components are not yet completed.

Extended VLANs

In Table 2-3, indicate whether the characteristic applies to normal range VLANs or extended range VLANs.

Table 2-3 Characteristics of VLAN Ranges

Characteristic	Normal Range VLANs	Extended Range VLANs
Used by service providers and large organizations.		
Configurations are stored within the vlan.dat file.		
Support fewer VLAN features than the other range.		
Used in small and medium-sized business and enterprise networks.		
Configurations are saved in the running configuration file.		
Identified by VLAN IDs between 1 and 1005.		
Identified by a VLAN ID between 1006 and 4094.		

DTP

DTP is a Cisco proprietary protocol that negotiates both the status of trunk ports and the trunk encapsulation of trunk ports. To enable trunking from a Cisco switch to a device that does not support DTP, use the _____ and _____ interface configuration mode commands. This causes the interface to become a trunk, but not generate DTP frames.

A switch port on a Cisco Catalyst switch supports a number of trunking modes. Identify the commands used to configure the trunking mode:

- _____: Puts the interface into permanent nontrunking mode and negotiates to convert the link into a nontrunk link.
- _____: Puts the interface into permanent trunking mode and negotiates to convert the neighboring link into a trunk link. The interface becomes a trunk interface even if the neighboring interface is not a trunk interface.
- _____: Makes the interface actively attempt to convert the link to a trunk link. The interface becomes a trunk interface if the neighboring interface is set to _____, _____, or _____ mode. This is the default switchport mode on older switches, such as the Catalyst 2950 and 3550 series switches.
- _____: Prevents the interface from generating DTP frames. You can use this command only when the interface switchport mode is **access** or **trunk**. You must manually configure the neighboring interface as a trunk interface to establish a trunk link.
- _____: Enables the interface to convert the link to a trunk link. The interface becomes a trunk interface if the neighboring interface is set to _____ or _____. This is the default switchport mode for all Ethernet interfaces.

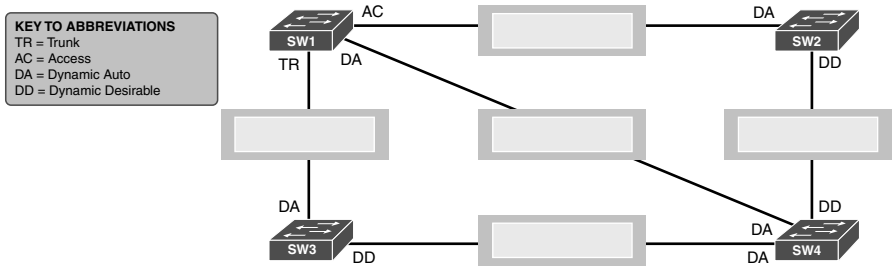
In Table 2-4, the arguments for the **switchport mode** command are listed for the local side of the link down the first column and for the remote side of the link across the first row. Indicate whether the link will transition to access mode or trunk mode after the two switches have sent DTP messages.

Table 2-4 Trunk Negotiation Combinations

	Dynamic Auto	Dynamic Desirable	Trunk	Access
Dynamic auto				
Dynamic desirable				
Trunk				Limited Connectivity
Access			Limited Connectivity	

In Figure 2-3, indicate which DTP combinations between two switches will become trunk links and which will become access links.

Figure 2-3 Predict DTP Behavior



Troubleshoot Multi-VLAN Issues

As you know, the **ping** and **tracert/traceroute** can be helpful in isolating the general location of a connectivity problem. But to further isolate an inter-VLAN routing issue, you might need several additional commands.

In Examples 2-1 and 2-2, fill in the command used to generate the output. Highlight relevant parts of the output that would help in isolating inter-VLAN routing issues. Then document the error and possible solution.

Example 2-1 Inter-VLAN Troubleshooting Scenario 1

```
Switch# _____________________
Name: Gi0/23
Switchport: Enabled
Administrative Mode: dynamic auto
Operational Mode: static access
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: native
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
(output omitted)
```

What error or errors do you see in Example 2-1?

_____

What solution would you recommend?

_____

_____

_____

Example 2-2 Inter-VLAN Troubleshooting Scenario 2

```
_____

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
GigabitEthernet0/0.10      172.17.10.1     YES manual up                    up
GigabitEthernet0/0.30      172.17.30.1     YES manual up                    up
GigabitEthernet0/1         unassigned      YES unset  administratively down down
Serial0/0/0                unassigned      YES unset  administratively down down
Serial0/0/1                unassigned      YES unset  administratively down down
```

What error or errors do you see in Example 2-2?

_____

What solution would you recommend?

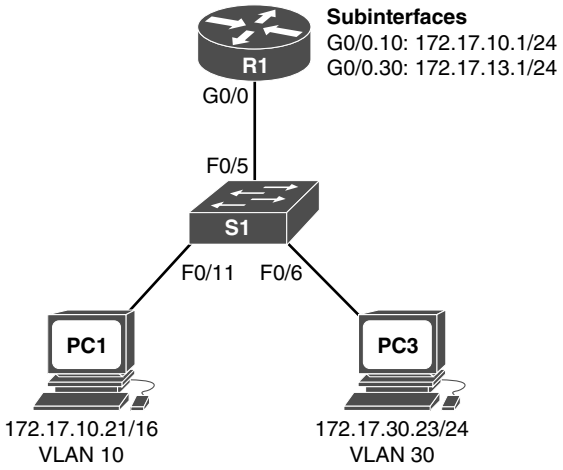
_____

_____

_____

Refer to the topology in Figure 2-4.

Figure 2-4 Inter-VLAN Troubleshooting Scenario 3



What error or errors do you see?

_____

_____

What solution would you recommend?

_____

_____

Layer 3 Switching

Router-on-a-stick is simple to implement because routers are usually available in every network. But most enterprise networks use multilayer switches to achieve high-packet processing rates using hardware-based switching.

Layer 3 Switching Operation

All Catalyst multilayer switches support the following types of Layer 3 interfaces:

- _____: A pure Layer 3 interface similar to a physical interface on a Cisco IOS router.
- _____ **(SVI):** A virtual VLAN interface for inter-VLAN routing. In other words, SVIs are the virtual-routed VLAN interfaces.

What kind of switch forwarding do high-performance Catalyst switches use?

_____

What are some reasons and advantages for configuring SVIs?

_____

_____

_____

_____

_____

_____

_____

What is the purpose of the **no switchport** command?

_____

What are two advantages of using a multilayer switch port?

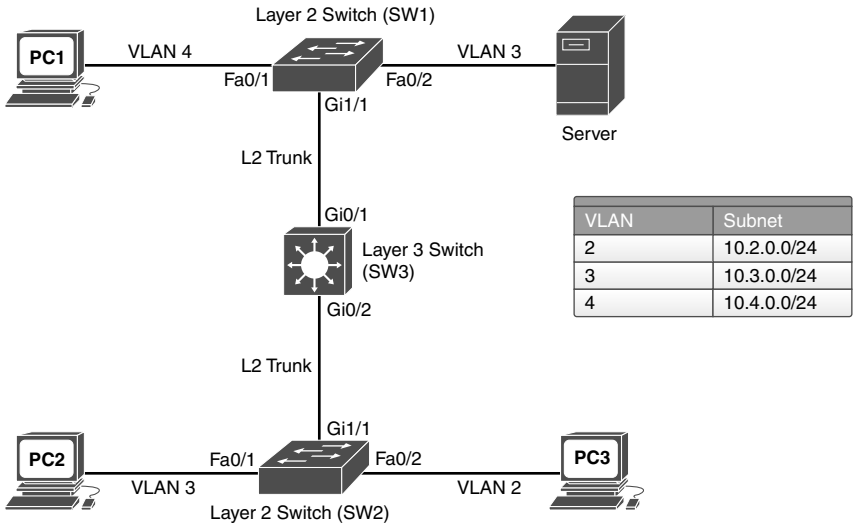
_____

_____

Layer 3 Switching Troubleshooting Scenarios

Use Figure 2-5 for each of the following Layer 3 switching troubleshooting scenarios.

Figure 2-5 Layer 3 Switching Troubleshooting Topology



PC2 is unable to communicate with PC3 but can communicate with all other devices. Refer to the command output in Example 2-3. Then select the most likely causes for this issue. More than one answer choice may be selected.

Example 2-3 Layer 3 Switching Troubleshooting Scenario 1

```
SW3# show ip route
<output omitted>
Gateway of last resort is not set
     10.0.0.0/8 is variably subnetted, 3 subnets, 3 masks
C       10.2.0.0/24 is directly connected, Vlan5
C       10.3.0.0/24 is directly connected, Vlan3
C       10.4.0.0/24 is directly connected, Vlan4
```

VLAN 5 IP address is not correct.
VLAN 4 has no IP address.
VLAN 3 IP address is not correct.
VLAN 2 is not configured.
VLAN 3 and 4 are shut down.

PC3 is unable to communicate with any of the other devices, including its own gateway. Refer to the command output in Example 2-4. Then select the most likely causes for this issue. More than one answer choice may be selected.

Example 2-4 Layer 3 Switching Troubleshooting Scenario 2

```
SW3# show ip route
<output omitted>
Gateway of last resort is not set
     10.0.0.0/8 is variably subnetted, 3 subnets, 3 masks
C       10.2.0.0/30 is directly connected, Vlan2
C       10.3.0.0/24 is directly connected, Vlan3
C       10.4.0.0/24 is directly connected, Vlan4
```

- VLAN 4 subnet mask is not correct.
- VLAN 4 IP address is not correct.
- VLAN 2 subnet mask is not correct.
- VLAN 2 is not configured.
- VLAN 3 IP address is not correct.

PC1 is unable to communicate with PC2 or PC3 but can communicate with the server. Refer to the command output in Example 2-5. Then select the most likely causes for this issue. More than one answer choice may be selected.

Example 2-5 Layer 3 Switching Troubleshooting Scenario 3

```
SW3# show interface trunk
Port        Mode         Encapsulation      Status       Native vlan
Gig0/1      auto         n-802.1q           trunking     1
```

- VLAN 2 and 3 are being pruned from the trunk links.
- SW2 is shut down.
- The trunk encapsulation is not correct.
- The gigabit 0/2 port is not configured as a trunk.
- The gigabit 0/1 port is not configured as a trunk.
- VLAN 2 is not configured.

Labs and Activities

Command Reference

In Table 2-5, record the command, including the correct router or switch prompt, that fits the description. Fill in any blanks with the appropriate missing information.

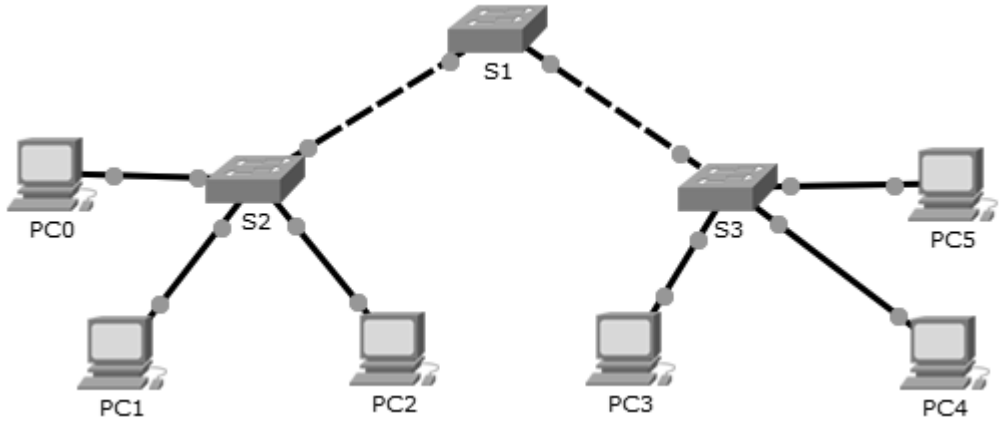
Table 2-5 Commands for Chapter 2, Scaling VLANs

Command	Description
	Configure S1 as the VTP server.
	Configure S2 as a VTP client.
	Configure S3 for local VLANs and to ignore VTP advertisements.
	Configure CCNA as the VTP domain.
	Configure cisco as the VTP password.
	Verify that S1 is the VTP server.
	Display the VTP password.
	Configure an interface into a permanent nontrunking mode.
	Configure an interface into a permanent trunking mode.
	Configure an interface to actively attempt to convert the link to a trunk.
	Configure an interface to convert to a trunk if the other side of the link is set to trunk or desirable.
	Disable DTP on an interface.

Packet Tracer Activity

2.1.4.4 Packet Tracer–Configure VLANs, VTP, and DTP

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask
PC0	NIC	192.168.10.1	255.255.255.0
PC1	NIC	192.168.20.1	255.255.255.0
PC2	NIC	192.168.30.1	255.255.255.0
PC3	NIC	192.168.30.2	255.255.255.0
PC4	NIC	192.168.20.2	255.255.255.0
PC5	NIC	192.168.10.2	255.255.255.0
S1	VLAN 99	192.168.99.1	255.255.255.0
S2	VLAN 99	192.168.99.2	255.255.255.0
S3	VLAN 99	192.168.99.3	255.255.255.0

Objectives

Part 1: Configure and Verify DTP

Part 2: Configure and Verify VTP

Background/Scenario

As the number of switches in a network increases, the administration necessary to manage the VLANs and trunks can be challenging. To ease some of the VLAN and trunking configurations, VLAN trunking protocol (VTP) allows a network administration to automate the management of VLANs. Trunk negotiation between network devices is managed by the Dynamic Trunking Protocol (DTP), and is automatically enabled on Catalyst 2960 and Catalyst 3560 switches.

In this activity, you will configure trunk links between the switches. You will configure a VTP server and VTP clients in the same VTP domain. You will also observe the VTP behavior when a switch is in

VTP transparent mode. You will assign ports to VLANs and verify end-to-end connectivity with the same VLAN.

Part 1: Configure and Verify DTP

In Part 1, you will configure trunk links among the switches, and you will configure VLAN 999 as the native VLAN.

Step 1. Verify VLAN configuration.

Verify the configured VLANs on the switches.

a. On S1, click the **CLI** tab. At the prompt, enter **enable** and enter the **show vlan brief** command to verify the configured VLANs on S1.

```
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, 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
                                                 Gig0/1, Gig0/2
99   Management                        active
999  VLAN0999                          active
1002 fddi-default                      active
1003 token-ring-default                active
1004 fddinet-default                   active
1005 trnet-default                     active
```

b. Repeat step a. on S2 and S3. What VLANs are configured on the switches?

_____

Step 2. Configure Trunks on S1, S2, and S3.

Dynamic trunking protocol (DTP) manages the trunk links between Cisco switches. Currently all the switch ports are in the default trunking mode, which is dynamic auto. In this step, you will change the trunking mode to dynamic desirable for the link between switches S1 and S2. For the link between switches S1 and S3, the link will be set as a static trunk. Use VLAN 999 as the native VLAN in this topology.

a. On S1, configure the trunk link to dynamic desirable on the GigabitEthernet 0/1 interface.

```
S1(config)# interface g0/1
S1(config-if)# switchport mode dynamic desirable
```

b. For the trunk link between S1 and S3, configure a static trunk link on the GigabitEthernet 0/2 interface.

```
S1(config)# interface g0/2
S1(config-if)# switchport mode trunk
S3(config)# interface g0/2
S3(config-if)# switchport mode trunk
```

c. Verify trunking is enabled on all the switches using the **show interfaces trunk** command.

```
S1# show interfaces trunk
Port        Mode         Encapsulation  Status        Native vlan
Gig0/1      desirable    n-802.1q       trunking      1
Gig0/2      on           802.1q         trunking      1

Port        Vlans allowed on trunk
Gig0/1      1-1005
Gig0/2      1-1005

Port        Vlans allowed and active in management domain
Gig0/1      1,99,999
Gig0/2      1,99,999

Port        Vlans in spanning tree forwarding state and not pruned
Gig0/1      none
Gig0/2      none
```

What is the native VLAN for these trunks currently? _____

d. Configure VLAN 999 as the native VLAN for the trunk links on S1.

```
S1(config)# interface range g0/1 - 2
S1(config-if-range)# switchport trunk native vlan 999
```

What messages did you receive on S1? How would you correct them?

_____

_____

_____

_____

_____

_____

e. On S2 and S3, configure VLAN 999 as the native VLAN.

f. Verify trunking is successfully configured on all the switches. You should be able to ping one switch from another switch in the topology using the IP addresses configured on the SVI.

Part 2: Configure and Verify VTP

S1 will be configured as the VTP server and S2 will be configured as VTP clients. All the switches will be configured to be in the VTP domain **CCNA** and use the VTP password **cisco**.

VLANs can be created on the VTP server and distributed to other switches in the VTP domain. In this part, you will create three new VLANs on the VTP server, S1. These VLANs will be distributed to S2 using VTP. Observe how the transparent VTP mode behaves.

Step 1. Configure S1 as the VTP server.

Configure S1 as the VTP server in the **CCNA** domain with the password **cisco**.

a. Configure S1 as a VTP server.

```
S1(config)# vtp mode server
Setting device to VTP SERVER mode.
```

b. Configure **CCNA** as the VTP domain name.

```
S1(config)# vtp domain CCNA
Changing VTP domain name from NULL to CCNA
```

c. Configure **cisco** as the VTP password.

```
S1(config)# vtp password cisco
Setting device VLAN database password to cisco
```

Step 2. Verify VTP on S1.

a. Use the **show vtp status** command on the switches to confirm that the VTP mode and domain are configured correctly.

```
S1# show vtp status
VTP Version                     : 2
Configuration Revision          : 0
Maximum VLANs supported locally : 255
Number of existing VLANs        : 7
VTP Operating Mode              : Server
VTP Domain Name                 : CCNA
VTP Pruning Mode                : Disabled
VTP V2 Mode                     : Disabled
VTP Traps Generation            : Disabled
MD5 digest                      : 0x8C 0x29 0x40 0xDD 0x7F 0x7A 0x63 0x17
Configuration last modified by 0.0.0.0 at 0-0-00 00:00:00
Local updater ID is 192.168.99.1 on interface Vl99 (lowest numbered VLAN inter-
face found)
```

b. To verify the VTP password, use the **show vtp password** command.

```
S1# show vtp password
VTP Password: cisco
```

Step 3. Add S2 and S3 to the VTP domain.

Before S2 and S3 will accept VTP advertisements from S1, they must belong to the same VTP domain. Configure S2 and S3 as VTP clients with **CCNA** as the VTP domain name and **cisco** as the VTP password. Remember that VTP domain names are case sensitive.

a. Configure S2 as a VTP client in the **CCNA** VTP domain with the VTP password **cisco**.

```
S2(config)# vtp mode client
Setting device to VTP CLIENT mode.
S2(config)# vtp domain CCNA
Changing VTP domain name from NULL to CCNA
S2(config)# vtp password cisco
Setting device VLAN database password to cisco
```

b. To verify the VTP password, use the **show vtp password** command.

```
S2# show vtp password
VTP Password: cisco
```

c. Configure S3 to be in the **CCNA** VTP domain with the VTP password **cisco**. Switch S3 will stay in VTP transparent mode.

```
S3(config)# vtp domain CCNA
Changing VTP domain name from NULL to CCNA
S3(config)# vtp password cisco
Setting device VLAN database password to cisco
```

d. Enter **show vtp status** command on all the switches to answer the following question.

Notice that the configuration revision number is 0 on all three switches. Explain.

_____

_____

_____

Step 4. Create more VLANs on S1.

a. On S1, create VLAN 10 and name it Red.

```
S1(config)# vlan 10
S1(config-vlan)# name Red
```

b. Create VLANs 20 and 30 according to the table below.

VLAN Number	VLAN Name
10	Red
20	Blue
30	Yellow

Verify the addition of the new VLANs. Enter **show vlan brief** at the privileged EXEC mode.

Which VLANs are configured on S1?

_____

c. Confirm configuration changes using the **show vtp status** command on S1 and S2 to confirm that the VTP mode and domain are configured correctly. Output for S2 is shown here.

```
S2# show vtp status
VTP Version                     : 2
Configuration Revision          : 6
Maximum VLANs supported locally : 255
Number of existing VLANs        : 10
VTP Operating Mode              : Client
VTP Domain Name                 : CCNA
VTP Pruning Mode                : Disabled
VTP V2 Mode                     : Disabled
VTP Traps Generation            : Disabled
MD5 digest                      : 0xE6 0x56 0x05 0xE0 0x7A 0x63 0xFB 0x33
Configuration last modified by 192.168.99.1 at 3-1-93 00:21:07
```

How many VLANs are configured on S2? Does S2 have the same VLANs as S1? Explain.

_____

_____

Step 5. Observe VTP transparent mode.

S3 is currently configured as VTP transparent mode.

a. Use **show vtp status** command to answer the following question.

How many VLANs are configured on S3 currently? What is the configuration revision number? Explain your answer.

_____

_____

How would you change the number of VLANs on S3?

_____

_____

b. Change VTP mode to client on S3.

Use show commands to verify the changes on VTP mode. How many VLANs exist on S3 now?

_____

Note: VTP advertisements are flooded throughout the management domain every five minutes, or whenever a change occurs in VLAN configurations. To accelerate this process, you can switch between Realtime mode and Simulation mode until the next round of updates. However, you may have to do this multiple times because this will only forward Packet Tracer's clock by 10 seconds each time. Alternatively, you can change one of the client switches to transparent mode and then back to client mode.

Step 6. Assign VLANs to Ports

Use the **switchport mode access** command to set access mode for the access links. Use the **switchport access vlan** *vlan-id* command to assign a VLAN to an access port.

Ports	Assignments	Network
S1 F0/1 – 8 S2 F0/1 – 8	VLAN 10 (Red)	192.168.10.0 /24
S1 F0/9 – 16 S2 F0/9 – 16	VLAN 20 (Blue)	192.168.20.0 /24
S1 F0/17 – 24 S2 F0/17 – 24	VLAN 30 (Yellow)	192.168.30.0 /24

a. Assign VLANs to ports on S2 using assignments from the table above.

```
S2(config-if)# interface range f0/1 - 8
S2(config-if-range)# switchport mode access
S2(config-if-range)# switchport access vlan 10
S2(config-if-range)# interface range f0/9 -16
S2(config-if-range)# switchport mode access
S2(config-if-range)# switchport access vlan 20
```

```
S2(config-if-range)# interface range f0/17 - 24
S2(config-if-range)# switchport mode access
S2(config-if-range)# switchport access vlan 30
```

b. Assign VLANs to ports on S3 using assignment from the table above.

Step 7. Verify end-to-end connectivity.

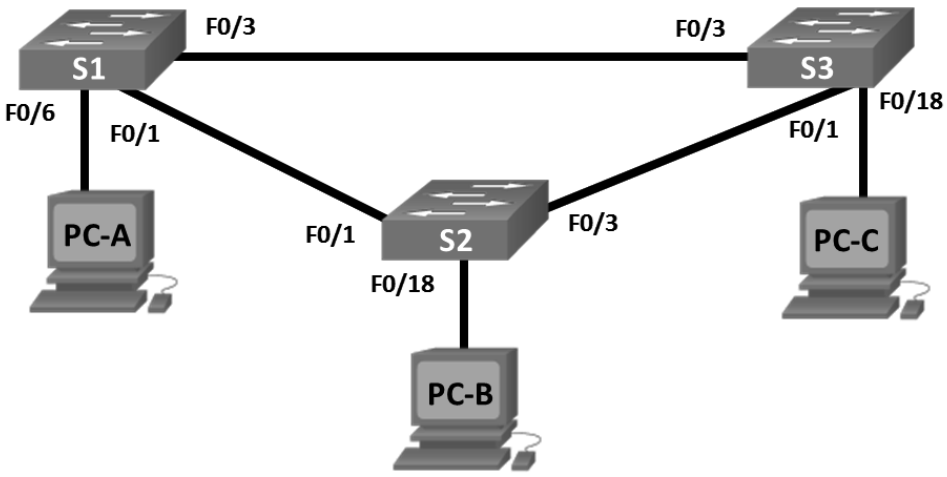
a. From PC0 ping PC5.

b. From PC1 ping PC4.

c. From PC2 ping PC3.

2.1.4.5 Lab–Configure Extended VLANs, VTP, and DTP

Topology



Addressing Table

Table Heading	Interface	IP Address	Subnet Mask
S1	VLAN 99	192.168.99.1	255.255.255.0
S2	VLAN 99	192.168.99.2	255.255.255.0
S3	VLAN 99	192.168.99.3	255.255.255.0
PC-A	NIC	192.168.10.1	255.255.255.0
PC-B	NIC	192.168.20.1	255.255.255.0
PC-C	NIC	192.168.10.2	255.255.255.0

Objectives

Part 1: Configure VTP

Part 2: Configure DTP

Part 3: Add VLANs and Assign Ports

Part 4: Configure Extended VLAN

Background/Scenario

It can become challenging to manage VLANs and trunks in a network, as the number of switches increases. VLAN trunking protocol (VTP) allows a network administrator to automate the management of VLANs. Automated trunk negotiation between network devices is managed by the Dynamic Trunking Protocol (DTP). DTP is enabled by default on Catalyst 2960 and Catalyst 3560 switches.

In this lab, you will configure trunk links between the switches. You will also configure a VTP server and VTP clients in the same VTP domain. Furthermore, you will configure an extended VLAN on one of the switches, assign ports to VLANs and verify end-to-end connectivity within the same VLAN.

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.

Required Resources

- 3 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- 3 PCs (Windows 7 or 8 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 VTP

All the switches will be configured to use VTP for VLAN updates. S2 will be configured as the server. Switches S1 and S3 will be configured as clients. They will be in the **CCNA** VTP domain using the password **cisco**.

a. Configure S2 as a VTP server in the **CCNA** VTP domain using **cisco** as the VTP password.

```
S2(config)# vtp domain CCNA
Changing VTP domain name from NULL to CCNA
S2(config)#
*Mar  1 00:03:44.193: %SW_VLAN-6-VTP_DOMAIN_NAME_CHG: VTP domain name changed
to CCNA.
S2(config)# vtp mode server
Device mode already VTP Server for VLANS.
S2(config)# vtp password cisco
Setting device VTP password to cisco
```

b. Configure S1 and S3 as VTP clients in the **CCNA** VTP domain using **cisco** as the VTP password. VTP configurations are displayed below.

```
S1(config)# vtp domain CCNA
Changing VTP domain name from NULL to CCNA
S1(config)#
*Mar  1 00:03:44.193: %SW_VLAN-6-VTP_DOMAIN_NAME_CHG: VTP domain name changed
to CCNA.
S1(config)# vtp mode client
Device mode VTP client for VLANS.
S1(config)# vtp password cisco
Setting device VTP password to cisco
```

c. Verify VTP configurations by entering the **show vtp status** command on all switches. The VTP status for S3 is displayed below.

```
S3# show vtp status
VTP Version capable             : 1 to 3
VTP version running             : 1
VTP Domain Name                 : CCNA
```

```
VTP Pruning Mode                : Disabled
VTP Traps Generation            : Disabled
Device ID                       : 0cd9.96d2.3580
Configuration last modified by 0.0.0.0 at 0-0-00 00:00:00

Feature VLAN:
--------------
VTP Operating Mode               : Client
Maximum VLANs supported locally  : 255
Number of existing VLANs         : 5
Configuration Revision           : 0
MD5 digest                       : 0x8B 0x58 0x3D 0x9D 0x64 0xBE 0xD5 0xF6
                                   0x62 0xCB 0x4B 0x50 0xE5 0x9C 0x6F 0xF6
```

Part 2: Configure DTP

Step 1. Configure dynamic trunk links between S1 and S2.

a. Enter the **show interfaces f0/1 switchport** command on S1 and S2.

What is the administrative and operational mode of switchport f0/1?

_____

_____

_____

_____

_____

_____

_____

b. In interface configuration mode, configure a dynamic trunk link between S1 and S2. Because the default mode is dynamic auto, only one side of the link needs to be configured as dynamic desirable.

```
S1(config)# interface f0/1
S1(config-if)# switchport mode dynamic desirable
S1(config-if)#
*Mar  1 00:30:45.082: %LINEPROTO-5-UPDOWN: Line protocol on Interface
FastEthernet0/1, changed state to down
*Mar  1 00:30:48.102: %LINEPROTO-5-UPDOWN: Line protocol on Interface
FastEthernet0/1, changed state to up
```

c. Verify trunking link between S1 and S2 using the **show interfaces trunk** command.

```
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

Port        Vlans in spanning tree forwarding state and not pruned
Fa0/1       none

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

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

Step 2. Configure static trunk link between S1 and S3.

a. Between S1 and S3, configure a static trunk link using the **switchport mode trunk** command in the interface configuration mode for port F0/3.

```
S1(config)# interface f0/3
S1(config-if)# switchport mode trunk
```

b. Verify the trunks using **show interfaces trunk** command on S1.

```
S1# show interface trunk

Port        Mode             Encapsulation  Status        Native vlan
Fa0/1       desirable        802.1q         trunking      1
Fa0/3       on               802.1q         trunking      1

Port        Vlans allowed on trunk
Fa0/1       1-4094
Fa0/3       1-4094

Port        Vlans allowed and active in management domain
Fa0/1       1
Fa0/3       1

Port        Vlans in spanning tree forwarding state and not pruned
Fa0/1       none
Fa0/3       none
```

c. Configure a permanent trunk between S2 and S3.

d. Record the commands you used to create the static trunk.

_____

_____

_____

_____

Part 3: Add VLANs and Assign Ports

Step 1. Add VLANs on the switches.

a. On S1, add VLAN 10.

```
S1(config)# vlan 10
```

Were you able to create VLAN 10 on S1? Explain.

_____

b. On S2, add the following VLANs.

VLAN	Name
10	Red
20	Blue
30	Yellow
99	Management

```
S2(config)# vlan 10
S2(config-vlan)# name Red
S2(config-vlan)# vlan 20
S2(config-vlan)# name Blue
S2(config-vlan)# vlan 30
S2(config-vlan)# name Yellow
S2(config-vlan)# vlan 99
S2(config-vlan)# name Management
S2(config-vlan)# end

S2# 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, Fa0/18
                                                Fa0/19, Fa0/20, Fa0/21, Fa0/22
                                                Fa0/23, Fa0/24, Gi0/1, Gi0/2
10   Red                              active
20   Blue                             active
30   Yellow                           active
99   Management                       active
<output omitted>
```

Step 2. Verify VTP updates on S1 and S3.

Because S2 is configured as a VTP server, and S1 and S3 are configured as VTP clients, S1 and S3 should learn and implement the VLAN information from S2.

What **show** commands did you use to verify the VTP updates on S1 and S3?

```
S1# 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, Fa0/18
                                                 Fa0/19, Fa0/20, Fa0/21, Fa0/22
                                                 Fa0/23, Fa0/24, Gi0/1, Gi0/2
10   Red                               active
20   Blue                              active
30   Yellow                            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

S1# show vtp status
VTP Version capable             : 1 to 3
VTP version running             : 1
VTP Domain Name                 : CCNA
VTP Pruning Mode                : Disabled
VTP Traps Generation            : Disabled
Device ID                       : 0cd9.96e2.3d00
Configuration last modified by 0.0.0.0 at 3-1-93 00:58:46

Feature VLAN:
--------------
VTP Operating Mode                : Client
Maximum VLANs supported locally   : 255
Number of existing VLANs          : 9
Configuration Revision            : 4
MD5 digest                        : 0xB2 0x9A 0x11 0x5B 0xBF 0x2E 0xBF 0xAA
                                    0x31 0x18 0xFF 0x2C 0x5E 0x54 0x0A 0xB7
```

Step 3. Assign ports to VLANs.

In this step, you will associate ports to VLANs and configure IP addresses according to the table below.

Port Assignment	VLAN	Attached PC IP Address and Prefix

S1 F0/6	VLAN 10	PC-A: 192.168.10.1 / 24
S2 F0/18	VLAN 20	PC-B: 192.168.20.1 /24
S3 F0/18	VLAN 10	PC-C: 192.168.10.2 /24

a. On S1, configure F0/6 to access mode and assign F0/6 to VLAN 10.

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

b. Repeat the procedure for switchport F0/18 on S2 and S3. Assign the VLAN according to the table above.

c. Assign the IP addresses to the PCs according to the table above.

Step 4. Configure IP addresses on the switches.

a. On S1, assign an IP address to the SVI for VLAN 99 according to the Addressing Table and activate the interface.

```
S1(config)# interface vlan 99
S1(config-if)# ip address 192.168.99.1 255.255.255.0
S1(config-fi)# no shutdown
```

b. Repeat step a. for S2 and S3.

Step 5. Verify end-to-end connectivity

a. Ping PC-A from PC-B. Was it successful? Explain.

_____

b. Ping PC-A from PC-C. Was it successful? Explain.

_____

c. Ping PC-A from S1. Was it successful? Explain.

_____

d. Ping S1 from S2. Was it successful? Explain.

_____

Part 4: Configure Extended VLAN

An extended VLAN is a VLAN between 1025 and 4096. Because the extended VLANs cannot be managed with VTP, VTP must be configured in transparent mode. In this part, you will change the VTP mode on S1 to transparent and create an extended VLAN on S1.

Step 1. Configure VTP mode to transparent on S1.

a. On switch S1, set VTP mode to transparent.

```
S1(config)# vtp mode transparent
Setting device to VTP Transparent mode for VLANS.
S1(config)# exit
```

b. Verify the VTP mode on S1.

```
S1# show vtp status
VTP Version capable             : 1 to 3
VTP version running             : 1
VTP Domain Name                 : CCNA
VTP Pruning Mode                : Disabled
VTP Traps Generation            : Disabled
Device ID                       : 0cd9.96e2.3d00
Configuration last modified by 0.0.0.0 at 3-1-93 02:36:11

Feature VLAN:
--------------
VTP Operating Mode                : Transparent
Maximum VLANs supported locally   : 255
Number of existing VLANs          : 9
Configuration Revision            : 0
MD5 digest                        : 0xB2 0x9A 0x11 0x5B 0xBF 0x2E 0xBF 0xAA
                                    0x31 0x18 0xFF 0x2C 0x5E 0x54 0x0A 0xB7
```

Step 2. Configure an extended VLAN on S1.

a. Display the current VLAN configurations on S1.

b. Create an extended VLAN 2000.

```
S1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
S1(config)# vlan 2000
S1(config-vlan)# end
```

c. Verify the VLAN creation.

```
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   Red                               active    Fa0/6
20   Blue                              active
30   Yellow                            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
2000 VLAN2000                         active
```

Reflection

What are the advantages and disadvantages of using VTP?

Router Interface Summary Table

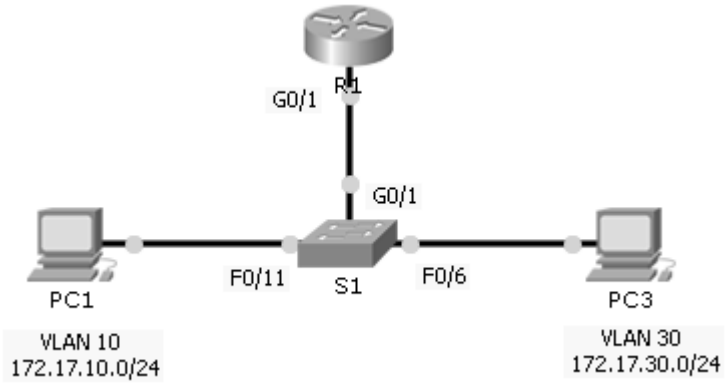
Router Interface Summary				
Router Model	**Ethernet Interface #1**	**Ethernet Interface #2**	**Serial Interface #1**	**Serial Interface #2**
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	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 parentheses is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Packet Tracer Activity

2.2.2.4 Packet Tracer–Troubleshooting Inter-VLAN Routing

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway	VLAN
R1	G0/1.10	172.17.10.1	255.255.255.0	N/A	VLAN 10
	G0/1.30	172.17.30.1	255.255.255.0	N/A	VLAN 30
PC1	NIC	172.17.10.10	255.255.255.0	172.17.10.1	VLAN 10
PC3	NIC	172.17.30.10	255.255.255.0	172.17.30.1	VLAN 30

Objectives

Part 1: Locate Network Problems

Part 2: Implement the Solution

Part 3: Verify Network Connectivity

Scenario

In this activity, you will troubleshoot connectivity problems caused by improper configurations related to VLANs and inter-VLAN routing.

Part 1: Locate the Network Problems

Examine the network and locate the source of any connectivity issues.

- Test connectivity and use the necessary **show** commands to verify configurations.
- List all of the problems and possible solutions in the **Documentation Table**.

Documentation Table

Problems	Solutions

Part 2: Implement the Solutions

Make changes according to your recommended solutions.

Part 3: Verify Network Connectivity

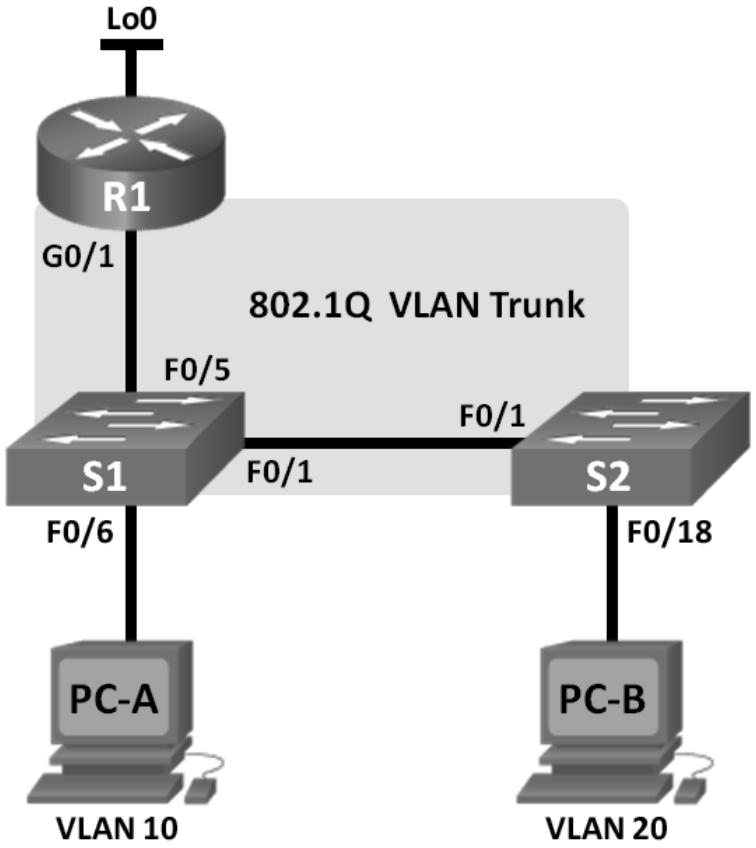
Verify the PCs can ping other PCs and R1. If not, continue to troubleshoot until the pings are successful.

Suggested Scoring Rubric

Packet Tracer scores 60 points. Completing the **Documentation Table** is worth 40 points.

2.2.2.5 Lab–Troubleshooting Inter-VLAN Routing

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.

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 (Microsoft Windows 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

 ____________________________________________________________________________

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 192.168.11.1 255.255.255.0

 ____________________________________________________________________________

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
```

```
interface fastethernet0/1
 switchport mode access
```

```
interface fastethernet0/5
 switchport mode trunk
```

```
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 20
 name Engineering
 exit
interface fastethernet0/1
 switchport mode trunk
interface fastethernet0/18
 switchport access vlan 10
 switchport mode access
```

```
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.

Which networks are listed?

_____

Are there any networks missing in the routing table? If so, which networks?

_____

What is one possible reason that a route would be missing from the routing table?

_____

b. On R1, issue the **show ip interface brief** command.

Based on the output, are there any interface issues on the router? If so, what commands would resolve the issues?

_____

_____

_____

c. On R1, re-issue the **show ip route** command.

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.

a. On S1, enter the **show vlan brief** command to view the VLAN database.

Which VLANs are listed? Ignore VLANs 1002 to 1005.

_____

Are there any VLANs numbers or names missing in the output? If so, list them.

_____

Are the access ports assigned to the correct VLANs? If not, list the missing or incorrect assignments.

_____

If required, what commands would resolve the VLAN issues?

_____

_____

_____

_____

_____

_____

b. On S1, re-issue the **show vlan brief** command to verify configuration.

c. On S2, enter the **show vlan brief** command to view the VLAN database.

Which VLANs are listed? Ignore VLANs 1002 to 1005.

_____

Are there any VLANs numbers or names missing in the output? If so, list them.

_____

Are the access ports assigned to the correct VLANs? If not, list the missing or incorrect assignments.

_____

If required, what commands would resolve the VLAN issues?

_____

_____

_____

_____

_____

d. On S2, re-issue the **show vlan brief** command to verify any configuration changes.

Step 2. Verify trunking interfaces.

a. On S1, enter the **show interface trunk** command to view the trunking interfaces.

Which ports are in trunking mode?

_____

Are there any ports missing in the output? If so, list them.

_____

If required, what commands would resolve the port trunking issues?

_____

_____

b. On S1, re-issue the **show interface trunk** command to verify any configuration changes.

c. On S2, enter the **show interface trunk** command to view the trunking interfaces.

Which ports are in trunking mode?

_____

Are there any ports missing in the output? If so, list them.

_____

If required, what commands would resolve the port trunking issues?

_____

_____

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? _____

From PC-A, is it possible to ping PC-B? _____

From PC-A, is it possible to ping Lo0? _____

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? _____

From PC-A, is it possible to ping S2? _____

List some of the issues that could still be preventing successful pings to the switches.

_____

_____

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.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

What commands would resolve any issues found?

_____

_____

_____

d. Verify that pings from PC-A now reach both S1 and S2.

From PC-A, is it possible to ping S1? _____

From PC-A, is it possible to ping S2? _____

Reflection

What are the advantages of viewing the routing table for troubleshooting purposes?

_____

_____

Router Interface Summary Table

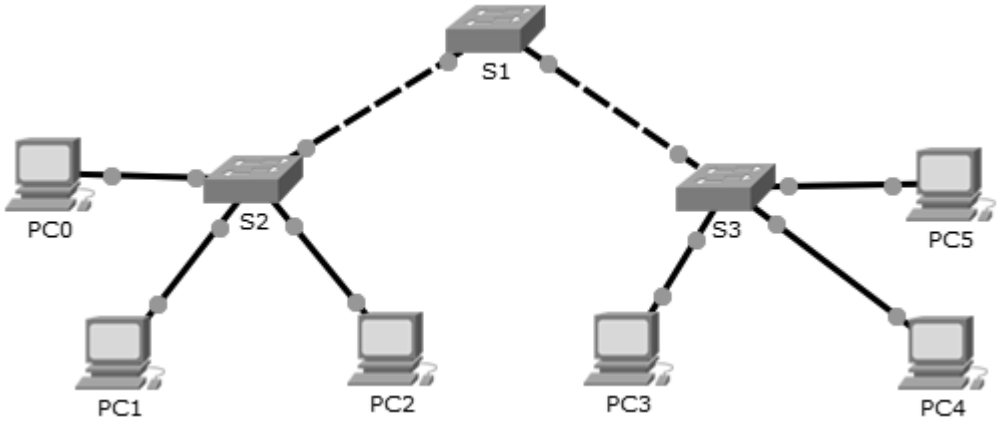
Router Interface Summary				
Router Model	**Ethernet Interface #1**	**Ethernet Interface #2**	**Serial Interface #1**	**Serial Interface #2**
1800	Fast Ethernet 0/0 (F0/0)	Fast Ethernet 0/1 (F0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
1900	Gigabit Ethernet 0/0 (G0/0)	Gigabit Ethernet 0/1 (G0/1)	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 parentheses is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Packet Tracer
Activity

2.2.3.3 Packet Tracer–Troubleshoot VTP and DTP

Topology



Addressing Table

Device	IP Address	Subnet Mask
PC0	172.16.10.1	255.255.255.0
PC1	172.16.20.1	255.255.255.0
PC2	172.16.30.1	255.255.255.0
PC3	172.16.30.2	255.255.255.0
PC4	172.16.20.2	255.255.255.0
PC5	172.16.10.2	255.255.255.0
S1	172.16.99.1	255.255.255.0
S2	172.16.99.2	255.255.255.0
S3	172.16.99.3	255.255.255.0

Objectives

Part 1: Troubleshoot DTP

Part 2: Troubleshoot VTP

Background/Scenario

In this activity, the switches S2 and S3 are not implementing VTP information. You will verify that DTP and VTP configurations are correctly implemented. When all the issues are resolved, the PCs in the same VLAN will be able to communicate with each other.

Part 1: Troubleshoot DTP

In Part 1, you will troubleshoot the trunk links among the switches. You will verify that permanent trunk links are used between the switches.

a. Enter **show interfaces trunk** at the privileged EXEC prompt on all the switches to determine the status of the trunk links. How many trunk links are configured currently?

_____

b. Enter **show interfaces g0/1 switchport** at the privileged EXEC prompt on S1. Do the same for g0/2 interface on S1.

What is the operational mode on the GigabitEthernet interfaces on S1?_____

c. Repeat the commands for g0/1 on S2 and g0/2 on S3.

Correct the trunk links. Record the commands you used to correct the trunking issue.

_____

_____

_____

_____

_____

_____

d. Verify the trunk links using the **show** commands.

Part 2: Troubleshoot VTP

S1 will be configured as the VTP server. S2 and S3 will be configured as VTP clients, and will be receiving VTP updates from S1. The VTP domain should be **CCNA** and the VTP password should be **cisco**. Currently all the desired VLANs are already configured on S1.

Step 1. Verify VLAN information.

Use the **show vlan brief** command on all the switches. Do all the switches have the same number of VLANs? How many does each switch have?

_____

Step 2. Verify VTP configurations.

Use the **show vtp status** and **show vtp password** commands on all the switches to verify the VTP status.

Record the VTP status information in the table below.

Device	Domain Name	Operating Mode	VTP Password
S1			
S2			
S3			

Step 3. Correct the VTP configurations.

Record the commands used to correct the VTP configurations.

Step 4. Verify port assignment.

The switchports connecting to the PCs need to be configured in the correct VLANs so the PCs can communicate with each other.

Use the **show vlan brief** command on S2 and S3 to determine if VLANs have been assigned to the switchports. Which VLAN is associated with these switchports? _____

Ports	Assignments	Network
S2 F0/1 S3 F0/8	VLAN 10 (Staff)	172.16.10.0/24
S2 F0/9 S3 F0/16	VLAN 20 (Student)	172.16.20.0 /24
S2 F0/17 S3 F0/24	VLAN 30 (Faculty)	172.16.30.0 /24

Using the table above, correct the VLAN assignments on S2 and S3. Record the VLAN assignment configurations below.

Step 5. Verify end-to-end connectivity.

a. From PC0 ping PC5.

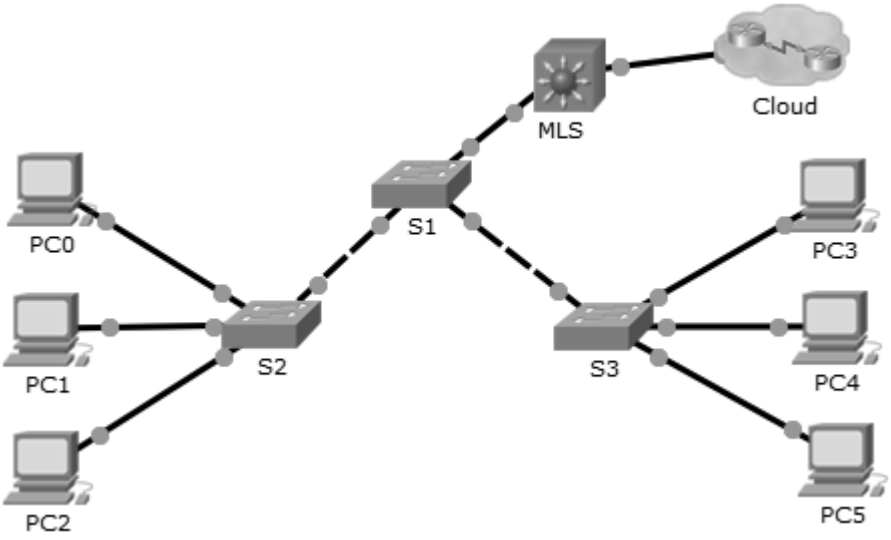
b. From PC1 ping PC4.

c. From PC2 ping PC3.

Packet Tracer Activity

2.3.1.5 Packet Tracer–Configure Layer 3 Switching and Inter-VLAN Routing

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask
MLS	VLAN 10	192.168.10.254	255.255.255.0
	VLAN 20	192.168.20.254	255.255.255.0
	VLAN 30	192.168.30.254	255.255.255.0
	VLAN 99	192.168.99.254	255.255.255.0
	G0/2	209.165.200.225	255.255.255.252
PC0	NIC	192.168.10.1	255.255.255.0
PC1	NIC	192.168.20.1	255.255.255.0
PC2	NIC	192.168.30.1	255.255.255.0
PC3	NIC	192.168.30.2	255.255.255.0
PC4	NIC	192.168.20.2	255.255.255.0
PC5	NIC	192.168.10.2	255.255.255.0
S1	VLAN 99	192.168.99.1	255.255.255.0
S2	VLAN 99	192.168.99.2	255.255.255.0
S3	VLAN 99	192.168.99.3	255.255.255.0

Objectives

Part 1: Configure Layer 3 Switching

Part 2: Configure Inter-VLAN Routing

Background/Scenario

A multilayer switch like the Cisco Catalyst 3560 is capable of both Layer 2 switching and Layer 3 routing. One of the advantages of using a multilayer switch is this dual functionality. A benefit for a small- to medium-sized company would be the ability to purchase a single multilayer switch instead of separate switching and routing network devices. Capabilities of a multilayer switch include the ability to route from one VLAN to another using multiple switched virtual interfaces (SVIs), as well as the ability to convert a Layer 2 switchport to a Layer 3 interface.

Note: The switches used in this lab are a Cisco Catalyst 3560 with Cisco IOS Release 12.2(37) (advipservicesk9) and 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.

Part 1: Configure Layer 3 Switching

In Part 1, you will configure the GigabitEthernet 0/2 port on switch MLS as a routed port and verify that you can ping another Layer 3 address.

a. On MLS, configure G0/2 as a routed port and assign an IP address according to the Addressing Table.

```
MLS(config)# interface g0/2
MLS(config-if)# no switchport
MLS(config-if)# ip address 209.165.200.225 255.255.255.252
```

b. Verify connectivity to **Cloud** by pinging 209.165.200.226.

```
MLS# ping 209.165.200.226

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.200.226, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms
```

Part 2: Configure Inter-VLAN Routing

Step 1. Add VLANs.

Add VLANs to MLS according to the table below.

VLAN Number	VLAN Name
10	Staff
20	Student
30	Faculty

Step 2. Configure SVI on MLS.

Configure and activate the SVI interface for VLANs 10, 20, 30, and 99 according to the Addressing Table. The configuration for VLAN 10 is shown below.

```
MLS(config)# interface vlan 10
MLS(config-if)# ip address 192.168.10.254 255.255.255.0
```

Step 3. Enable routing.

a. Use the **show ip route** command. Are there any active routes? _____

b. Enter the **ip routing** command to enable routing in global configuration mode.

```
MLS(config)# ip routing
```

c. Use the **show ip route** command to verify routing is enabled.

```
MLS# show ip route
Codes: C - connected, S - static, I - IGRP, 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

C    192.168.10.0/24 is directly connected, Vlan10
C    192.168.20.0/24 is directly connected, Vlan20
C    192.168.30.0/24 is directly connected, Vlan30
C    192.168.99.0/24 is directly connected, Vlan99
     209.165.200.0/30 is subnetted, 1 subnets
C       209.165.200.224 is directly connected, GigabitEthernet0/2
```

Step 4. Verify end-to-end connectivity.

a. From PC0, ping PC3 or MLS to verify connectivity within VLAN 10.

b. From PC1, ping PC4 or MLS to verify connectivity within VLAN 20.

c. From PC2, ping PC5 or MLS to verify connectivity within VLAN 30.

d. From S1, ping S2, S3, or MLS to verify connectivity with VLAN 99.

e. To verify inter-VLAN routing, ping devices outside the sender's VLAN.

f. From any device, ping this address inside **Cloud**, 209.165.200.226

CHAPTER 3

STP

Computer networks are inextricably linked to productivity in today's small and medium-sized businesses. Consequently, IT administrators have to implement redundancy in their hierarchical networks. When a switch connection is lost, another link needs to quickly take its place without introducing any traffic loops. This chapter investigates how Spanning Tree Protocol (STP) logically blocks physical loops in the network and how STP has evolved into a robust protocol that rapidly calculates which ports should be blocked in a VLAN-based network.

Study Guide

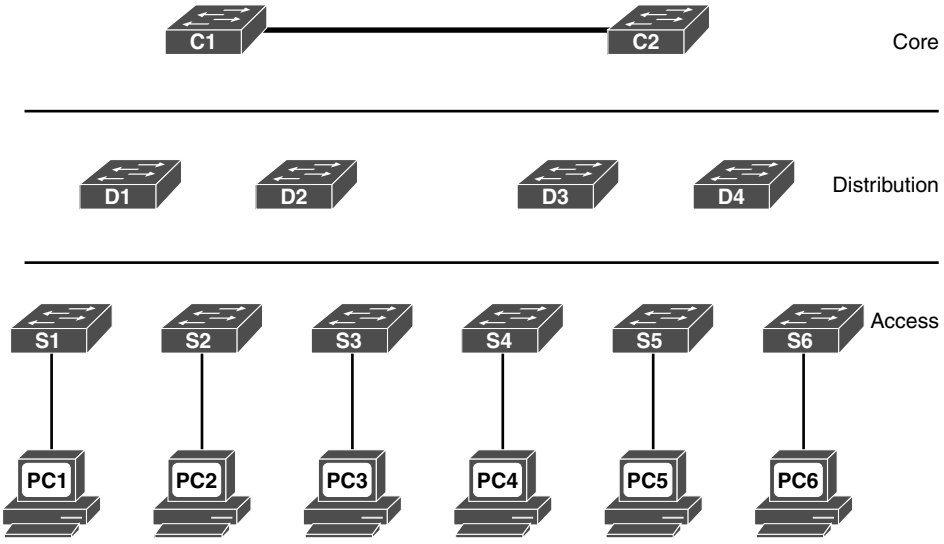
Spanning Tree Concepts

Redundancy increases the availability of a network topology by protecting the network from a single point of failure, such as a failed network cable or switch. STP was developed to address the issue of loops in a redundant Layer 2 design.

Draw a Redundant Topology

In Figure 3-1, draw redundant links between the access, distribution, and core switches. Each access switch should have two links to the distribution layer with each link connecting to a different distribution layer switch. Each distribution layer switch should have two links to the core layer with each link connecting to a different core layer switch.

Figure 3-1 Redundant Topology



Purpose of Spanning Tree

STP prevents specific types of issues in a redundant topology like the one in Figure 3-1. Specifically, three potential issues would occur if STP was not implemented. Describe each of the following issues:

- **MAC database instability:**

_____

_____

_____

- **Broadcast storms:**

_____

_____

- **Multiple frame transmission:**

  _____

  _____

  _____

You should be prepared to use a topology like Figure 3-1 to explain exactly how these three issues would occur if STP was not implemented.

Spanning Tree Operation

Because _____, which is documented in IEEE _____-2004, supersedes the original STP documented in IEEE _____-1998, all references to STP assume RSTP unless otherwise indicated.

STP ensures that there is only one logical path between all destinations on the network by intentionally blocking redundant paths that could cause a _____. A switch port is considered _____ when network traffic is prevented from entering or leaving that port.

STP uses the _____ (STA) to determine which switch ports on a network need to be _____ to prevent _____ from occurring. The STA designates a single switch as the root bridge and uses it as the reference point for all subsequent calculations. Switches participating in STP determine which switch has the lowest _____ (BID) on the network. This switch automatically becomes the _____ bridge.

A _____ (BPDU) is a frame containing STP information exchanged by switches running STP. Each BPDU contains a BID that identifies the switch that sent the BPDU. The _____ BID value determines which switch is root.

After the root bridge has been determined, the STA calculates the shortest path to the root bridge. If there is more than one path to choose from, STA chooses the path with the lowest _____.

When the STA has determined the "best" paths emanating from the root bridge, it configures the switch ports into distinct port roles. The port roles describe their relation in the network to the root bridge and whether they are allowed to forward traffic:

- _____ **ports:** Switch ports closest to the root bridge
- _____ **ports:** Nonroot ports that are still permitted to forward traffic on the network
- _____ **ports:** Ports in a blocking state to prevent loops
- _____ **port:** Ports that are administratively shut down

After a switch boots, it sends BPDU frames containing the switch BID and the root ID every 2 seconds. Initially, each switch identifies itself as the root bridge after boot.

How would a switch determine that another switch is now the root bridge?

_____

_____

How does the STA determine path cost?

_____

_____

Record the default port costs for various link speeds in Table 3-1.

Table 3-1 Port Costs

Link Speed	Cost (Revised IEEE Specification)	Cost (Previous IEEE Specification)
10 Gbps		
1 Gbps		
100 Mbps		
10 Mbps		

Although switch ports have a default port cost associated with them, the port cost is configurable.

To configure the port cost of an interface, enter the **spanning-tree cost value** command in interface configuration mode. The range value can be between 1 and 200,000,000.

Record the commands, including the switch prompt, to configure the port cost for F0/1 as 15:

_____

_____

To verify the port and path cost to the root bridge, enter the **show spanning-tree** privileged EXEC mode command, as shown here:

```
S2# _____________________________________________________________________________
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     c025.5cd7.ef00
              Cost        15
              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     c07b.bcc4.a980
              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 15        128.1    P2p
Fa0/2               Altn BLK 19        128.2    P2p
Fa0/3               Desg LIS 19        128.3    P2p
Fa0/4               Desg LIS 19        128.4    P2p
Fa0/6               Desg FWD 19        128.6    P2p
<output omitted>
```

The BID field of a BPDU frame contains three separate fields: _____, _____, and _____.

Of these three fields, the _____ is a customizable value that you can use to influence which switch becomes the root bridge. The default value for this field is _____.

Cisco enhanced its implementation of STP to include support for the extended system ID field, which contains the ID of the _____ with which the BPDU is associated.

Because using the extended system ID changes the number of bits available for the bridge priority, the customizable values can only be multiples of _____.

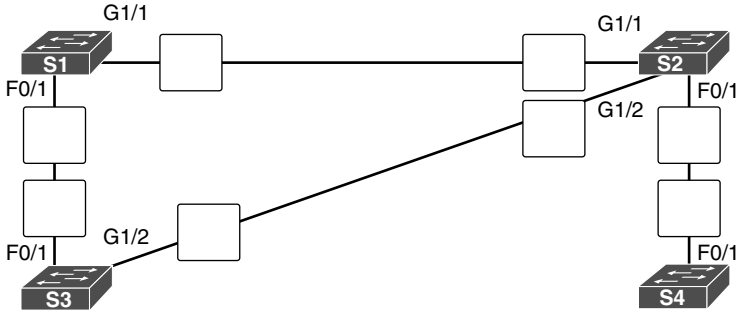
When two switches are configured with the same priority and have the same extended system ID, the switch with the lowest _____ has the lower BID.

Identify the 802.1D Port Roles

The topologies in the next three figures do not necessarily represent an appropriate network design. However, they provide good exercise topologies for you to practice determining the STP port roles. In Figures 3-2 through 3-4, use the priority values and MAC addresses to determine the root bridge. Then label the ports with one of the following:

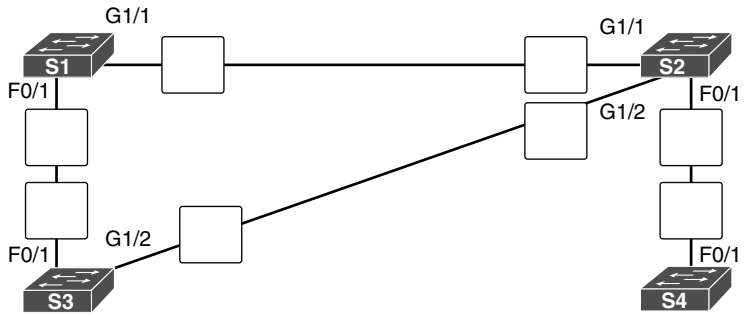
- **RP:** Root Port
- **DP:** Designated Port
- **AP:** Alternate Port

Figure 3-2 802.1D Port Roles - Scenario 1



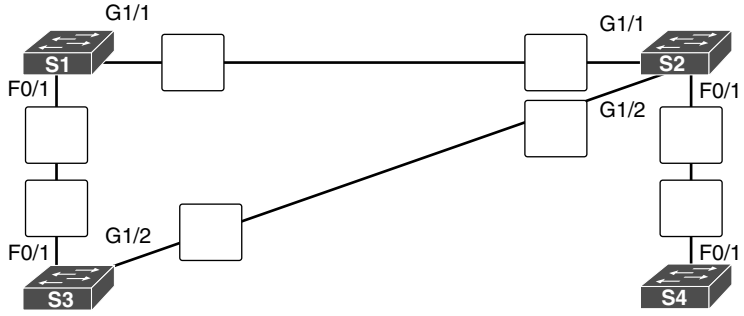
Device	Priority	MAC Address
S1	32769	000a:0001:1111
S2	24577	000a:0002:2222
S3	32769	000a:0003:3333
S4	32769	000a:0004:4444

Figure 3-3 802.1D Port Roles - Scenario 2



Device	Priority	MAC Address
S1	24577	000a:0001:1111
S2	32769	000a:0002:2222
S3	32769	000a:0003:3333
S4	32769	000a:0004:4444

Figure 3-4 802.1D Port Roles - Scenario 3



Device	Priority	MAC Address
S1	32769	000a:0001:1111
S2	32769	000a:0002:2222
S3	24577	000a:0003:3333
S4	32769	000a:0004:4444

Varieties of Spanning Tree Protocols

STP has been improved multiple times since its introduction in the original IEEE 802.1D specification. A network administrator should know which type to implement based on the equipment and topology needs.

Comparing the STP Varieties

Identify each of the STP varieties described in the following list:

- _____: This is the original IEEE 802.1D version (802.1D-1998 and earlier) that provides a loop-free topology in a network with redundant links.
- _____: This is a Cisco enhancement of STP that provides a separate 802.1D spanning tree instance for each VLAN configured in the network.

- _____: This is an updated version of the STP standard, incorporating IEEE 802.1w.
- _____: This is an evolution of STP that provides faster convergence than STP.
- _____: This is a Cisco enhancement that provides a separate instance of 802.1w per VLAN.
- _____: This is an IEEE that maps multiple VLANs into the same spanning tree instance.

Complete the cells in Table 3-2 to identify the characteristics of each STP variety.

Table 3-2 STP Characteristics - Exercise 1

Protocol	Standard	Resources Needed	Convergence	Tree Calculation
STP		Low		
	Cisco			
	802.1w			
Rapid PVST+				
	802.1s, Cisco	Medium or high		

In Table 3-3, indicate which varieties of STP are best described by the characteristic. Some characteristics apply to more than one STP variety.

Table 3-3 STP Characteristics - Exercise 2

Characteristic	STP	PVST+	RSTP	Rapid PVST+	MSTP	MST
A Cisco implementation of 802.1s that provides up to 16 instances of RSTP.						
Cisco enhancement of RSTP.						
The default STP mode for Cisco Catalyst switches.						
Has the highest CPU and memory requirements.						
Can lead to suboptimal traffic flows.						
Cisco proprietary versions of STP.						
Cisco enhancement of STP. Provides a separate 802.1D spanning-tree instance for each VLAN.						
There is only 1 root bridge and 1 tree.						
Uses 1 IEEE 802.1D spanning-tree instance for the entire bridged network, regardless of the number of VLANs.						
Supports PortFast, BPDU guard, BPDU filter, root guard, and loop guard.						
An evolution of STP that provides faster STP convergence.						
Maps multiple VLANs that have the same traffic flow requirements into the same spanning-tree instance.						
First version of STP to address convergence issues, but still provided only one STP instance.						

PVST+ Operation

After a switch boots, the spanning tree is immediately determined as ports transition through five possible states and three BPDU timers on the way to convergence. Briefly describe each state:

- **Blocking:**

  _____

  _____

  _____

- **Listening:**

  _____

  _____

  _____

  _____

  _____

- **Learning:**

  _____

  _____

- **Forwarding:**

  _____

  _____

- **Disabled:**

  _____

  _____

Once stable, every active port in the switched network is either in the _____ state or the _____ state.

List and briefly describe the four steps PVST+ performs for each VLAN to provide a loop-free logical topology.

_____

_____

_____

_____

_____

_____

In Table 3-4, answer the "Operation Allowed" question with "yes" or "no" for each port state.

Table 3-4 Operations Allowed at Each Port State

Operation Allowed	Port State				
	Blocking	Listening	Learning	Forwarding	Disabled
Can receive and process BPDUs					
Can forward data frames received on interface					
Can forward data frames switched from another interface					
Can learn MAC addresses					

Rapid PVST+ Operation

RSTP (IEEE _____) is an evolution of the original _____ standard and is incorporated into the IEEE _____-2004 standard. Rapid PVST+ is the Cisco implementation of RSTP on a per-VLAN basis. What is the primary difference between Rapid PVST+ and RSTP?

_____

Briefly describe the RSTP concept that corresponds to the PVST+ PortFast feature.

_____

_____

_____

What command implements Cisco's version of an edge port?

_____

In Table 3-5, indicate whether the characteristic describes PVST+, Rapid PVST+, or both.

Table 3-5 Comparing PVST+ and Rapid PVST+

Characteristic	PVST+	Rapid PVST+	Both
Cisco proprietary protocol.			
Port roles: root, designated, alternate, edge, backup.			
CPU processing and trunk bandwidth usage is greater than with STP.			
Ports can transition to forwarding state without relying on a timer.			
The root bridge is determined by the lowest BID + VLAN ID + MAC.			
Runs a separate IEEE 802.1D STP instance for each VLAN.			
Possible to have load sharing with some VLANs forwarding on each trunk.			
Sends a BPDU "hello message" every 2 seconds.			

Spanning Tree Configuration

It is crucial to understand the impact of a default switch configuration on STP convergence and what configurations can be applied to adjust the default behavior.

PVST+ and Rapid PVST+ Configuration

Complete Table 3-6 to show the default spanning-tree configuration for a Cisco Catalyst 2960 series switch.

Table 3-6 Default Switch Configuration

Feature	Default Setting
Enable state	Enabled on VLAN 1
Spanning-tree mode	
Switch priority	
Spanning-tree port priority configurable on a per-interface basis)	
Spanning-tree port cost (configurable on a per-interface basis)	1000 Mbps: 100 Mbps: 10 Mbps:
Spanning-tree VLAN port priority (configurable on a per-VLAN basis)	
Spanning-tree VLAN port cost (configurable on a per-VLAN basis)	1000 Mbps: 100 Mbps: 10 Mbps:
Spanning-tree timers	Hello time: ____ seconds Forward-delay time: ____ seconds Maximum-aging time: ____ seconds Transmit hold count: ____ BPDUs

Document the two different configuration commands that you can use to configure the bridge priority value so that the switch is root for VLAN 1. Use the value 4096 when necessary:

_____

_____

_____

Record the command to verify that the local switch is now root:

```
S1# _____

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    24577
              Address     000A.0033.3333
              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     0019.aa9e.b000
```

```
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface         Role Sts Cost      Prio.Nbr Type
----------------- ---- --- --------- -------- --------------------------------
Fa0/1             Desg FWD 4         128.1    Shr
Fa0/2             Desg FWD 4         128.2    Shr
```

Explain the purpose of the BPDU guard feature on Cisco switches.

_____

_____

What command interface configuration command enables BPDU guard?

_____

What global configuration command will configure all nontrunking ports as edge ports?

_____

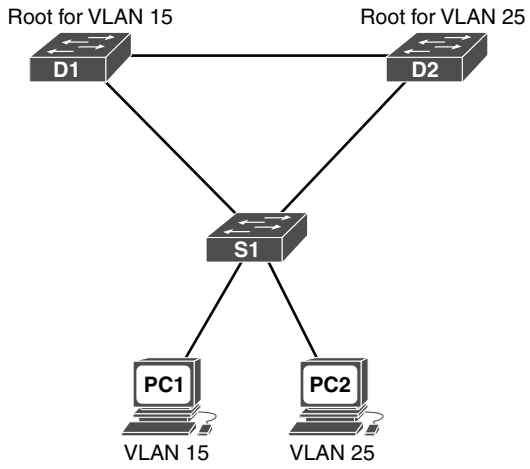
What global configuration command will configure BPDU guard on all PortFast-enabled ports?

_____

The power of PVST+ is that it can load balance across redundant links. By default, the least-favored redundant link is not used. So, you must manually configure PVST+ to use the link.

Figure 3-5 represents a small section of Figure 3-1, showing only two distribution layer switches and one access layer switch. For this example, we have attached PC2 to S1. PC1 is assigned to VLAN 15, and PC2 is assigned to VLAN 25. D1 should be the primary root for VLAN 1 and VLAN 15 and the secondary root for VLAN 25 and VLAN 99. D2 should be the primary root for VLAN 25 and VLAN 99 and the secondary root for VLAN 1 and VLAN 15.

Figure 3-5 PVST+ Configuration Topology



Based on these requirements, document the commands to modify the default PVST+ operation on D1 and D2.

D1 commands

_____

_____

_____

_____

D2 commands

_____

_____

_____

_____

Document the commands to configure all nontrunking ports on S1 as edge ports with BPDU guard enabled.

_____

_____

Now, assume that you want to run rapid PVST+ on all three switches. What command is required?

_____

Packet Tracer Activity

Packet Tracer Exercise 3-1: STP Configuration

Now you are ready to use Packet Tracer to apply your documented configuration. Download and open the file LSG03-0301.pka found at the companion website for this book. Refer to the Introduction of this book for specifics on accessing files.

Note: The following instructions are also contained within the Packet Tracer Exercise.

In this Packet Tracer activity, you will configure Rapid PVST+ to load balance VLAN traffic between two switches. Use the commands you documented in the section "PVST+ and Rapid PVST+ Configuration."

Requirements

Configure the switches with the following settings:

- D1 is the primary for VLAN 1 and 15 and the secondary root for VLAN 25 and VLAN 99.
- D2 is the primary for VLAN 25 and 99 and the secondary root for VLAN 1 and 15.
- All nontrunk links on S1 should be configured with portfast.
- The links to PC1 and PC2 should be configured to block BPDUs.

Note: Packet Tracer does not support the global command for blocking BPDUs.

Your completion percentage should be 100%. If not, click **Check Results** to see which required components are not yet completed.

Labs and Activities

Command Reference

In Table 3-7, record the command, including the correct router or switch prompt, that fits the description. Fill in any blanks with the appropriate missing information.

Table 3-7 Commands for Chapter 3, STP

Command	Description
	Change the STP cost for S1's Fa0/1 interface to 20.
	Verify the port and path costs for all interfaces on S1.
	Configure S1 as the root for VLAN 1.
	Configure S1 as the backup root for VLAN 10.
	Configure S1's Fa0/5 interface to drop all BPDUs.
	Configure all nontrunk links as portfast.
	Configure S1's Fa0/5 interface as portfast.
	Configure S1 to use Rapid PVST+

3.0.1.2 Class Activity–Stormy Traffic

Objective

Explain the purpose of the Spanning Tree Protocol (STP) in a switched LAN environment with redundant switch links.

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?

   _____

   _____

   _____

   _____

2. What is a definition of a switching loop? What causes a switching loop?

3. How can you mitigate broadcast storms and switching loops caused by introducing redundant switches to your network?

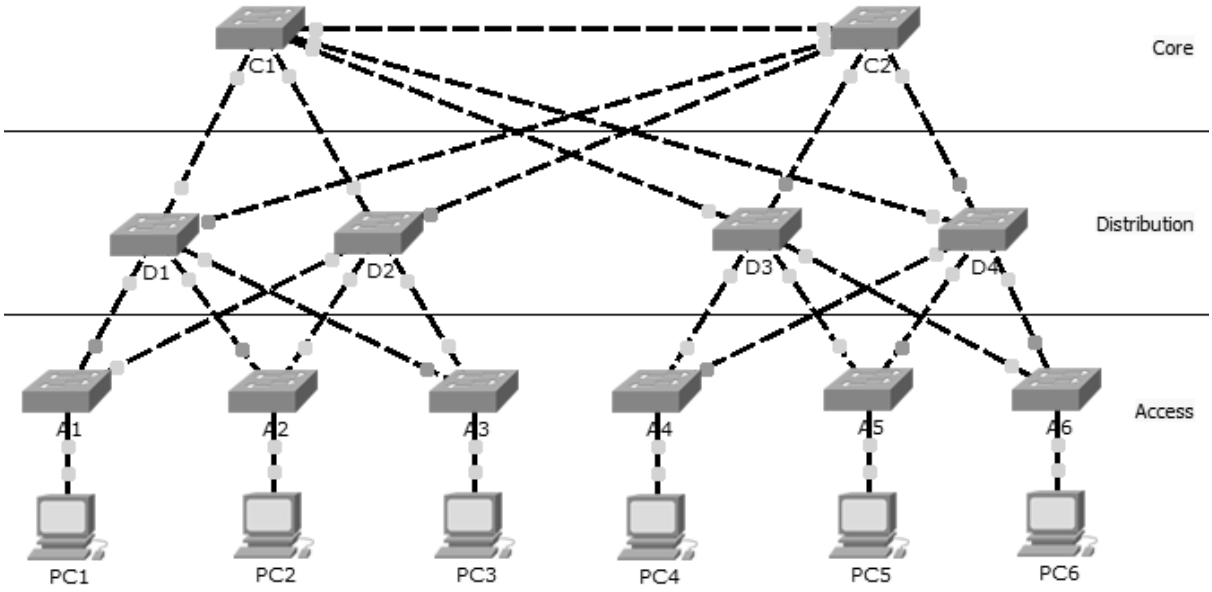
4. What is the IEEE standard for STP and some other STP variations, as mentioned in the hyperlinks provided?

5. In answer to this scenario, what would be your first step (after visually checking your network) to correcting the described network problem?

Packet Tracer Activity

3.1.1.5 Packet Tracer–Examining a Redundant Design

Topology



Objectives

Part 1: Check for STP Convergence

Part 2: Examine the ARP Process

Part 3: Test Redundancy in a Switched Network

Background

In this activity, you will observe how STP operates, by default, and how it reacts when faults occur. Switches have been added to the network "out of the box." Cisco switches can be connected to a network without any additional action required by the network administrator. For the purpose of this activity, the bridge priority was modified.

Part 1: Check for STP Convergence

When STP is fully converged, the following conditions exist:

- All PCs have green link lights on the switched ports.
- Access layer switches have one forwarding uplink (green link) to a distribution layer switch and a blocking uplink (amber link) to a second distribution layer switch.
- Distribution layer switches have one forwarding uplink (green link) to a core layer switch and a blocking uplink (amber link) to another core layer switch.

Part 2: Examine the ARP Process

Step 1. Switch to Simulation mode.

Step 2. Ping from PC1 to PC6.

a. Use the **Add Simple PDU** tool to create a PDU from **PC1** to **PC6**. Verify that ARP and ICMP are selected in the **Event List Filters**. Click **Capture/Forward** to examine the ARP process as the switched network learns the MAC addresses of **PC1** and **PC6**. Notice that all possible loops are stopped by blocking ports. For example, the ARP request from **PC1** travels from **A1** to **D2** to **C1** to **D1** and then back to **A1**. However, because STP is blocking the link between **A1** and **D1**, no loop occurs.

b. Notice that the ARP reply from **PC6** travels back along one path. Why?

_____

c. Record the loop-free path between **PC1** and **PC6**.

_____

Step 3. Examine the ARP process again.

a. Below the **Scenario 0** drop-down list, click **New** to create **Scenario 1**. Examine the ARP process again by pinging between two different PCs.

b. What part of the path changed from the last set of pings?

_____

Part 3: Test Redundancy in a Switched Network

Step 1. Delete the link between A1 and D2.

Switch to **Realtime** mode. Delete the link between **A1** and **D2**. It takes some time for STP to converge and establish a new, loop-free path. Because only **A1** is affected, watch for the amber light on the link between **A1** and **D1** to change to green. You can click **Fast Forward Time** to accelerate the STP convergence process.

Step 2. Ping between PC1 and PC6.

a. After the link between **A1** and **D1** is active (indicated by a green light), switch to **Simulation** mode and create **Scenario 2**. Ping between **PC1** and **PC6** again.

b. Record the new loop-free path.

_____

Step 3. Delete the link between C1 and D3.

a. Switch to **Realtime** mode. Notice that the links between **D3** and **D4** to **C2** are amber. Delete the link between **C1** and **D3**. It takes some time for STP to converge and establish a new, loop-free path. Watch the amber links on **D3** and **D4**. You can click **Fast Forward Time** to accelerate the STP convergence process.

b. Which link is now the active link to **C2**?

_____

Step 4. Ping between PC1 and PC6.

a. Switch to **Simulation** mode and create **Scenario 3**. Ping between **PC1** and **PC6**.

b. Record the new loop-free path.

_____

Step 5. Delete D4.

Switch to **Realtime** mode. Notice that **A4**, **A5**, and **A6** are all forwarding traffic to **D4**. Delete **D4**. It takes some time for STP to converge and establish a new, loop-free path. Watch for the links between **A4**, **A5**, and **A6** to **D3** transition to forwarding (green). All three switches should now be forwarding to **D3**.

Step 6. Ping between PC1 and PC6.

a. Switch to **Simulation** mode and create **Scenario 4**. Ping between **PC1** and **PC6**.

b. Record the new loop-free path.

_____

c. What is unique about the new path that you have not seen before?

_____

_____

Step 7. Delete C1.

Switch to **Realtime** mode. Notice that **D1** and **D2** are both forwarding traffic to **C1**. Delete **C1**. It takes some time for STP to converge and establish a new, loop-free path. Watch for the links between **D1** and **D2** to **C2** to transition to forwarding (green). Once converged, both switches should now be forwarding to **C2**.

Step 8. Ping between PC1 and PC6.

a. Switch to **Simulation** mode and create **Scenario 5**. Ping between **PC1** and **PC6**.

b. Record the new loop-free path.

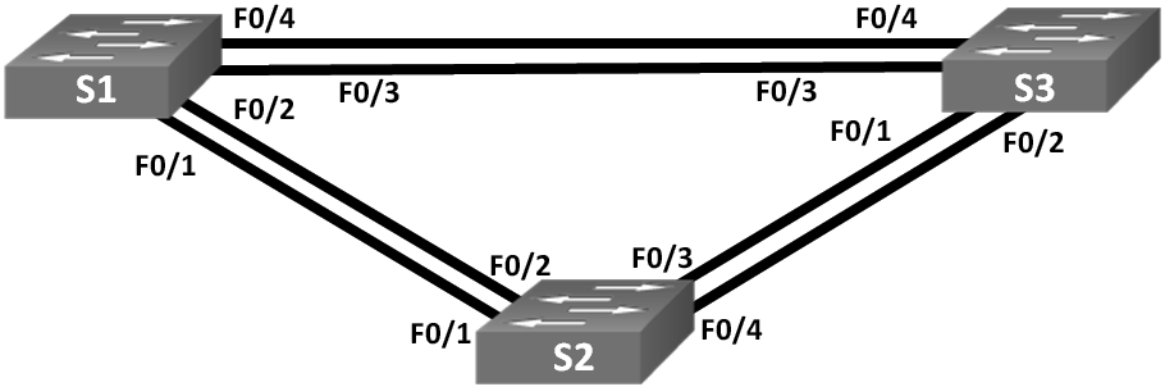
_____

Suggested Scoring Rubric

Activity Section	Question Location	Possible Points	Earned Points
Part 2: Examine the ARP Process	Step 2b	5	
	Step 2c	15	
	Step 3	5	
	Part 2 Total	**25**	
Part 3: Test Redundancy in a Switched Network	Step 2	15	
	Step 3	5	
	Step 4	15	
	Step 6b	15	
	Step 6c	10	
	Step 8	15	
	Part 3 Total	**75**	
	Total Score	**100**	

3.1.2.12 Lab–Building a Switched Network with Redundant Links

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.

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.

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.

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 and enable login for console and vty lines.

e. Configure logging synchronous for the console line.

f. Configure a message of the day (MOTD) banner to warn users that unauthorized access is prohibited.

g. Configure the IP address listed in the Addressing Table for VLAN 1 on all switches.

h. Copy the running configuration to the startup configuration.

Step 4. Test connectivity.

Verify that the switches can ping one another.

Can S1 ping S2? _____

Can S1 ping S3? _____

Can S2 ping S3? _____

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.

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.

Step 2. Configure connected ports as trunks.

Step 3. Activate ports F0/2 and F0/4 on all switches.

Step 4. Display spanning tree information.

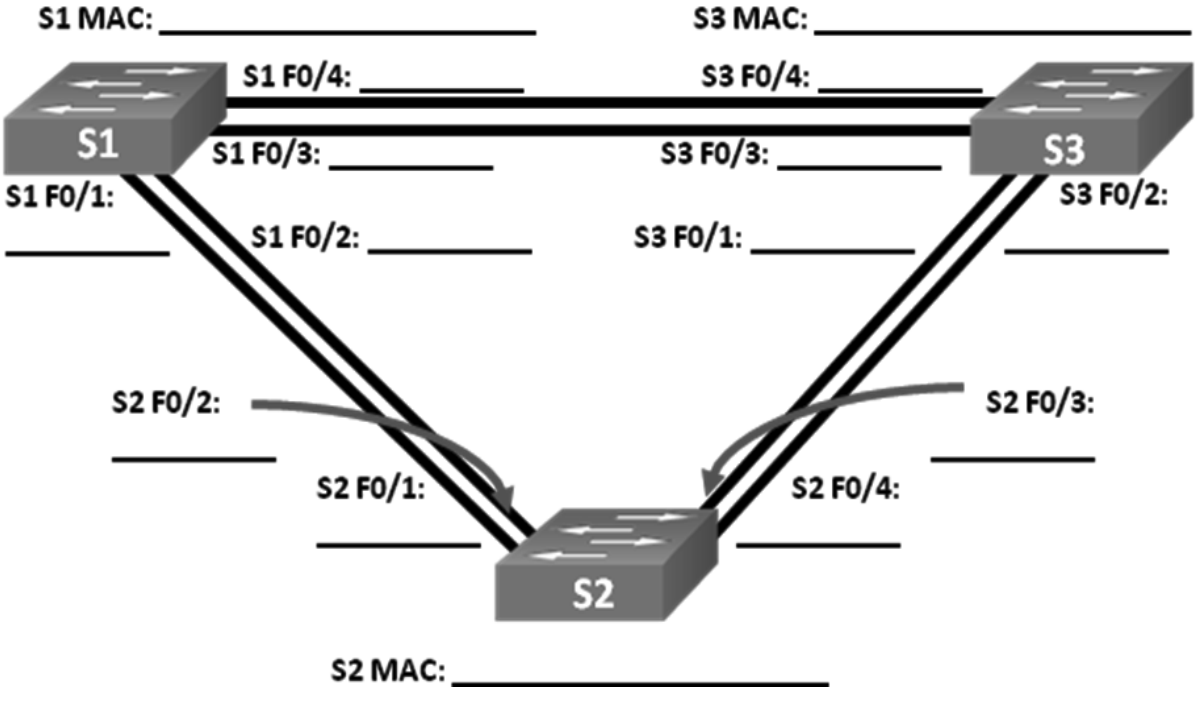
Issue the **show spanning-tree** command on all three switches. The Bridge ID Priority is calculated by adding the priority value and the extended system ID. The extended system ID is always the VLAN number. In the example below, all three switches have equal Bridge ID Priority values (32769 = 32768 + 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
  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? _____

Why did spanning tree select this switch as the root bridge?

_____

Which ports are the root ports on the switches? _____

Which ports are the designated ports on the switches? _____

What port is showing as an alternate port and is currently being blocked? _____

Why did spanning tree select this port as the non-designated (blocked) port?

_____

_____

_____

_____

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

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?

_____

Step 4. Remove port cost changes.

a. 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
```

b. 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.

a. Activate ports F0/1 and F0/3 on all switches.

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
             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? _____

_____

Why did STP select these ports as the root port on these switches?

_____

_____

Reflection

1. After a root bridge has been selected, what is the first value STP uses to determine port selection?

   _____

2. If the first value is equal on the two ports, what is the next value that STP uses to determine port selection?

   _____

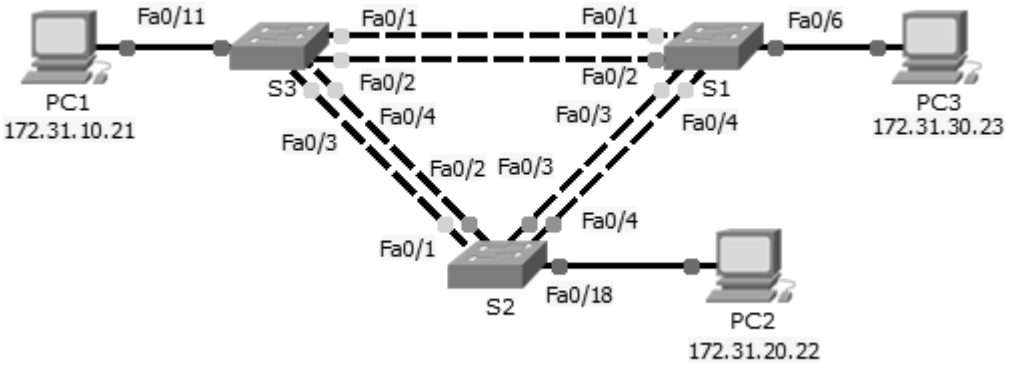
3. If both values are equal on the two ports, what is the next value that STP uses to determine port selection?

   _____

Packet Tracer Activity

3.3.1.5 Packet Tracer–Configuring PVST+

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
S1	VLAN 99	172.31.99.1	255.255.255.0	N/A
S2	VLAN 99	172.31.99.2	255.255.255.0	N/A
S3	VLAN 99	172.31.99.3	255.255.255.0	N/A
PC1	NIC	172.31.10.21	255.255.255.0	172.31.10.254
PC2	NIC	172.31.20.22	255.255.255.0	172.31.20.254
PC3	NIC	172.31.30.23	255.255.255.0	172.31.30.254

Switch Port Assignment Specifications

Ports	Assignments	Network
S1 F0/6	VLAN 30	172.17.30.0/24
S2 F0/18	VLAN 20	172.17.20.0/24
S3 F0/11	VLAN 10	172.17.10.0/24

Objectives

Part 1: Configure VLANs

Part 2: Configure Spanning Tree PVST+ and Load Balancing

Part 3: Configure PortFast and BPDU Guard

Background

In this activity, you will configure VLANs and trunks, and examine and configure the Spanning Tree Protocol primary and secondary root bridges. You will also optimize the switched topology using PVST+, PortFast, and BPDU guard.

Part 1: Configure VLANs

Step 1. Enable the user ports on S1, S2, and S3 in access mode.

Refer to the topology diagram to determine which switch ports (**S1**, **S2**, and **S3**) are activated for end-user device access. These three ports will be configured for access mode and enabled with the **no shutdown** command.

Step 2. Create VLANs.

Using the appropriate command, create VLANs 10, 20, 30, 40, 50, 60, 70, 80, and 99 on all of the switches.

Step 3. Assign VLANs to switch ports.

Port assignments are listed in the table at the beginning of the activity. Save your configurations after assigning switch ports to the VLANs.

Step 4. Verify the VLANs.

Use the **show vlan brief** command on all switches to verify that all VLANs are registered in the VLAN table.

Step 5. Assign the trunks to native VLAN 99.

Use the appropriate command to configure ports F0/1 to F0/4 on each switch as trunk ports, and assign these trunk ports to native VLAN 99.

Step 6. Configure the management interface on all three switches with an address.

Verify that the switches are correctly configured by pinging between them.

Part 2: Configure Spanning Tree PVST+ and Load Balancing

Because there is a separate instance of the spanning tree for every active VLAN, a separate root election is conducted for each instance. If the default switch priorities are used in root selection, the same root is elected for every spanning tree instance, as we have seen. This could lead to an inferior design. Some reasons to control the selection of the root switch include:

- The root switch is responsible for generating BPDUs for STP 802.1D and is the focal point for spanning tree to control traffic. The root switch must be capable of handling this additional load.
- The placement of the root defines the active switched paths in the network. Random placement is likely to lead to suboptimal paths. Ideally the root is in the distribution layer.
- Consider the topology used in this activity. Of the six trunks configured, only three are carrying traffic. While this prevents loops, it is a waste of resources. Because the root can be defined on the basis of the VLAN, you can have some ports blocking for one VLAN and forwarding for another. This is demonstrated below.

Step 1. Configure STP mode.

Use the **spanning-tree mode** command to configure the switches so they use PVST as the STP mode.

Step 2. Configure Spanning Tree PVST+ load balancing.

a. Configure **S1** to be the primary root for VLANs 1, 10, 30, 50, and 70. Configure **S3** to be the primary root for VLANs 20, 40, 60, 80, and 99. Configure **S2** to be the secondary root for all VLANs.

b. Verify your configurations using the **show spanning-tree** command.

Part 3: Configure PortFast and BPDU Guard

Step 1. Configure PortFast on the switches.

PortFast causes a port to enter the forwarding state almost immediately by dramatically decreasing the time of the listening and learning states. PortFast minimizes the time it takes for the server or workstation to come online. Configure PortFast on the switch interfaces that are connected to PCs.

Step 2. Configure BPDU guard on the switches.

The STP PortFast BPDU guard enhancement allows network designers to enforce the STP domain borders and keep the active topology predictable. The devices behind the ports that have STP PortFast enabled are unable to influence the STP topology. At the reception of BPDUs, the BPDU guard operation disables the port that has PortFast configured. The BPDU guard transitions the port into the err-disable state, and a message appears on the console. Configure BPDU guard on switch interfaces that are connected to PCs.

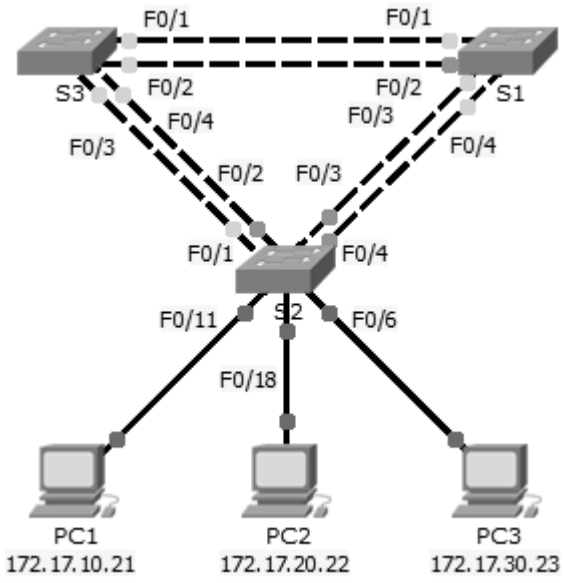
Step 3. Verify your configuration.

Use the **show running-configuration** command to verify your configuration.

Packet Tracer Activity

3.3.2.2 Packet Tracer–Configuring Rapid PVST+

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
S1	VLAN 99	172.17.99.11	255.255.255.0	N/A
S2	VLAN 99	172.17.99.12	255.255.255.0	N/A
S3	VLAN 99	172.17.99.13	255.255.255.0	N/A
PC1	NIC	172.17.10.21	255.255.255.0	172.17.10.254
PC2	NIC	172.17.20.22	255.255.255.0	172.17.20.254
PC3	NIC	172.17.30.23	255.255.255.0	172.17.30.254

Switch Port Assignment Specifications

Ports	Assignments	Network
S2 F0/6	VLAN 30	172.17.30.0/24
S2 F0/18	VLAN 20	172.17.20.0/24
S2 F0/11	VLAN 10	172.17.10.0/24

Objectives

Part 1: Configure VLANs

Part 2: Configure Rapid Spanning Tree PVST+ Load Balancing

Part 3: Configure PortFast and BPDU Guard

Background

In this activity, you will configure VLANs and trunks, Rapid Spanning Tree PVST+, primary and secondary root bridges, and examine the configuration results. You will also optimize the network by configuring PortFast, and BPDU Guard on edge ports.

Part 1: Configure VLANs

Step 1. Enable the user ports on S2 in access mode.

Refer to the topology diagram to determine which switch ports on **S2** are activated for end-user device access. These three ports will be configured for access mode and enabled with the **no shutdown** command.

Step 2. Create VLANs.

Using the appropriate command, create VLANs 10, 20, 30, 40, 50, 60, 70, 80, and 99 on all of the switches.

Step 3. Assign VLANs to switch ports.

Port assignments are listed in the table at the beginning of the activity. Save your configurations after assigning switch ports to the VLANs.

Step 4. Verify the VLANs.

Use the **show vlan brief** command on all switches to verify that all VLANs are registered in the VLAN table.

Step 5. Assign the trunks to native VLAN 99.

Use the appropriate command to configure ports F0/1 to F0/4 on each switch as trunk ports and assign these trunk ports to native VLAN 99.

_____

_____

_____

_____

_____

_____

_____

_____

_____

Step 6. Configure the management interface on all three switches with an address.

Verify that the switches are correctly configured by pinging between them.

Part 2: Configure Rapid Spanning Tree PVST+ Load Balancing

The Rapid Spanning Tree Protocol (RSTP; IEEE 802.1w) can be seen as an evolution of the 802.1D standard more so than a revolution. The 802.1D terminology remains primarily the same. Most parameters have been left unchanged so users familiar with 802.1D can rapidly configure the new protocol comfortably. In most cases, RSTP performs better than proprietary extensions of Cisco without any additional configuration. 802.1w can also revert back to 802.1D in order to interoperate with legacy bridges on a per-port basis.

Step 1. Configure STP mode.

Use the **spanning-tree mode** command to configure the switches to use rapid PVST as the STP mode.

Step 2. Configure Rapid Spanning Tree PVST+ load balancing.

Configure **S1** to be the primary root for VLANs 1, 10, 30, 50, and 70. Configure **S3** to be the primary root for VLANs 20, 40, 60, 80, and 99. Configure **S2** to be the secondary root for all of the VLANs.

Verify your configurations by using the **show spanning-tree** command.

Part 3: Configure PortFast and BPDU Guard

Step 1. Configuring PortFast on S2.

PortFast causes a port to enter the forwarding state almost immediately by dramatically decreasing the time of the listening and learning states. PortFast minimizes the time it takes for the server or workstation to come online. Configure PortFast on **S2** interfaces that are connected to PCs.

Step 2. Configuring BPDU Guard on S2.

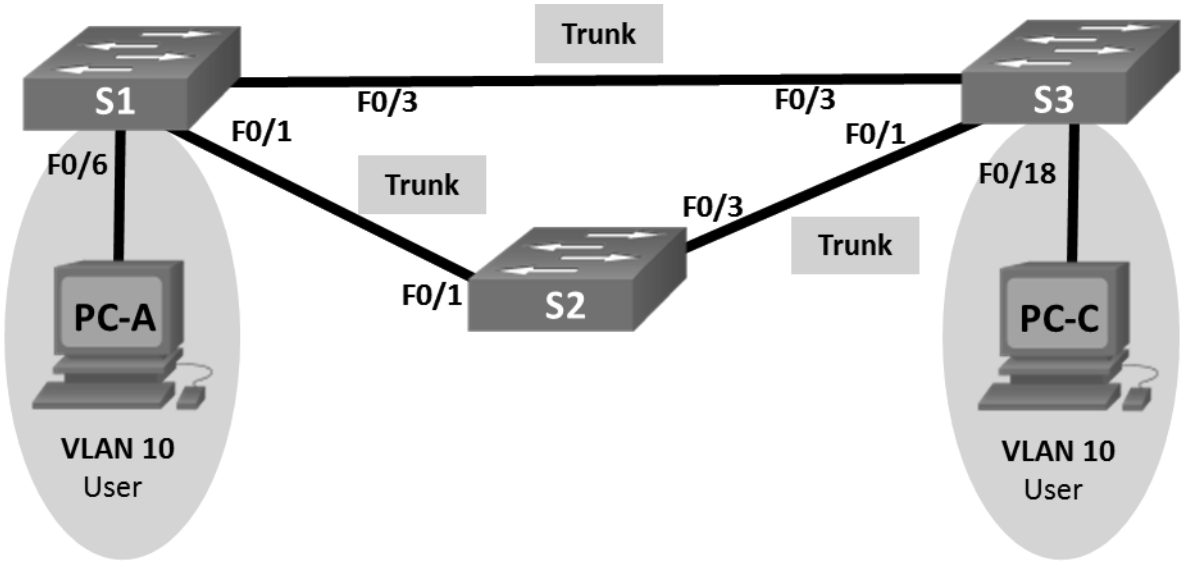
The STP PortFast BPDU Guard enhancement allows network designers to enforce the STP domain borders and keep the active topology predictable. The devices behind the ports that have STP PortFast enabled are not able to influence the STP topology. At the reception of BPDUs, the BPDU Guard operation disables the port that has PortFast configured. The BPDU Guard transitions the port into err-disable state, and a message appears on the console. Configure BPDU Guard on **S2** interfaces that are connected to PCs.

Step 3. Verify your configuration.

Use the **show run** command to verify your configuration.

3.3.2.3 Lab–Configuring Rapid PVST+, PortFast, and BPDU Guard

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 BDPU 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.

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.

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.

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.

Step 5. Verify configurations and connectivity.

What is the default setting for spanning-tree mode on Cisco switches?

_____

Verify connectivity between PC-A and PC-C. Was your ping successful? _____

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+.

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.

_____

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? _____

What is the bridge priority of switch S2 for VLAN 1? _____

What is the bridge priority of switch S3 for VLAN 1? _____

Which switch is the root bridge? _____

Why was this switch elected as the root bridge?

_____

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.

a. Configure switch S2 to be the primary root bridge for all existing VLANs. Write the command in the space provided.

_____

b. Configure switch S1 to be the secondary root bridge for all existing VLANs. Write the command in the space provided.

_____

Use the **show spanning-tree** command to answer the following questions:

What is the bridge priority of S1 for VLAN 1? _____

What is the bridge priority of S2 for VLAN 1? _____

Which interface in the network is in a blocking state? _____

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.

a. 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
```

b. 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
*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?

_____

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 time-stamp format is date hh.mm.ss:msec.

_____

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+.

a. Configure S1 for Rapid PVST+. Write the command in the space provided.

_____

b. Configure S2 and S3 for Rapid PVST+.

_____

_____

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.

_____

b. Configure interface F0/6 on S1 with BPDU guard. Write the command in the space provided.

_____

c. Globally configure all non-trunking ports on switch S3 with PortFast. Write the command in the space provided.

_____

d. Globally configure all non-trunking PortFast ports on switch S3 with BPDU guard. Write the command in the space provided.

_____

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
*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.

_____

Reflection

1. What is the main benefit of using Rapid PVST+?

   _____

2. How does configuring a port with PortFast allow for faster convergence?

   _____

3. What protection does BPDU guard provide?

   _____

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
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
```

3.4.1.1 Class Activity–Documentation Tree

Objective

Identify common STP configuration issues.

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 to 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