Chapter 2 — LAN Redundancy

2.0.1.2 Class Activity – Stormy Traffic ( )

Objective

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

Notes:

- Spanning Tree Protocol (STP) and its variations are the focus of this chapter. This modeling activity is designed to help students realize that a switched network can be shaped using STP or its variations.
- This activity can be completed individually, in small groups, or as a class.

Scenario

It is your first day on the job as a network administrator for a small- to medium-sized business. The previous network administrator left suddenly after a network upgrade took place for the business.

During the upgrade, a new switch was added. Since the upgrade, many employees complain that they are having trouble accessing the Internet and servers on your network. In fact, most of them cannot access the network at all. Your corporate manager asks you to immediately research what could be causing these connectivity problems and delays.

So you take a look at the equipment operating on your network at your main distribution facility in the building. You notice that the network topology seems to be visually correct and that cables have been connected correctly, routers and switches are powered on and operational, and switches are connected together to provide backup or redundancy.

However, one thing you do notice is that all of your switches' status lights are constantly blinking at a very fast pace to the point that they almost appear solid. You think you have found the problem with the connectivity issues your employees are experiencing.

Use the Internet to research STP. As you research, take notes and describe:

- Broadcast storm
- Switching loops
- The purpose of STP
- Variations of STP

Complete the reflection questions that accompany the PDF file for this activity. Save your work and be prepared to share your answers with the class.

Resources

- Internet access to the World Wide Web

Reflection

1. What is a definition of a broadcast storm? How does a broadcast storm develop?

A broadcast storm develops when switches forward traffic out of all ports while looking for a destination for the traffic. It develops when switches continuously forward traffic between themselves without time to block interfaces on the switches to create one good path to the destination.

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

A switching loop forms when redundancy is present on switches and the paths formed create a circle of delivery. Packets travel endlessly along the redundant paths, particularly with multicast and broadcast traffic. This causes a myriad of traffic on the network, causing hosts to have problems accessing the network.

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

Implement STP or one of its variations. Create VLANs to limit broadcast domains. Check physical connections to make sure that cabling is correct so that switches are not perpetuating broadcasts and routing loops within your network.

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

802.1D (STP), 802.1W (RSTP), and 802.1I (MST)

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

Three answers would be appropriate for this question.

- A network protocol analyzer could be used to check and map network traffic, thus identifying what kind of network problem is present.
- Removing the new switch and its cables to isolate the problem might be a troubleshooting step.
- Checking each switch to make sure that STP is operational is another possible troubleshooting step.

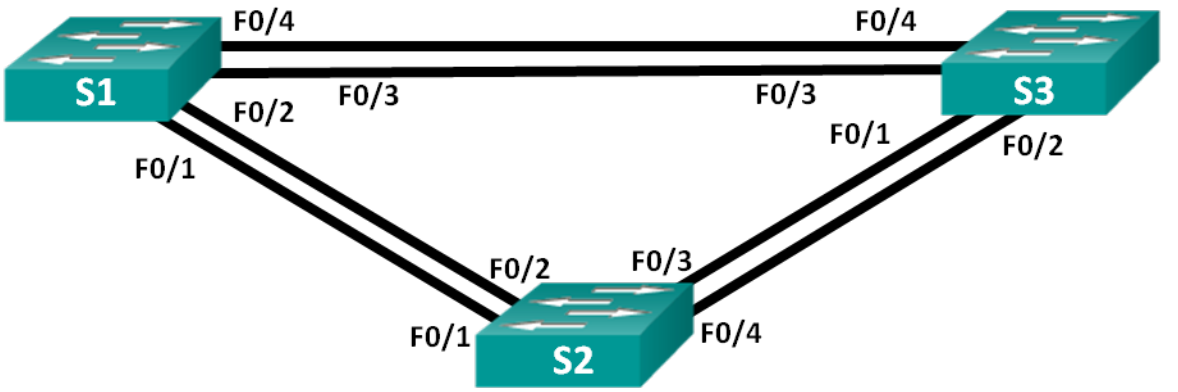
Identify elements of the model that map to IT-related content:

- Spanning Tree Protocol (STP)
- Broadcast storms
- Switching loops
- IEEE STP standards (802.1D, 802.1S, 802.1I)

2.1.2.10 Lab – Building a Switched Network with Redundant Links

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

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask
S1	VLAN 1	192.168.1.1	255.255.255.0
S2	VLAN 1	192.168.1.2	255.255.255.0
S3	VLAN 1	192.168.1.3	255.255.255.0

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Determine the Root Bridge

Part 3: Observe STP Port Selection Based on Port Cost

Part 4: Observe STP Port Selection Based on Port Priority

Background / Scenario

Redundancy increases the availability of devices in the network topology by protecting the network from a single point of failure. Redundancy in a switched network is accomplished through the use of multiple switches or multiple links between switches. When physical redundancy is introduced into a network design, loops and duplicate frames can occur.

The Spanning Tree Protocol (STP) was developed as a Layer 2 loop-avoidance mechanism for redundant links in a switched network. STP ensures that there is only one logical path between all destinations on the network by intentionally blocking redundant paths that could cause a loop.

In this lab, you will use the **show spanning-tree** command to observe the STP election process of the root bridge. You will also observe the port selection process based on cost and priority.

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.

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

Required Resources

- 3 Switches (Cisco 2960 with Cisco IOS Release 15.0(2) lanbasek9 image or comparable)
- Console cables to configure the Cisco IOS devices via the console ports
- Ethernet cables as shown in the topology

Part 1: Build the Network and Configure Basic Device Settings

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

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

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

Step 2: Initialize and reload the switches as necessary.

Step 3: Configure basic settings for each switch.

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? _____ Yes

Can S1 ping S3? _____ Yes

Can S2 ping S3? _____ Yes

Troubleshoot until you are able to answer yes to all questions.

Part 2: Determine the Root Bridge

Every spanning-tree instance (switched LAN or broadcast domain) has a switch designated as the root bridge. The root bridge serves as a reference point for all spanning-tree calculations to determine which redundant paths to block.

An election process determines which switch becomes the root bridge. The switch with the lowest bridge identifier (BID) becomes the root bridge. The BID is made up of a bridge priority value, an extended system ID, and the MAC address of the switch. The priority value can range from 0 to 65,535, in increments of 4,096, with a default value of 32,768.

Step 1: Deactivate all ports on the switches.

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

S2(config)# interface range f0/1-24, g0/1-2
S2(config-if-range)# shutdown
S2(config-if-range)# end

S3(config)# interface range f0/1-24, g0/1-2
S3(config-if-range)# shutdown
S3(config-if-range)# end
```

Step 2: Configure connected ports as trunks.

```
S1(config)# interface range f0/1-4
S1(config-if-range)# switchport mode trunk
S1(config-if-range)# end

S2(config)# interface range f0/1-4
S2(config-if-range)# switchport mode trunk
S2(config-if-range)# end

S3(config)# interface range f0/1-4
S3(config-if-range)# switchport mode trunk
S3(config-if-range)# end
```

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

```
S1(config)# interface range f0/2, f0/4
```

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

S2(config)# interface range f0/2, f0/4
S2(config-if-range)# no shutdown
S2(config-if-range)# end

S3(config)# interface range f0/2, f0/4
S3(config-if-range)# no shutdown
S3(config-if-range)# end
```

Step 4: Display spanning tree information.

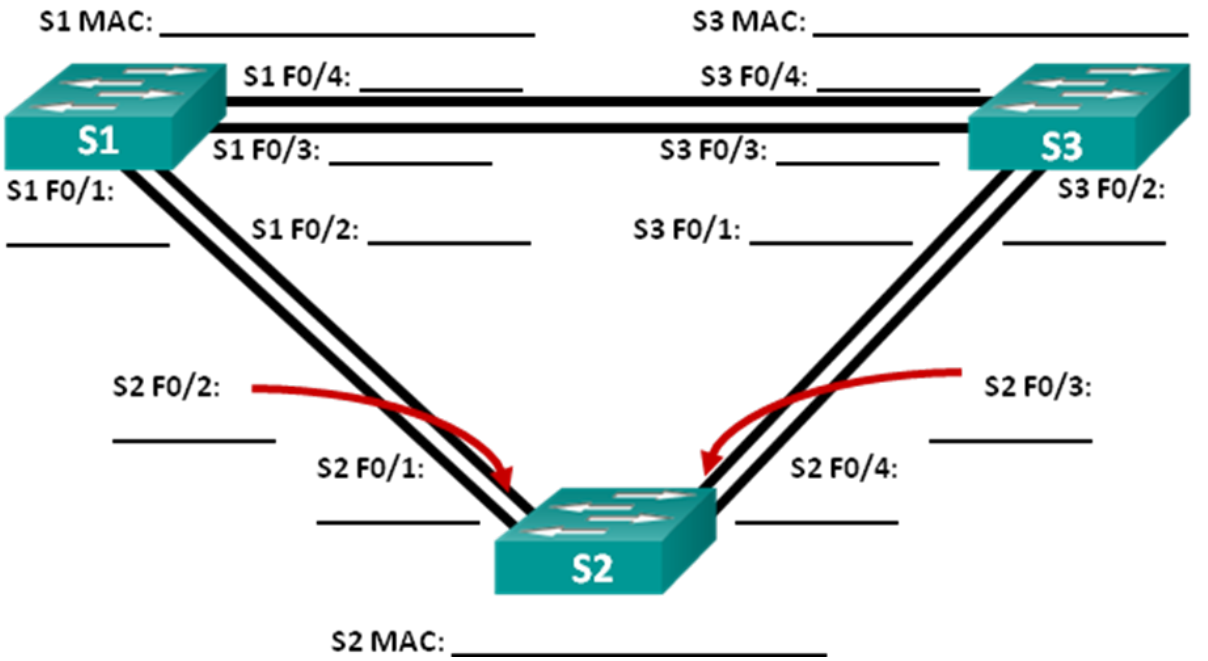
Issue the **show spanning-tree** command on all three switches. The Bridge ID Priority is calculated by adding the priority value and the extended system ID. The extended system ID is always the VLAN number. In the example below, all three switches have equal Bridge ID Priority values (32769 = 32768 + 1, where default priority = 32768, VLAN number = 1); therefore, the switch with the lowest MAC address becomes the root bridge (S2 in the example).

```
S1# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0cd9.96d2.4000
              Cost        19
              Port        2 (FastEthernet0/2)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0cd9.96e8.8a00
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/2               Root FWD 19        128.2    P2p
Fa0/4               Altn BLK 19        128.4    P2p

S2# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
```

```
  Root ID     Priority    32769
              Address     0cd9.96d2.4000
              This bridge is the root
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0cd9.96d2.4000
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/2               Desg FWD 19        128.2    P2p
Fa0/4               Desg FWD 19        128.4    P2p

S3# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0cd9.96d2.4000
              Cost        19
              Port        2 (FastEthernet0/2)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0cd9.96e8.7400
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/2               Root FWD 19        128.2    P2p
Fa0/4               Desg FWD 19        128.4    P2p
```

Note: The default STP mode on the 2960 switch is Per VLAN Spanning Tree (PVST).

In the diagram below, record the Role and Status (Sts) of the active ports on each switch in the Topology.



Based on the output from your switches, answer the following questions.

Which switch is the root bridge? _____ Answers will vary, the above output shows S2 as the root bridge.

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

_____

The root bridge was chosen because it had the lowest bridge ID (Priority value + extended system ID (VLAN) + MAC address of switch).

Which ports are the root ports on the switches? _____ Answers will vary, the above output shows S1 – F0/2, and S3 – F0/2.

Which ports are the designated ports on the switches? _____ Answers will vary, the above output shows S2 – F0/2 and F0/4, S3 – F0/4

What port is showing as an alternate port and is currently being blocked? _____ Answers will vary, the above output shows S1 – F0/4.

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

_____

_____

_____

_____

The spanning tree algorithm (STA) uses the root bridge as the reference point and then determines which ports to block based on path cost. If path costs are equal it then compares BIDs. Lower numbers are preferred. In the output above, the link between S1 and S3 has the highest cost to the root bridge. The path cost through both switches is the same, so STA selected the path through the switch with the lower BID, and blocked the port (F0/4) on the switch with the higher BID (S1).

Part 3: Observe STP Port Selection Based on Port Cost

The spanning tree algorithm (STA) uses the root bridge as the reference point and then determines which ports to block, based on path cost. The port with the lower path cost is preferred. If port costs are equal, then spanning tree compares BIDs. If the BIDs are equal, then the port priorities are used to break the tie. Lower values are always preferred. In Part 3, you will change the port cost to control which port is blocked by spanning tree.

Step 1: Locate the switch with the blocked port.

With the current configuration, only one switch should have a port that is blocked by STP. Issue the **show spanning-tree** command on both non-root switches. In the example below, spanning tree is blocking port F0/4 on the switch with the highest BID (S1).

```
S1# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0cd9.96d2.4000
              Cost        19
              Port        2 (FastEthernet0/2)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0cd9.96e8.8a00
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/2               Root FWD 19        128.2    P2p
Fa0/4               Altn BLK 19        128.4    P2p

S3# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0cd9.96d2.4000
              Cost        19
              Port        2 (FastEthernet0/2)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
```

```
              Address     0cd9.96e8.7400
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  15  sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/2               Root FWD 19        128.2    P2p
Fa0/4               Desg FWD 19        128.4    P2p
```

Note: Root bridge and port selection may differ in your topology.

Step 2: Change port cost.

In addition to the blocked port, the only other active port on this switch is the port designated as the root port. Lower the cost of this root port to 18 by issuing the **spanning-tree cost 18** interface configuration mode command.

```
S1(config)# interface f0/2
S1(config-if)# spanning-tree cost 18
```

Step 3: Observe spanning tree changes.

Re-issue the **show spanning-tree** command on both non-root switches. Observe that the previously blocked port (S1 - F0/4) is now a designated port and spanning tree is now blocking a port on the other non-root switch (S3 - F0/4).

```
S1# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0cd9.96d2.4000
              Cost        18
              Port        2 (FastEthernet0/2)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0cd9.96e8.8a00
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/2               Root FWD 18        128.2    P2p
Fa0/4               Desg FWD 19        128.4    P2p
```

```
S3# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0cd9.96d2.4000
              Cost        19
              Port        2 (FastEthernet0/2)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0cd9.96e8.7400
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/2               Root FWD 19        128.2    P2p
Fa0/4               Altn BLK 19        128.4    P2p
```

Why did spanning tree change the previously blocked port to a designated port, and block the port that was a designated port on the other switch?

STP looks at path cost first. The port with the lower path cost will always be preferred over a port with a higher path cost.

Step 4: Remove port cost changes.

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.

```
S1(config)# interface range f0/1, f0/3
```

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

S2(config)# interface range f0/1, f0/3
S2(config-if-range)# no shutdown
S2(config-if-range)# end

S3(config)# interface range f0/1, f0/3
S3(config-if-range)# no shutdown
S3(config-if-range)# end
```

b. Wait 30 seconds for STP to complete the port transition process, and then issue the **show spanning-tree** command on the non-root switches. Observe that the root port has moved to the lower numbered port linked to the root switch, and blocked the previous root port.

```
S1# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0cd9.96d2.4000
              Cost        19
              Port        1 (FastEthernet0/1)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0cd9.96e8.8a00
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  15  sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Root FWD 19        128.1    P2p
Fa0/2               Altn BLK 19        128.2    P2p
Fa0/3               Altn BLK 19        128.3    P2p
Fa0/4               Altn BLK 19        128.4    P2p

S3# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0cd9.96d2.4000
```

```
               Cost        19
               Port        1 (FastEthernet0/1)
               Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     0cd9.96e8.7400
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  15  sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Root FWD 19        128.1    P2p
Fa0/2               Altn BLK 19        128.2    P2p
Fa0/3               Desg FWD 19        128.3    P2p
Fa0/4               Desg FWD 19        128.4    P2p
```

What port did STP select as the root port on each non-root switch? _____

Answers will vary, but in the example above S1 – F0/1, and S3 – F0/1.

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

_____

_____

The default port value of the ports is 128; therefore, STP used the port number to break the tie. It selected the lower port number as the root port, and blocked the higher-numbered port with the redundant path to the root bridge.

Reflection

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

_____

Path cost. It selects the path with the lower accumulated cost.

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

_____

BID by selecting the lower value.

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

_____

An aggregation of the port priority and the port number, the lower value is preferred.

Device Configs - Final

Switch S1

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

Current configuration : 1829 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 switchport mode trunk
!
interface FastEthernet0/2
 switchport mode trunk
!
interface FastEthernet0/3
 switchport mode trunk
!
```

```
interface FastEthernet0/4
 switchport mode trunk
!
interface FastEthernet0/5
 shutdown
!
interface FastEthernet0/6
 shutdown
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
!
interface FastEthernet0/11
 shutdown
!
interface FastEthernet0/12
 shutdown
!
interface FastEthernet0/13
 shutdown
!
interface FastEthernet0/14
 shutdown
!
interface FastEthernet0/15
 shutdown
!
interface FastEthernet0/16
 shutdown
!
interface FastEthernet0/17
```

```
 shutdown
!
interface FastEthernet0/18
 shutdown
!
interface FastEthernet0/19
 shutdown
!
interface FastEthernet0/20
 shutdown
!
interface FastEthernet0/21
 shutdown
!
interface FastEthernet0/22
 shutdown
!
interface FastEthernet0/23
 shutdown
!
interface FastEthernet0/24
 shutdown
!
interface GigabitEthernet0/1
 shutdown
!
interface GigabitEthernet0/2
 shutdown
!
interface Vlan1
 ip address 192.168.1.1 255.255.255.0
!
ip http server
ip http secure-server
!
!
banner motd ^C Unauthorized Access is Prohibited! ^C
!
line con 0
 password cisco
```

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

Switch S2

```
S2# show run
Building configuration...

Current configuration : 1827 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
```

```
interface FastEthernet0/1
 switchport mode trunk
!
interface FastEthernet0/2
 switchport mode trunk
!
interface FastEthernet0/3
 switchport mode trunk
!
interface FastEthernet0/4
 switchport mode trunk
!
interface FastEthernet0/5
 shutdown
!
interface FastEthernet0/6
 shutdown
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
!
interface FastEthernet0/11
 shutdown
!
interface FastEthernet0/12
 shutdown
!
interface FastEthernet0/13
 shutdown
!
interface FastEthernet0/14
```

```
 shutdown
!
interface FastEthernet0/15
 shutdown
!
interface FastEthernet0/16
 shutdown
!
interface FastEthernet0/17
 shutdown
!
interface FastEthernet0/18
 shutdown
!
interface FastEthernet0/19
 shutdown
!
interface FastEthernet0/20
 shutdown
!
interface FastEthernet0/21
 shutdown
!
interface FastEthernet0/22
 shutdown
!
interface FastEthernet0/23
 shutdown
!
interface FastEthernet0/24
 shutdown
!
interface GigabitEthernet0/1
 shutdown
!
interface GigabitEthernet0/2
 shutdown
!
interface Vlan1
ip address 192.168.1.2 255.255.255.0
```

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

Switch S3

```
S3# show run
Building configuration...

Current configuration : 1829 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S3
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
```

```
!
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 switchport mode trunk
!
interface FastEthernet0/2
 switchport mode trunk
!
interface FastEthernet0/3
 switchport mode trunk
!
interface FastEthernet0/4
 switchport mode trunk
!
interface FastEthernet0/5
 shutdown
!
interface FastEthernet0/6
 shutdown
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
!
interface FastEthernet0/11
```

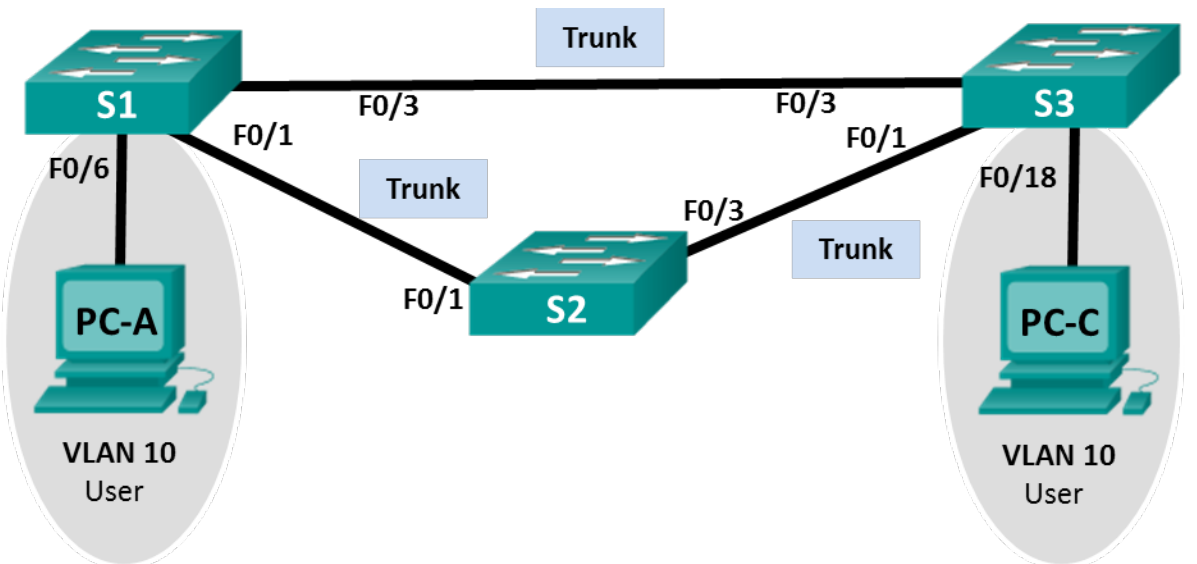
```
 shutdown
!
interface FastEthernet0/12
 shutdown
!
interface FastEthernet0/13
 shutdown
!
interface FastEthernet0/14
 shutdown
!
interface FastEthernet0/15
 shutdown
!
interface FastEthernet0/16
 shutdown
!
interface FastEthernet0/17
 shutdown
!
interface FastEthernet0/18
 shutdown
!
interface FastEthernet0/19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

```
!
interface GigabitEthernet0/1
 shutdown
!
interface GigabitEthernet0/2
 shutdown
!
interface Vlan1
 ip address 192.168.1.3 255.255.255.0
!
ip http server
ip http secure-server
!
banner motd ^C Unauthorized Access is Prohibited! ^C
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

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

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

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask
S1	VLAN 99	192.168.1.11	255.255.255.0
S2	VLAN 99	192.168.1.12	255.255.255.0
S3	VLAN 99	192.168.1.13	255.255.255.0
PC-A	NIC	192.168.0.2	255.255.255.0
PC-C	NIC	192.168.0.3	255.255.255.0

VLAN Assignments

VLAN	Name
10	User
99	Management

Objectives

Part 1: Build the Network and Configure Basic Device Settings

Part 2: Configure VLANs, Native VLAN, and Trunks

Part 3: Configure the Root Bridge and Examine PVST+ Convergence

Part 4: Configure Rapid PVST+, PortFast, BPDU Guard, and Examine Convergence

Background / Scenario

The Per-VLAN Spanning Tree (PVST) protocol is Cisco proprietary. Cisco switches default to PVST. Rapid PVST+ (IEEE 802.1w) is an enhanced version of PVST+ and allows for faster spanning-tree calculations and convergence in response to Layer 2 topology changes. Rapid PVST+ defines three port states: discarding, learning, and forwarding, and provides multiple enhancements to optimize network performance.

In this lab, you will configure the primary and secondary root bridge, examine PVST+ convergence, configure Rapid PVST+ and compare its convergence to PVST+. In addition, you will configure edge ports to transition immediately to a forwarding state using PortFast and prevent the edge ports from forwarding BDPUs using 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.

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

Required Resources

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

Part 1: Build the Network and Configure Basic Device Settings

In Part 1, you will set up the network topology and configure basic settings, such as the interface IP addresses, device access, and passwords.

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

Step 2: Configure PC hosts.

Step 3: Initialize and reload the switches as necessary.

Step 4: Configure basic settings for each switch.

a. Disable DNS lookup.

b. Configure the device name as shown in the Topology.

c. Assign **cisco** as the console and vty passwords and enable login.

d. Assign **class** as the encrypted privileged EXEC mode password.

e. Configure **logging synchronous** to prevent console messages from interrupting command entry.

f. Shut down all switch ports.

g. Copy the running configuration to startup configuration.

Part 2: Configure VLANs, Native VLAN, and Trunks

In Part 2, you will create VLANs, assign switch ports to VLANs, configure trunk ports, and change the native VLAN for all switches.

Note: The required commands for Part 2 are provided in Appendix A. Test your knowledge by trying to configure the VLANs, native VLAN, and trunks without referring to the appendix.

Step 1: Create VLANs.

Use the appropriate commands to create VLANs 10 and 99 on all of the switches. Name VLAN 10 as **User** and VLAN 99 as **Management**.

```
S1(config)# vlan 10
S1(config-vlan)# name User
S1(config-vlan)# vlan 99
S1(config-vlan)# name Management

S2(config)# vlan 10
S2(config-vlan)# name User
S2(config-vlan)# vlan 99
S2(config-vlan)# name Management

S3(config)# vlan 10
S3(config-vlan)# name User
S3(config-vlan)# vlan 99
S3(config-vlan)# name Management
```

Step 2: Enable user ports in access mode and assign VLANs.

For S1 F0/6 and S3 F0/18, enable the ports, configure them as access ports, and assign them to VLAN 10.

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

S3(config)# interface f0/18
S3(config-if)# no shutdown
S3(config-if)# switchport mode access
S3(config-if)# switchport access vlan 10
```

Step 3: Configure trunk ports and assign to native VLAN 99.

For ports F0/1 and F0/3 on all switches, enable the ports, configure them as trunk ports, and assign them to native VLAN 99.

```
S1(config)# interface range f0/1,f0/3
S1(config-if)# no shutdown
S1(config-if)# switchport mode trunk
S1(config-if)# switchport trunk native vlan 99

S2(config)# interface range f0/1,f0/3
S2(config-if)# no shutdown
S2(config-if)# switchport mode trunk
S2(config-if)# switchport trunk native vlan 99

S3(config)# interface range f0/1,f0/3
S3(config-if)# no shutdown
S3(config-if)# switchport mode trunk
S3(config-if)# switchport trunk native vlan 99
```

Step 4: Configure the management interface on all switches.

Using the Addressing Table, configure the management interface on all switches with the appropriate IP address.

```
S1(config)# interface vlan 99
S1(config-if)# ip address 192.168.1.11 255.255.255.0

S2(config)# interface vlan 99
S2(config-if)# ip address 192.168.1.12 255.255.255.0

S3(config)# interface vlan 99
S3(config-if)# ip address 192.168.1.13 255.255.255.0
```

Step 5: Verify configurations and connectivity.

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

```
S1# show vlan brief

VLAN Name                              Status    Ports
---- --------------------------------- --------- -------------------------------
1    default                           active    Fa0/2, Fa0/4, Fa0/5, Fa0/7
```

```
                                          Fa0/8, Fa0/9, Fa0/10, Fa0/11
                                          Fa0/12, Fa0/13, Fa0/14, Fa0/15
                                          Fa0/16, Fa0/17, Fa0/18, Fa0/19
                                          Fa0/20, Fa0/21, Fa0/22, Fa0/23
                                          Fa0/24, Gi0/1, Gi0/2
10   User                                 active    Fa0/6
99   Management                           active
1002 fddi-default                         act/unsup
1003 token-ring-default                   act/unsup
1004 fddinet-default                      act/unsup
1005 trnet-default                        act/unsup

S2# show vlan brief

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

S3# show vlan brief

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

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

Use the **show interfaces trunk** command on all switches to verify trunk interfaces.

```
S1# show interfaces trunk

Port        Mode             Encapsulation  Status        Native vlan
Fa0/1       on               802.1q         trunking      99
Fa0/3       on               802.1q         trunking      99

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

Port        Vlans allowed and active in management domain
Fa0/1       1,10,99
Fa0/3       1,10,99

Port        Vlans in spanning tree forwarding state and not pruned
Fa0/1       none
Fa0/3       1,10,99

S2# show interfaces trunk

Port        Mode             Encapsulation  Status        Native vlan
Fa0/1       on               802.1q         trunking      99
Fa0/3       on               802.1q         trunking      99

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

Port        Vlans allowed and active in management domain
Fa0/1       1,10,99
Fa0/3       1,10,99

Port        Vlans in spanning tree forwarding state and not pruned
Fa0/1       1,10,99
Fa0/3       1,10,99
```

```
S3# show interfaces trunk

Port        Mode             Encapsulation  Status        Native vlan
Fa0/1       on               802.1q         trunking      99
Fa0/3       on               802.1q         trunking      99

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

Port        Vlans allowed and active in management domain
Fa0/1       1,10,99
Fa0/3       1,10,99

Port        Vlans in spanning tree forwarding state and not pruned
Fa0/1       1,10,99
Fa0/3       1,10,99
```

Use the **show running-config** command on all switches to verify all other configurations.

```
S1# show running-config
Building configuration...

Current configuration : 1857 bytes
!

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

```
!
no ip domain-lookup
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 switchport trunk native vlan 99
 switchport mode trunk
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 switchport trunk native vlan 99
 switchport mode trunk
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
 shutdown
!
interface FastEthernet0/6
 switchport access vlan 10
 switchport mode access
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
```

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

```
 shutdown
!
interface FastEthernet0/24
 shutdown
!
interface GigabitEthernet0/1
 shutdown
!
interface GigabitEthernet0/2
 shutdown
!
interface Vlan1
 no ip address
!
interface Vlan99
 ip address 192.168.1.11 255.255.255.0
!
ip http server
ip http secure-server
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

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

_____

The default spanning-tree mode is PVST+.

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

If your ping was unsuccessful, troubleshoot the configurations until the issue is resolved.

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

Part 3: Configure the Root Bridge and Examine PVST+ Convergence

In Part 3, you will determine the default root in the network, assign the primary and secondary root, and use the **debug** command to examine convergence of PVST+.

Note: The required commands for Part 3 are provided in Appendix A. Test your knowledge by trying to configure the root bridge without referring to the appendix.

Step 1: Determine the current root bridge.

Which command allows a user to determine the spanning-tree status of a Cisco Catalyst switch for all VLANs? Write the command in the space provided.

_____

show spanning-tree

Use the command on all three switches to determine the answers to the following questions:

Note: There are three instances of the spanning tree on each switch. The default STP configuration on Cisco switches is PVST+, which creates a separate spanning tree instance for each VLAN (VLAN 1 and any user-configured VLANs).

What is the bridge priority of switch S1 for VLAN 1? _____ 32769

What is the bridge priority of switch S2 for VLAN 1? _____ 32769

What is the bridge priority of switch S3 for VLAN 1? _____ 32769

Which switch is the root bridge? _____ Answers will vary. In this configuration, it is switch S3.

Why was this switch elected as the root bridge?

_____

By default, spanning tree elects the root bridge based on lowest MAC address.

```
S1# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0cd9.96d2.5100
              Cost        19
              Port        3 (FastEthernet0/3)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0cd9.96e2.3d80
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
```

```
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Desg FWD 19        128.1    P2p
Fa0/3               Root FWD 19        128.3    P2p

VLAN0010
  Spanning tree enabled protocol ieee
  Root ID     Priority    32778
              Address     0cd9.96d2.5100
              Cost        19
              Port        3 (FastEthernet0/3)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32778  (priority 32768 sys-id-ext 10)
              Address     0cd9.96e2.3d80
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Desg FWD 19        128.1    P2p
Fa0/3               Root FWD 19        128.3    P2p
Fa0/6               Desg FWD 19        128.6    P2p

VLAN0099
  Spanning tree enabled protocol ieee
  Root ID     Priority    32867
              Address     0cd9.96d2.5100
              Cost        19
              Port        3 (FastEthernet0/3)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32867  (priority 32768 sys-id-ext 99)
              Address     0cd9.96e2.3d80
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec
```

```
Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Desg FWD 19        128.1    P2p
Fa0/3               Root FWD 19        128.3    P2p

S2# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0cd9.96d2.5100
              Cost        19
              Port        3 (FastEthernet0/3)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0cd9.96e8.6f80
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Altn BLK 19        128.1    P2p
Fa0/3               Root FWD 19        128.3    P2p

VLAN0010
  Spanning tree enabled protocol ieee
  Root ID     Priority    32778
              Address     0cd9.96d2.5100
              Cost        19
              Port        3 (FastEthernet0/3)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32778  (priority 32768 sys-id-ext 10)
              Address     0cd9.96e8.6f80
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Altn BLK 19        128.1    P2p
Fa0/3               Root FWD 19        128.3    P2p
```

```
VLAN0099
  Spanning tree enabled protocol ieee
  Root ID     Priority    32867
              Address     0cd9.96d2.5100
              Cost        19
              Port        3 (FastEthernet0/3)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32867  (priority 32768 sys-id-ext 99)
              Address     0cd9.96e8.6f80
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Altn BLK 19        128.1    P2p
Fa0/3               Root FWD 19        128.3    P2p

S3# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0cd9.96d2.5100
              This bridge is the root
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0cd9.96d2.5100
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Desg FWD 19        128.1    P2p
Fa0/3               Desg FWD 19        128.3    P2p

VLAN0010
  Spanning tree enabled protocol ieee
  Root ID     Priority    32778
              Address     0cd9.96d2.5100
```

```
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32778  (priority 32768 sys-id-ext 10)
             Address     0cd9.96d2.5100
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Desg FWD 19        128.1    P2p
Fa0/3               Desg FWD 19        128.3    P2p
Fa0/18              Desg FWD 19        128.18   P2p

VLAN0099
  Spanning tree enabled protocol ieee
  Root ID    Priority    32867
             Address     0cd9.96d2.5100
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32867  (priority 32768 sys-id-ext 99)
             Address     0cd9.96d2.5100
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Desg FWD 19        128.1    P2p
Fa0/3               Desg FWD 19        128.3    P2p
```

Step 2: Configure a primary and secondary root bridge for all existing VLANs.

Having a root bridge (switch) elected by MAC address may lead to a suboptimal configuration. In this lab, you will configure switch S2 as the root bridge and S1 as the secondary root bridge.

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

```
S2(config)# spanning-tree vlan 1,10,99 root primary
```

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

```
S1(config)# spanning-tree vlan 1,10,99 root secondary
```

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

What is the bridge priority of S1 for VLAN 1? _____ 28673

What is the bridge priority of S2 for VLAN 1? _____ 24577

Which interface in the network is in a blocking state? _____
Interface F0/3 on switch S3

```
S1# show spanning-tree vlan 1

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    24577
              Address     0cd9.96d2.4000
              Cost        19
              Port        1 (FastEthernet0/1)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    28673  (priority 28672 sys-id-ext 1)
              Address     0cd9.96e8.8a00
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  15  sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Root FWD 19        128.1    P2p
Fa0/3               Desg FWD 19        128.3    P2p

S2# show spanning-tree vlan 1

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    24577
              Address     0cd9.96d2.4000
              This bridge is the root
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    24577  (priority 24576 sys-id-ext 1)
              Address     0cd9.96d2.4000
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  15  sec
```

```
Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Desg FWD 19        128.1    P2p
Fa0/3               Desg FWD 19        128.3    P2p

S3# show spanning-tree vlan 1

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    24577
              Address     0cd9.96d2.4000
              Cost        19
              Port        1 (FastEthernet0/1)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0cd9.96e8.7400
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Fa0/1               Root FWD 19        128.1    P2p
Fa0/3               Altn BLK 19        128.3    P2p
```

Step 3: Change the Layer 2 topology and examine convergence.

To examine PVST+ convergence, you will create a Layer 2 topology change while using the **debug** command to monitor spanning-tree events.

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 ad-
ministratively 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?

Listening, learning, and forwarding

Using the time stamp from the first and last STP debug message, calculate the time (to the nearest second) that it took for the network to converge. **Hint**: The debug timestamp format is date hh.mm.ss:msec.

Answers may vary slightly but convergence time should be approximately 30 seconds.

Part 4: Configure Rapid PVST+, PortFast, BPDU Guard, and Examine Convergence

In Part 4, you will configure Rapid PVST+ on all switches. You will configure PortFast and BPDU guard on all access ports, and then use the **debug** command to examine Rapid PVST+ convergence.

Note: The required commands for Part 4 are provided in Appendix A. Test your knowledge by trying to configure the Rapid PVST+, PortFast, and BPDU guard without referring to the appendix.

Step 1: Configure Rapid PVST+.

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

```
S1(config)# spanning-tree mode rapid-pvst
```

b. Configure S2 and S3 for Rapid PVST+.

```
S2(config)# spanning-tree mode rapid-pvst
S3(config)# spanning-tree mode 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.

```
S1(config)# interface f0/6
S1(config-if)# spanning-tree portfast
```

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

```
S1(config)# interface f0/6
S1(config-if)# spanning-tree bpduguard enable
```

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

```
S3(config)# spanning-tree portfast default
```

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

_____

```
S3(config)# spanning-tree portfast bpduguard default
```

Step 3: Examine Rapid PVST+ convergence.

a. Enter the **debug spanning-tree events** command in privileged EXEC mode on switch S3.

b. Create a topology change by enabling interface F0/1 on switch S3.

```
S3(config)# interface f0/1
S3(config-if)# no shutdown
*Mar  1 01:28:34.946: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Mar  1 01:28:37.588: RSTP(1): initializing port Fa0/1
*Mar  1 01:28:37.588: RSTP(1): Fa0/1 is now designated
*Mar  1 01:28:37.588: RSTP(10): initializing port Fa0/1
*Mar  1 01:28:37.588: RSTP(10): Fa0/1 is now designated
*Mar  1 01:28:37.588: RSTP(99): initializing port Fa0/1
*Mar  1 01:28:37.588: RSTP(99): Fa0/1 is now designated
*Mar  1 01:28:37.597: RSTP(1): transmitting a proposal on Fa0/1
*Mar  1 01:28:37.597: RSTP(10): transmitting a proposal on Fa0/1
*Mar  1 01:28:37.597: RSTP(99): transmitting a proposal on Fa0/1
*Mar  1 01:28:37.597: RSTP(1): updt roles, received superior bpdu on Fa0/1
*Mar  1 01:28:37.597: RSTP(1): Fa0/1 is now root port
*Mar  1 01:28:37.597: RSTP(1): Fa0/3 blocked by re-root
*Mar  1 01:28:37.597: RSTP(1): synced Fa0/1
*Mar  1 01:28:37.597: RSTP(1): Fa0/3 is now alternate
*Mar  1 01:28:37.597: RSTP(10): updt roles, received superior bpdu on Fa0/1
*Mar  1 01:28:37.597: RSTP(10): Fa0/1 is now root port
*Mar  1 01:28:37.597: RSTP(10): Fa0/3 blocked by re-root
*Mar  1 01:28:37.597: RSTP(10): synced Fa0/1
*Mar  1 01:28:37.597: RSTP(10): Fa0/3 is now alternate
*Mar  1 01:28:37.597: RSTP(99): updt roles, received superior bpdu on Fa0/1
*Mar  1 01:28:37.605: RSTP(99): Fa0/1 is now root port
*Mar  1 01:28:37.605: RSTP(99): Fa0/3 blocked by re-root
*Mar  1 01:28:37.605: RSTP(99): synced Fa0/1
*Mar  1 01:28:37.605: RSTP(99): Fa0/3 is now alternate
*Mar  1 01:28:37.605: STP[1]: Generating TC trap for port FastEthernet0/1
*Mar  1 01:28:37.605: STP[10]: Generating TC trap for port FastEthernet0/1
*Mar  1 01:28:37.605: STP[99]: Generating TC trap for port FastEthernet0/1
*Mar  1 01:28:37.622: RSTP(1): transmitting an agreement on Fa0/1 as a response to a
proposal
```

```
*Mar  1 01:28:37.622: RSTP(10): transmitting an agreement on Fa0/1 as a response to a
proposal
*Mar  1 01:28:37.622: RSTP(99): transmitting an agreement on Fa0/1 as a response to a
proposal
*Mar  1 01:28:38.595: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1,
changed state to up
```

Using the time stamp from the first and last RSTP debug message, calculate the time that it took for the network to converge.

_____

Answers may vary slightly but convergence time should be under a second.

Reflection

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

_____

Rapid PVST+ decreases the time of Layer 2 convergence significantly over PVST+.

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

_____

PortFast allows for an access port to immediately transition into a forwarding state which decreases Layer 2 convergence time.

3. What protection does BPDU guard provide?

_____

BPDU guard protects the STP domain by disabling access ports that receive a BPDU. BPDUs can be used in a denial of service attack that changes a domain's root bridge and forces an STP recalculation.

Appendix A – Switch Configuration Commands

Switch S1

```
S1(config)# vlan 10
S1(config-vlan)# name User
S1(config-vlan)# vlan 99
S1(config-vlan)# name Management
S1(config-vlan)# exit
S1(config)# interface f0/6
S1(config-if)# no shutdown
S1(config-if)# switchport mode access
S1(config-if)# switchport access vlan 10
S1(config-if)# interface f0/1
S1(config-if)# no shutdown
S1(config-if)# switchport mode trunk
```

```
S1(config-if)# switchport trunk native vlan 99
S1(config-if)# interface f0/3
S1(config-if)# no shutdown
S1(config-if)# switchport mode trunk
S1(config-if)# switchport trunk native vlan 99
S1(config-if)# interface vlan 99
S1(config-if)# ip address 192.168.1.11 255.255.255.0
S1(config-if)# exit
S1(config)# spanning-tree vlan 1,10,99 root secondary
S1(config)# spanning-tree mode rapid-pvst
S1(config)# interface f0/6
S1(config-if)# spanning-tree portfast
S1(config-if)# spanning-tree bpduguard enable
```

Switch S2

```
S2(config)# vlan 10
S2(config-vlan)# name User
S2(config-vlan)# vlan 99
S2(config-vlan)# name Management
S2(config-vlan)# exit
S2(config)# interface f0/1
S2(config-if)# no shutdown
S2(config-if)# switchport mode trunk
S2(config-if)# switchport trunk native vlan 99
S2(config-if)# interface f0/3
S2(config-if)# no shutdown
S2(config-if)# switchport mode trunk
S2(config-if)# switchport trunk native vlan 99
S2(config-if)# interface vlan 99
S2(config-if)# ip address 192.168.1.12 255.255.255.0
S2(config-if)# exit
S2(config)# spanning-tree vlan 1,10,99 root primary
S2(config)# spanning-tree mode rapid-pvst
```

Switch S3

```
S3(config)# vlan 10
S3(config-vlan)# name User
S3(config-vlan)# vlan 99
S3(config-vlan)# name Management
```

```
S3(config-vlan)# exit
S3(config)# interface f0/18
S3(config-if)# no shutdown
S3(config-if)# switchport mode access
S3(config-if)# switchport access vlan 10
S3(config-if)# spanning-tree portfast
S3(config-if)# spanning-tree bpduguard enable
S3(config-if)# interface f0/1
S3(config-if)# no shutdown
S3(config-if)# switchport mode trunk
S3(config-if)# switchport trunk native vlan 99
S3(config-if)# interface f0/3
S3(config-if)# no shutdown
S3(config-if)# switchport mode trunk
S3(config-if)# switchport trunk native vlan 99
S3(config-if)# interface vlan 99
S3(config-if)# ip address 192.168.1.13 255.255.255.0
S3(config-if)# exit
S3(config)# spanning-tree mode rapid-pvst
```

Device Configs – Final

Switch S1

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

Current configuration : 1963 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode rapid-pvst
```

```
spanning-tree extend system-id
spanning-tree vlan 1,10,99 priority 28672
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 switchport trunk native vlan 99
 switchport mode trunk
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 switchport trunk native vlan 99
 switchport mode trunk
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
 shutdown
!
interface FastEthernet0/6
 switchport access vlan 10
 switchport mode access
 spanning-tree portfast
 spanning-tree bpduguard enable
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
!
interface FastEthernet0/11
 shutdown
!
interface FastEthernet0/12
 shutdown
!
interface FastEthernet0/13
 shutdown
!
interface FastEthernet0/14
 shutdown
!
interface FastEthernet0/15
 shutdown
!
interface FastEthernet0/16
 shutdown
!
```

```
interface FastEthernet0/17
 shutdown
!
interface FastEthernet0/18
 shutdown
!
interface FastEthernet0/19
 shutdown
!
interface FastEthernet0/20
 shutdown
!
interface FastEthernet0/21
 shutdown
!
interface FastEthernet0/22
 shutdown
!
interface FastEthernet0/23
 shutdown
!
interface FastEthernet0/24
 shutdown
!
interface GigabitEthernet0/1
 shutdown
!
interface GigabitEthernet0/2
 shutdown
!
interface Vlan1
 no ip address
!
interface Vlan99
 ip address 192.168.1.11 255.255.255.0
!
ip http server
ip http secure-server
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

Switch S2

```
S2#show run
Building configuration...
```

```
Current configuration : 1864 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S2
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode rapid-pvst
spanning-tree extend system-id
spanning-tree vlan 1,10,99 priority 24576
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
 switchport trunk native vlan 99
 switchport mode trunk
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 switchport trunk native vlan 99
 switchport mode trunk
!
interface FastEthernet0/4
 shutdown
!
```

```
interface FastEthernet0/5
 shutdown
!
interface FastEthernet0/6
 shutdown
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
!
interface FastEthernet0/11
 shutdown
!
interface FastEthernet0/12
 shutdown
!
interface FastEthernet0/13
 shutdown
!
interface FastEthernet0/14
 shutdown
!
interface FastEthernet0/15
 shutdown
!
interface FastEthernet0/16
 shutdown
!
interface FastEthernet0/17
 shutdown
!
interface FastEthernet0/18
```

```
 shutdown
!
interface FastEthernet0/19
 shutdown
!
interface FastEthernet0/20
 shutdown
!
interface FastEthernet0/21
 shutdown
!
interface FastEthernet0/22
 shutdown
!
interface FastEthernet0/23
 shutdown
!
interface FastEthernet0/24
 shutdown
!
interface GigabitEthernet0/1
 shutdown
!
interface GigabitEthernet0/2
 shutdown
!
interface Vlan1
 no ip address
!
interface Vlan99
 ip address 192.168.1.12 255.255.255.0
!
ip http server
ip http secure-server
!
!
line con 0
 password cisco
 logging synchronous
 login
```

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

Switch S3

```
S3#show run
Building configuration...

Current configuration : 1935 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S3
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
no ip domain-lookup
!
spanning-tree mode rapid-pvst
spanning-tree portfast default
spanning-tree portfast bpduguard default
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
```

```
interface FastEthernet0/1
 switchport trunk native vlan 99
 switchport mode trunk
!
interface FastEthernet0/2
 shutdown
!
interface FastEthernet0/3
 switchport trunk native vlan 99
 switchport mode trunk
!
interface FastEthernet0/4
 shutdown
!
interface FastEthernet0/5
 shutdown
!
interface FastEthernet0/6
 shutdown
!
interface FastEthernet0/7
 shutdown
!
interface FastEthernet0/8
 shutdown
!
interface FastEthernet0/9
 shutdown
!
interface FastEthernet0/10
 shutdown
!
interface FastEthernet0/11
 shutdown
!
interface FastEthernet0/12
 shutdown
!
interface FastEthernet0/13
 shutdown
```

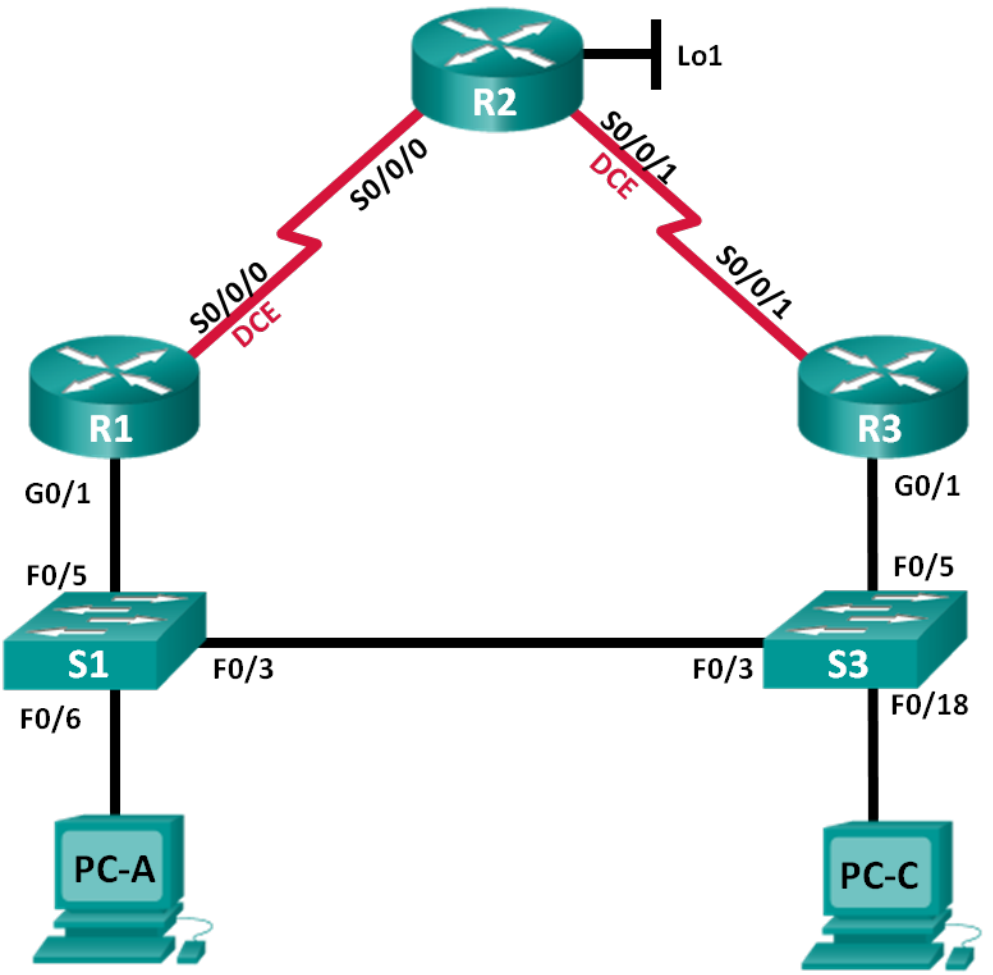
```
!
interface FastEthernet0/14
 shutdown
!
interface FastEthernet0/15
 shutdown
!
interface FastEthernet0/16
 shutdown
!
interface FastEthernet0/17
 shutdown
!
interface FastEthernet0/18
 switchport access vlan 10
 switchport mode access
!
interface FastEthernet0/19
 shutdown
!
interface FastEthernet0/20
 shutdown
!
interface FastEthernet0/21
 shutdown
!
interface FastEthernet0/22
 shutdown
!
interface FastEthernet0/23
 shutdown
!
interface FastEthernet0/24
 shutdown
!
interface GigabitEthernet0/1
 shutdown
!
interface GigabitEthernet0/2
 shutdown
```

```
!
interface Vlan1
 no ip address
!
interface Vlan99
 ip address 192.168.1.13 255.255.255.0
!
ip http server
ip http secure-server
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

2.4.3.4 Lab – Configuring HSRP and GLBP (Instructor Version)

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

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	G0/1	192.168.1.1	255.255.255.0	N/A
	S0/0/0 (DCE)	10.1.1.1	255.255.255.252	N/A
R2	S0/0/0	10.1.1.2	255.255.255.252	N/A
	S0/0/1 (DCE)	10.2.2.2	255.255.255.252	N/A
	Lo1	209.165.200.225	255.255.255.224	N/A
R3	G0/1	192.168.1.3	255.255.255.0	N/A
	S0/0/1	10.2.2.1	255.255.255.252	N/A
S1	VLAN 1	192.168.1.11	255.255.255.0	192.168.1.1
S3	VLAN 1	192.168.1.13	255.255.255.0	192.168.1.3
PC-A	NIC	192.168.1.31	255.255.255.0	192.168.1.1
PC-C	NIC	192.168.1.33	255.255.255.0	192.168.1.3

Objectives

Part 1: Build the Network and Verify Connectivity

Part 2: Configure First Hop Redundancy using HSRP

Part 3: Configure First Hop Redundancy using GLBP

Background / Scenario

Spanning tree provides loop-free redundancy between switches within your LAN. However, it does not provide redundant default gateways for end-user devices within your network if one of your routers fails. First Hop Redundancy Protocols (FHRPs) provide redundant default gateways for end devices with no end-user configuration necessary.

In this lab, you will configure two FHRPs. In Part 2, you will configure Cisco's Hot Standby Routing Protocol (HSRP), and in Part 3 you will configure Cisco's Gateway Load Balancing Protocol (GLBP).

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

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

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

Required Resources

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

Part 1: Build the Network and Verify Connectivity

In Part 1, you will set up the network topology and configure basic settings, such as the interface IP addresses, static routing, device access, and passwords.

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

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

Step 2: Configure PC hosts.

Step 3: Initialize and reload the routers and switches as necessary.

Step 4: Configure basic settings for each router.

a. Disable DNS lookup.

b. Configure the device name as shown in the topology.

c. Configure IP addresses for the routers as listed in the Addressing Table.

d. Set clock rate to **128000** for all DCE serial interfaces.

e. Assign **class** as the encrypted privileged EXEC mode password.

f. Assign **cisco** for the console and vty password and enable login.

g. Configure **logging synchronous** to prevent console messages from interrupting command entry.

h. Copy the running configuration to the startup configuration.

Step 5: 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. Configure IP addresses for the switches as listed in the Addressing Table.

e. Configure the default gateway on each switch.

f. Assign **cisco** for the console and vty password and enable login.

g. Configure **logging synchronous** to prevent console messages from interrupting command entry.

h. Copy the running configuration to the startup configuration.

Step 6: Verify connectivity between PC-A and PC-C.

Ping from PC-A to PC-C. Were the ping results successful? _____ Yes

If the pings are not successful, troubleshoot the basic device configurations before continuing.

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

Step 7: Configure routing.

a. Configure EIGRP on the routers and use AS of 1. Add all the networks, except 209.165.200.224/27 into the EIGRP process.

b. Configure a default route on R2 using Lo1 as the exit interface to 209.165.200.224/27 network and redistribute this route into the EIGRP process.

Step 8: Verify connectivity.

a. From PC-A, you should be able to ping every interface on R1, R2, R3, and PC-C. Were all pings successful? _____ Yes

b. From PC-C, you should be able to ping every interface on R1, R2, R3, and PC-A. Were all pings successful? _____ Yes

Part 2: Configure First Hop Redundancy Using HSRP

Even though the topology has been designed with some redundancy (two routers and two switches on the same LAN network), both PC-A and PC-C are configured with only one gateway address. PC-A is using R1 and PC-C is using R3. If either of these routers or the interfaces on the routers went down, the PC could lose its connection to the Internet.

In Part 2, you will test how the network behaves both before and after configuring HSRP. To do this, you will determine the path that packets take to the loopback address on R2.

Step 1: Determine the path for Internet traffic for PC-A and PC-C.

a. From a command prompt on PC-A, issue a **tracert** command to the 209.165.200.225 loopback address of R2.

```
C:\ tracert 209.165.200.225
Tracing route to 209.165.200.225 over a maximum of 30 hops

  1     1 ms     1 ms     1 ms  192.168.1.1
  2    13 ms    13 ms    13 ms  209.165.200.225

Trace complete.
```

What path did the packets take from PC-A to 209.165.200.225? _____
PC-A to R1 to R2

b. From a command prompt on PC-C, issue a **tracert** command to the 209.165.200.225 loopback address of R2.

What path did the packets take from PC-C to 209.165.200.225? _____
PC-C to R3 to R2

Step 2: Start a ping session on PC-A, and break the connection between S1 and R1.

a. From a command prompt on PC-A, issue a **ping –t** command to the **209.165.200.225** address on R2. Make sure you leave the command prompt window open.

Note: The pings continue until you press **Ctrl+C**, or until you close the command prompt window.

```
C:\ ping -t 209.165.200.225
Pinging 209.165.200.225 with 32 bytes of data:
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
```

```
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
<output omitted>
```

b. As the ping continues, disconnect the Ethernet cable from F0/5 on S1. You can also shut down the S1 F0/5 interface, which creates the same result.

What happened to the ping traffic?

After the cable was disconnected from F0/5 on S1 (or the interface was shut down), pings failed. Sample output is below.

```
Request timed out.
Request timed out.
Request timed out.
Request timed out.
<output omitted>
```

c. Repeat Steps 2a and 2b on PC-C and S3. Disconnect cable from F0/5 on S3.

What were your results?

The results were the same as on PC-A. After the Ethernet cable was disconnected from F0/5 on S3, the pings failed.

d. Reconnect the Ethernet cables to F0/5 or enable the F0/5 interface on both S1 and S3, respectively. Re-issue pings to 209.165.200.225 from both PC-A and PC-C to make sure connectivity is re-established.

Step 3: Configure HSRP on R1 and R3.

In this step, you will configure HSRP and change the default gateway address on PC-A, PC-C, S1, and S2 to the virtual IP address for HSRP. R1 becomes the active router via configuration of the HSRP priority command.

a. Configure HSRP on R1.

```
R1(config)# interface g0/1
R1(config-if)# standby 1 ip 192.168.1.254
R1(config-if)# standby 1 priority 150
R1(config-if)# standby 1 preempt
```

b. Configure HSRP on R3.

```
R3(config)# interface g0/1
R3(config-if)# standby 1 ip 192.168.1.254
```

c. Verify HSRP by issuing the **show standby** command on R1 and R3.

```
R1# show standby
GigabitEthernet0/1 - Group 1
  State is Active
    1 state change, last state change 00:02:11
  Virtual IP address is 192.168.1.254
  Active virtual MAC address is 0000.0c07.ac01
    Local virtual MAC address is 0000.0c07.ac01 (v1 default)
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 0.784 secs
  Preemption enabled
  Active router is local
  Standby router is 192.168.1.3, priority 100 (expires in 9.568 sec)
  Priority 150 (configured 150)
  Group name is "hsrp-Gi0/1-1" (default)

R3# show standby
GigabitEthernet0/1 - Group 1
  State is Standby
    4 state changes, last state change 00:02:20
  Virtual IP address is 192.168.1.254
  Active virtual MAC address is 0000.0c07.ac01
    Local virtual MAC address is 0000.0c07.ac01 (v1 default)
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 2.128 secs
  Preemption disabled
  Active router is 192.168.1.1, priority 150 (expires in 10.592 sec)
  Standby router is local
  Priority 100 (default 100)
  Group name is "hsrp-Gi0/1-1" (default)
```

Using the output shown above, answer the following questions:

Which router is the active router? _____ R1

What is the MAC address for the virtual IP address? _____ 0000.0c07.ac01

What is the IP address and priority of the standby router?

_____

_____

IP address is 192.168.1.3 and the priority is 100 (the default which is less than that of R1, the active router, with a priority of 150).

d. Use the **show standby brief** command on R1 and R3 to view an HSRP status summary. Sample output is shown below.

```
R1# show standby brief
                     P indicates configured to preempt.
                     |
Interface   Grp  Pri P State   Active          Standby         Virtual IP
Gi0/1       1    150 P Active  local           192.168.1.3     192.168.1.254

R3# show standby brief
                     P indicates configured to preempt.
                     |
Interface   Grp  Pri P State   Active          Standby         Virtual IP
Gi0/1       1    100   Standby 192.168.1.1     local           192.168.1.254
```

e. Change the default gateway address for PC-A, PC-C, S1, and S3. Which address should you use?

_____

192.168.1.254

Verify the new settings. Issue a ping from both PC-A and PC-C to the loopback address of R2. Are the pings successful? _____ Yes

Step 4: Start a ping session on PC-A and break the connection between the switch that is connected to the Active HSRP router (R1).

a. From a command prompt on PC-A, issue a **ping –t** command to the 209.165.200.225 address on R2. Ensure that you leave the command prompt window open.

b. As the ping continues, disconnect the Ethernet cable from F0/5 on S1 or shut down the F0/5 interface.

What happened to the ping traffic?

_____

_____

_____

A few packets may be dropped while the Standby router takes over. Sample output is shown below:

```
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Request timed out.
Request timed out.
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
<output Omitted>
```

Step 5: Verify HSRP settings on R1 and R3.

a. Issue the **show standby brief** command on R1 and R3.

Which router is the active router? _____ R3 is now the active router.

b. Reconnect the cable between the switch and the router or enable interface F0/5.

c. Disable the HSRP configuration commands on R1 and R3.

```
R1(config)# interface g0/1
R1(config-if)# no standby 1

R3(config)# interface g0/1
R3(config-if)# no standby 1
```

Part 3: Configure First Hop Redundancy Using GLBP

By default, HSRP does NOT do load balancing. The active router always handles all of the traffic, while the standby router sits unused, unless there is a link failure. This is not an efficient use of resources. GLBP provides nonstop path redundancy for IP by sharing protocol and MAC addresses between redundant gateways. GLBP also allows a group of routers to share the load of the default gateway on a LAN. Configuring GLBP is very similar to HSRP. Load balancing can be done in a variety of ways using GLBP. In this lab, you will use the round-robin method.

Step 1: Configure GLBP on R1 and R3.

a. Configure GLBP on R1.

```
R1(config)# interface g0/1
R1(config-if)# glbp 1 ip 192.168.1.254
R1(config-if)# glbp 1 preempt
R1(config-if)# glbp 1 priority 150
R1(config-if)# glbp 1 load-balancing round-robin
```

b. Configure GLBP on R3.

```
R3(config)# interface g0/1
R3(config-if)# glbp 1 ip 192.168.1.254
R3(config-if)# glbp 1 load-balancing round-robin
```

Step 2: Verify GLBP on R1 and R3.

a. Issue the **show glbp brief** command on R1 and R3.

```
R1# show glbp brief
Interface   Grp  Fwd Pri State    Address         Active router   Standby router
Gi0/1       1    -   150 Active   192.168.1.254   local           192.168.1.3
Gi0/1       1    1   -   Active   0007.b400.0101  local           -
Gi0/1       1    2   -   Listen   0007.b400.0102  192.168.1.3     -

R3# show glbp brief
Interface   Grp  Fwd Pri State    Address         Active router   Standby router
Gi0/1       1    -   100 Standby  192.168.1.254   192.168.1.1     local
Gi0/1       1    1   -   Listen   0007.b400.0101  192.168.1.1     -
Gi0/1       1    2   -   Active   0007.b400.0102  local           -
```

Step 3: Generate traffic from PC-A and PC-C to the R2 loopback interface.

a. From a command prompt on PC-A, ping the 209.165.200.225 address of R2.

```
C:\> ping 209.165.200.225
```

b. Issue an **arp –a** command on PC-A. Which MAC address is used for the 192.168.1.254 address?

Answers will vary due to timing, but the MAC address will be either R1 or R3 GLBP G0/1 interface MAC.

c. Generate more traffic to the loopback interface of R2. Issue another **arp –a** command. Did the MAC address change for the default gateway address of 192.168.1.254?

Yes. The MAC address changed from R1 to R3 and back. Note: You may need to have students generate traffic multiple times to see the change.

As you can see, both R1 and R3 play a role in forwarding traffic to the loopback interface of R2. Neither router remains idle.

Step 4: Start a ping session on PC-A, and break the connection between the switch that is connected to R1.

a. From a command prompt on PC-A, issue a **ping –t** command to the 209.165.200.225 address on R2. Make sure you leave the command prompt window open.

b. As the ping continues, disconnect the Ethernet cable from F0/5 on S1 or shut down the F0/5 interface.

What happened to the ping traffic?

A few packets are dropped while transitioning to the Standby router. Sample output is shown below.

```
Reply from 209.165.200.225: bytes=32 time=9ms TTL=254
Request timed out.
Reply from 209.165.200.225: bytes=32 time=18ms TTL=252
Reply from 209.165.200.225: bytes=32 time=18ms TTL=252
```

Reflection

1. Why would there be a need for redundancy in a LAN?

In today's networks, down time can be a critical issue affecting sales, productivity, and general connectivity (IP Telephony phones for example).

2. If you had a choice, which protocol would you implement in your network, HSRP or GLBP? Explain your choice.

Answers will vary. HSRP is easier to configure. There are more options with GLBP which can make it complex to configure.

Router Interface Summary Table

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

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

Device Configs

Router R1 (After Part 3 of this lab)

```
R1# show run
Building configuration...

Current configuration : 1375 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R1
!
boot-start-marker
boot-end-marker
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
no ip domain lookup
ip cef
```

```
no ipv6 cef
multilink bundle-name authenticated
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 ip address 192.168.1.1 255.255.255.0
 glbp 1 ip 192.168.1.254
 glbp 1 priority 150
 glbp 1 preempt
 duplex auto
 speed auto
!
interface Serial0/0/0
 ip address 10.1.1.1 255.255.255.252
 clock rate 128000
!
interface Serial0/0/1
 no ip address
 shutdown
!
!
router eigrp 1
 network 10.1.1.0 0.0.0.3
 network 192.168.1.0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
```

```
!
control-plane
!
line con 0
 password cisco
 logging synchronous
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password cisco
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R2

```
R2# show run
Building configuration...

Current configuration : 1412 bytes
!
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R2
!
boot-start-marker
boot-end-marker
!
```

```
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
interface Loopback1
 ip address 209.165.200.225 255.255.255.224
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Serial0/0/0
 ip address 10.1.1.2 255.255.255.252
!
interface Serial0/0/1
 ip address 10.2.2.2 255.255.255.252
 clock rate 128000
!
!
router eigrp 1
 network 10.1.1.0 0.0.0.3
 network 10.2.2.0 0.0.0.3
```

```
 redistribute static
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
ip route 0.0.0.0 0.0.0.0 Loopback1
!
!
control-plane
!
!
line con 0
 password cisco
 logging synchronous
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password cisco
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Router R3 (After Part 3 of this Lab)

```
R3# show run
Building configuration...

Current configuration : 1319 bytes
!
```

```
version 15.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname R3
!
boot-start-marker
boot-end-marker
!
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
!
no ip domain lookup
ip cef
no ipv6 cef
multilink bundle-name authenticated
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 ip address 192.168.1.3 255.255.255.0
 glbp 1 ip 192.168.1.254
 duplex auto
 speed auto
!
interface Serial0/0/0
 no ip address
 shutdown
 clock rate 2000000
```

```
!
interface Serial0/0/1
 ip address 10.2.2.1 255.255.255.252
!
!
router eigrp 1
 network 10.2.2.0 0.0.0.3
 network 192.168.1.0
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
control-plane
!
line con 0
 password cisco
 logging synchronous
 login
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 password cisco
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

Switch S1

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

Current configuration : 3114 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname S1
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
crypto pki trustpoint TP-self-signed-2530377856
 enrollment selfsigned
 subject-name cn=IOS-Self-Signed-Certificate-2530377856
 revocation-check none
 rsakeypair TP-self-signed-2530377856
!
!
!1panning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
!
interface FastEthernet0/1
!
```

```
interface FastEthernet0/2
!
interface FastEthernet0/3
!
interface FastEthernet0/4
!
interface FastEthernet0/5
!
interface FastEthernet0/6
!
interface FastEthernet0/7
!
interface FastEthernet0/8
!
interface FastEthernet0/9
!
interface FastEthernet0/10
!
interface FastEthernet0/11
!
interface FastEthernet0/12
!
interface FastEthernet0/13
!
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
!
interface FastEthernet0/17
!
interface FastEthernet0/18
!
interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
```

```
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
!
interface Vlan1
 ip address 192.168.1.11 255.255.255.0
!
ip default-gateway 192.168.1.254
ip http server
ip http secure-server
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

Switch S3

```
S3# show run
Building configuration...

Current configuration : 2974 bytes
!
version 15.0
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
```

```
no service password-encryption
!
hostname S3
!
boot-start-marker
boot-end-marker
!
enable secret 4 06YFDUHH61wAE/kLkDq9BGho1QM5EnRtoyr8cHAUg.2
!
no aaa new-model
system mtu routing 1500
!
!
no ip domain-lookup
!
!
crypto pki trustpoint TP-self-signed-2530358400
 enrollment selfsigned
 subject-name cn=IOS-Self-Signed-Certificate-2530358400
 revocation-check none
 rsakeypair TP-self-signed-2530358400
!
!
!
spanning-tree mode pvst
spanning-tree extend system-id
!
vlan internal allocation policy ascending
!
interface FastEthernet0/1
!
interface FastEthernet0/2
!
interface FastEthernet0/3
!
interface FastEthernet0/4
!
interface FastEthernet0/5
!
interface FastEthernet0/6
```

```
!
interface FastEthernet0/7
!
interface FastEthernet0/8
!
interface FastEthernet0/9
!
interface FastEthernet0/10
!
interface FastEthernet0/11
!
interface FastEthernet0/12
!
interface FastEthernet0/13
!
interface FastEthernet0/14
!
interface FastEthernet0/15
!
interface FastEthernet0/16
!
interface FastEthernet0/17
!
interface FastEthernet0/18
!
interface FastEthernet0/19
!
interface FastEthernet0/20
!
interface FastEthernet0/21
!
interface FastEthernet0/22
!
interface FastEthernet0/23
!
interface FastEthernet0/24
!
interface GigabitEthernet0/1
!
interface GigabitEthernet0/2
```

```
!
interface Vlan1
 ip address 192.168.1.13 255.255.255.0
!
ip default-gateway 192.168.1.254
ip http server
ip http secure-server
!
!
line con 0
 password cisco
 logging synchronous
 login
line vty 0 4
 password cisco
 login
line vty 5 15
 password cisco
 login
!
end
```

2.5.1.1 Class Activity– Documentation Tree (Instructor Version)

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

Objective

Identify common STP configuration issues.

This activity may be completed individually or in small groups.

Scenario

The employees in your building are having difficulty accessing a web server on the network. You look for the network documentation that the previous network engineer used before he transitioned to a new job; however, you cannot find any network documentation whatsoever.

Therefore, you decide create your own network recordkeeping system. You decide to start at the access layer of your network hierarchy. This is where redundant switches are located, as well as the company servers, printers, and local hosts.

You create a matrix to record your documentation and include access layer switches on the list. You also decide to document switch names, ports in use, cabling connections, and root ports, designated ports, and alternate ports.

For more detailed instructions on how to design your model, use the student PDF that accompanies this activity.

Resources

- Packet Tracer software
- Word processing software

Directions

Step 1: Create the topology diagram with three redundant switches.

Step 2: Connect host devices to the switches.

Step 3: Create the switch documentation matrix.

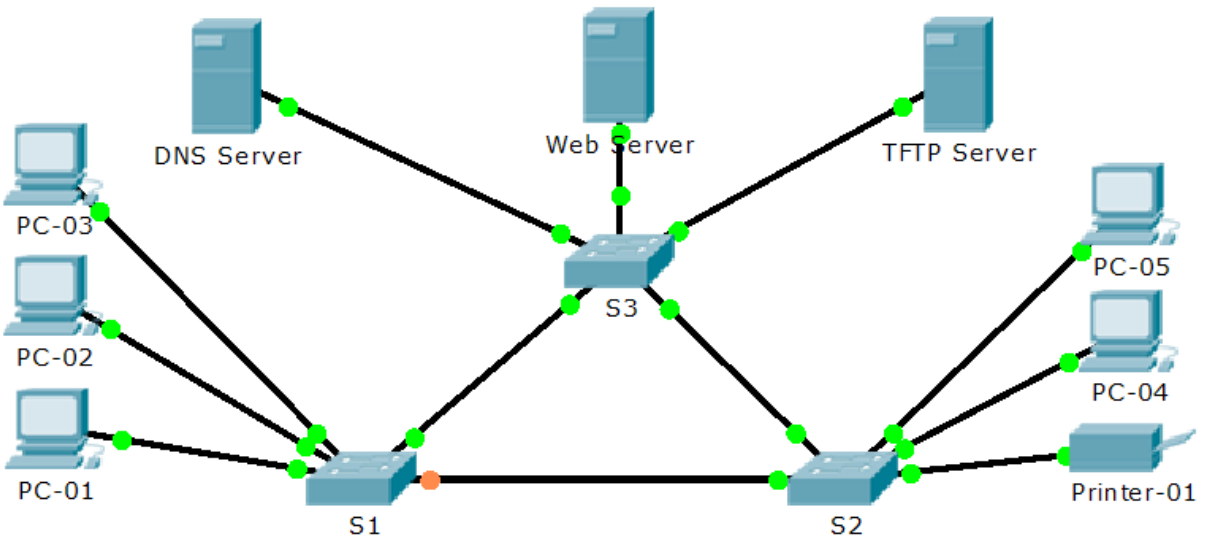
a. Name and switch location
b. General switch description
c. Model, IOS version, and image name
d. Switch serial number
e. MAC address
f. Ports currently in use
g. Cable connections
h. Root ports
i. Designated ports, status, and cost
j. Alternate ports, status, and cost

Step 4: Use show commands to locate Layer 2 switch information.

a. show version
b. show cdp neighbors detail
c. show spanning-tree

Instructor – Example Activity Answer

Topology Diagram Example



Documentation Form Example (S1 only)

Switch Name and Location	S1 – Main Distribution Facility
General Switch Description	Access Layer Switch – grants network access for PCs 01-03
Switch Model, IOS Version, and Image Name	WS-C2960-24TT 12.2 C2960-LANBASE-M
Switch Serial Number	FOC1033Z1EY
Switch MAC Address	0050.0F5C.A2D1
Ports in Use	Fa0/2 Fa0/3 Fa0/1 Gi1/1 Gi1/2
Cable Connections	Fa0/2 connected to PC-02 Fa0/3 connected to PC-03 Fa0/1 connected to PC-01 Gi1/1 connected to S2 Gi1/1 Gi1/2 connected to S3 Gi1/2
Root Port	Gi1/2
Designated Port(s), Status, and Cost	Fa0/1, Forwarding, Cost 19 Fa0/3, Forwarding, Cost 19 Fa0/2, Forwarding, Cost 19
Alternate Port(s), Status, and Cost	(non-designated port) Gi1/1, Blocking, Cost 4

```
S1# show version
Cisco IOS Software, C2960 Software (C2960-LANBASE-M), Version 12.2(25)FX, RELEASE
SOFTWARE (fc1)
Copyright (c) 1986-2005 by Cisco Systems, Inc.
Compiled Wed 12-Oct-05 22:05 by pt_team

ROM: C2960 Boot Loader (C2960-HBOOT-M) Version 12.2(25r)FX, RELEASE SOFTWARE (fc4)

System returned to ROM by power-on

Cisco WS-C2960-24TT (RC32300) processor (revision C0) with 21039K bytes of memory.


24 FastEthernet/IEEE 802.3 interface(s)
2 Gigabit Ethernet/IEEE 802.3 interface(s)

63488K bytes of flash-simulated non-volatile configuration memory.
Base ethernet MAC Address       : 0050.0F5C.A2D1
Motherboard assembly number     : 73-9832-06
Power supply part number        : 341-0097-02
Motherboard serial number       : FOC103248MJ
Power supply serial number      : DCA102133JA
Model revision number           : B0
Motherboard revision number     : C0
Model number                    : WS-C2960-24TT
System serial number            : FOC1033Z1EY
Top Assembly Part Number        : 800-26671-02
Top Assembly Revision Number    : B0
Version ID                      : V02
CLEI Code Number                : COM3K00BRA
Hardware Board Revision Number  : 0x01


Switch   Ports  Model              SW Version              SW Image
------   -----  -----              ----------              ----------
*    1   26     WS-C2960-24TT      12.2                    C2960-LANBASE-M

Configuration register is 0xF

S1#

S1# show cdp neighbors detail
```

```
Device ID: S2
Entry address(es):
Platform: cisco 2960, Capabilities: Switch
Interface: GigabitEthernet1/1, Port ID (outgoing port): GigabitEthernet1/1
Holdtime: 151

Version :
Cisco IOS Software, C2960 Software (C2960-LANBASE-M), Version 12.2(25)FX, RELEASE
SOFTWARE (fc1)
Copyright (c) 1986-2005 by Cisco Systems, Inc.
Compiled Wed 12-Oct-05 22:05 by pt_team

advertisement version: 2
Duplex: full
---------------------------

Device ID: S3
Entry address(es):
Platform: cisco 2960, Capabilities: Switch
Interface: GigabitEthernet1/2, Port ID (outgoing port): GigabitEthernet1/2
Holdtime: 151

Version :
Cisco IOS Software, C2960 Software (C2960-LANBASE-M), Version 12.2(25)FX, RELEASE
SOFTWARE (fc1)
Copyright (c) 1986-2005 by Cisco Systems, Inc.
Compiled Wed 12-Oct-05 22:05 by pt_team

advertisement version: 2
Duplex: full

S1#

S1# show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     0001.635E.CE64
              Cost        4
              Port        26(GigabitEthernet1/2)
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
```

```
  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     0050.0F5C.A2D1
             Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  20

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/1            Desg FWD 19        128.1    P2p
Fa0/3            Desg FWD 19        128.3    P2p
Fa0/2            Desg FWD 19        128.2    P2p
Gi1/1            Altn BLK 4         128.25   P2p
Gi1/2            Root FWD 4         128.26   P2p

S1#
```

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

- Designated ports
- Root ports
- Alternate ports
- STP switch commands output
- LAN, Access-Layer documentation

```
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::A
    FF02::1:FF00:4
    FF02::1:FF0E:5201
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  Hosts use stateless autoconfig for addresses.
Serial0/1/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::2D0:BCFF:FE0E:5202
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:9::6, subnet is 2001:DB8:ACAD:9::6/127
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::A
    FF02::1:FF00:6
    FF02::1:FF0E:5202
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  Hosts use stateless autoconfig for addresses.
Serial0/2/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::202:4AFF:FE35:602
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ABCD::, subnet is 2001:DB8:ABCD::/127
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::A
    FF02::1:FF00:0
    FF02::1:FF35:602
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
```

```
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  Hosts use stateless autoconfig for addresses.
Vlan1 is administratively down, line protocol is down
  Internet protocol processing disabled

ISP# show ipv6 interface
GigabitEthernet0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::260:2FFF:FE66:401
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:CAFE:1::, subnet is 2001:DB8:CAFE:1::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:0
    FF02::1:FF66:401
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND advertised reachable time is 0 milliseconds
  ND advertised retransmit interval is 0 milliseconds
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  ND advertised default router preference is Medium
  Hosts use stateless autoconfig for addresses.
Serial0/0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::260:3EFF:FE10:B901
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ABCD::1, subnet is 2001:DB8:ABCD::/127
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF00:1
    FF02::1:FF10:B901
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  Hosts use stateless autoconfig for addresses.
```

```
Vlan1 is administratively down, line protocol is down
  Internet protocol processing disabled

Branch1# show ipv6 interface
GigabitEthernet0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::201:C9FF:FE85:3A01
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:1:FFFF:FFFF:FFFF:FFFF, subnet is 2001:DB8:ACAD:1::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::A
    FF02::1:FF85:3A01
    FF02::1:FFFF:FFFF
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND advertised reachable time is 0 milliseconds
  ND advertised retransmit interval is 0 milliseconds
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  ND advertised default router preference is Medium
  Hosts use stateless autoconfig for addresses.
GigabitEthernet0/1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::201:C9FF:FE85:3A02
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:2:FFFF:FFFF:FFFF:FFFF, subnet is 2001:DB8:ACAD:2::/64
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::A
    FF02::1:FF85:3A02
    FF02::1:FFFF:FFFF
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND advertised reachable time is 0 milliseconds
  ND advertised retransmit interval is 0 milliseconds
```

```
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  ND advertised default router preference is Medium
  Hosts use stateless autoconfig for addresses.
Serial0/0/0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::202:17FF:FEE2:A401
  No Virtual link-local address(es):
  Global unicast address(es):
    2001:DB8:ACAD:9::1, subnet is 2001:DB8:ACAD:9::/127
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::A
    FF02::1:FF00:1
    FF02::1:FFE2:A401
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ICMP unreachables are sent
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  Hosts use stateless autoconfig for addresses.
Vlan1 is administratively down, line protocol is down
  Internet protocol processing disabled
```

Show IPv6 Route

```
HQ# show ipv6 route
IPv6 Routing Table - 17 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route, M - MIPv6
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
       D - EIGRP, EX - EIGRP external
S   ::/0 [1/0]
     via ::, Serial0/2/1
C   2001:DB8:ABCD::/127 [0/0]
     via ::, Serial0/2/1
L   2001:DB8:ABCD::/128 [0/0]
     via ::, Serial0/2/1
D   2001:DB8:ACAD::/60 [5/2169856]
     via ::, Null0
D   2001:DB8:ACAD::/61 [90/2170112]
     via FE80::2D0:FFFF:FE73:E101, Serial0/0/1
D   2001:DB8:ACAD::/62 [90/2170112]
     via FE80::202:17FF:FEE2:A401, Serial0/0/0
```

```
D   2001:DB8:ACAD:5::/64 [90/2170112]
     via FE80::20D:BDFF:FE23:9801, Serial0/1/0
D   2001:DB8:ACAD:6::/64 [90/2170112]
     via FE80::20D:BDFF:FE23:9801, Serial0/1/0
C   2001:DB8:ACAD:9::/127 [0/0]
     via ::, Serial0/0/0
L   2001:DB8:ACAD:9::/128 [0/0]
     via ::, Serial0/0/0
C   2001:DB8:ACAD:9::2/127 [0/0]
     via ::, Serial0/0/1
L   2001:DB8:ACAD:9::2/128 [0/0]
     via ::, Serial0/0/1
C   2001:DB8:ACAD:9::4/127 [0/0]
     via ::, Serial0/1/0
L   2001:DB8:ACAD:9::4/128 [0/0]
     via ::, Serial0/1/0
C   2001:DB8:ACAD:9::6/127 [0/0]
     via ::, Serial0/1/1
L   2001:DB8:ACAD:9::6/128 [0/0]
     via ::, Serial0/1/1
L   FF00::/8 [0/0]
     via ::, Null0

Branch1# show ipv6 route
IPv6 Routing Table - 17 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route, M - MIPv6
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
       D - EIGRP, EX - EIGRP external
EX  ::/0 [170/7289856]
     via FE80::260:3EFF:FE77:E701, Serial0/0/0
D   2001:DB8:ABCD::/127 [90/2681856]
     via FE80::260:3EFF:FE77:E701, Serial0/0/0
D   2001:DB8:ACAD::/60 [90/2682112]
     via FE80::260:3EFF:FE77:E701, Serial0/0/0
D   2001:DB8:ACAD::/61 [90/2682112]
     via FE80::260:3EFF:FE77:E701, Serial0/0/0
D   2001:DB8:ACAD::/62 [5/2816]
     via ::, Null0
C   2001:DB8:ACAD:1::/64 [0/0]
     via ::, GigabitEthernet0/0
L   2001:DB8:ACAD:1:FFFF:FFFF:FFFF:FFFF/128 [0/0]
     via ::, GigabitEthernet0/0
C   2001:DB8:ACAD:2::/64 [0/0]
```

```
     via ::, GigabitEthernet0/1
L    2001:DB8:ACAD:2:FFFF:FFFF:FFFF:FFFF/128 [0/0]
     via ::, GigabitEthernet0/1
D    2001:DB8:ACAD:5::/64 [90/2682112]
     via FE80::260:3EFF:FE77:E701, Serial0/0/0
D    2001:DB8:ACAD:6::/64 [90/2682112]
     via FE80::260:3EFF:FE77:E701, Serial0/0/0
C    2001:DB8:ACAD:9::/127 [0/0]
     via ::, Serial0/0/0
L    2001:DB8:ACAD:9::1/128 [0/0]
     via ::, Serial0/0/0
D    2001:DB8:ACAD:9::2/127 [90/2681856]
     via FE80::260:3EFF:FE77:E701, Serial0/0/0
D    2001:DB8:ACAD:9::4/127 [90/2681856]
     via FE80::260:3EFF:FE77:E701, Serial0/0/0
D    2001:DB8:ACAD:9::6/127 [90/2681856]
     via FE80::260:3EFF:FE77:E701, Serial0/0/0
L    FF00::/8 [0/0]
     via ::, Null0
```

Show IPv6 Protocols

```
HQ# show ipv6 protocol
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "static
IPv6 Routing Protocol is "eigrp 100"
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Interfaces:
    Serial0/0/0
    Serial0/0/1
    Serial0/1/0
    Serial0/1/1
    Serial0/2/1
Redistributing: eigrp 100, static
  Address Summarization:
  2001:DB8:ACAD::/60 for Serial0/2/1
  Maximum path: 16
  Distance: internal 90 external 170

Branch1#show ipv6 protocol
IPv6 Routing Protocol is "connected"
IPv6 Routing Protocol is "static
IPv6 Routing Protocol is "eigrp 100"
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
```

```
  EIGRP maximum metric variance 1
  Interfaces:
    GigabitEthernet0/0
    GigabitEthernet0/1
    Serial0/0/0
Redistributing: eigrp 100
  Address Summarization:
  2001:DB8:ACAD::/62 for Serial0/0/0
  Maximum path: 16
  Distance: internal 90 external 170
```

Show IPv6 EIGRP Topology

```
HQ# show ipv6 eigrp topology
IPv6-EIGRP Topology Table for AS 100/ID(1.1.1.1)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - Reply status

P 2001:DB8:ACAD:9::4/127, 1 successors, FD is 2169856
         via Connected, Serial0/1/0
P 2001:DB8:ACAD:9::6/127, 1 successors, FD is 2169856
         via Connected, Serial0/1/1
P 2001:DB8:ACAD:9::/127, 1 successors, FD is 2169856
         via Connected, Serial0/0/0
P 2001:DB8:ACAD:5::/64, 1 successors, FD is 2170112
         via FE80::20D:BDFF:FE23:9801 (2170112/2816), Serial0/1/0
P 2001:DB8:ACAD:6::/64, 1 successors, FD is 2170112
         via FE80::20D:BDFF:FE23:9801 (2170112/2816), Serial0/1/0
P 2001:DB8:ACAD:9::2/127, 1 successors, FD is 2169856
         via Connected, Serial0/0/1
P 2001:DB8:ACAD::/61, 1 successors, FD is 2170112
         via FE80::2D0:FFFF:FE73:E101 (2170112/2816), Serial0/0/1
P 2001:DB8:ACAD::/62, 1 successors, FD is 2170112
         via FE80::202:17FF:FEE2:A401 (2170112/2816), Serial0/0/0
P 2001:DB8:ACAD::/60, 1 successors, FD is 2169856
         via Summary (2169856/0), Null0
P ::/0, 1 successors, FD is 6777856
         via Rstatic (6777856/0)
P 2001:DB8:ABCD::/127, 1 successors, FD is 2169856
         via Connected, Serial0/2/1

Branch1# show ipv6 eigrp topology
IPv6-EIGRP Topology Table for AS 100/ID(2.2.2.2)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - Reply status
```

```
P 2001:DB8:ACAD:1::/64, 1 successors, FD is 2816
         via Connected, GigabitEthernet0/0
P 2001:DB8:ACAD:2::/64, 1 successors, FD is 2816
         via Connected, GigabitEthernet0/1
P 2001:DB8:ACAD:9::/127, 1 successors, FD is 1340928
         via Connected, Serial0/0/0
P 2001:DB8:ACAD::/62, 1 successors, FD is 2816
         via Summary (2816/0), Null0
P 2001:DB8:ACAD:9::4/127, 1 successors, FD is 2681856
         via FE80::260:3EFF:FE77:E701 (2681856/2169856), Serial0/0/0
P 2001:DB8:ACAD:9::6/127, 1 successors, FD is 2681856
         via FE80::260:3EFF:FE77:E701 (2681856/2169856), Serial0/0/0
P 2001:DB8:ACAD:5::/64, 1 successors, FD is 2682112
         via FE80::260:3EFF:FE77:E701 (2682112/2170112), Serial0/0/0
P 2001:DB8:ACAD:6::/64, 1 successors, FD is 2682112
         via FE80::260:3EFF:FE77:E701 (2682112/2170112), Serial0/0/0
P 2001:DB8:ACAD:9::2/127, 1 successors, FD is 2681856
         via FE80::260:3EFF:FE77:E701 (2681856/2169856), Serial0/0/0
P 2001:DB8:ACAD::/61, 1 successors, FD is 2682112
         via FE80::260:3EFF:FE77:E701 (2682112/2170112), Serial0/0/0
P 2001:DB8:ACAD::/60, 1 successors, FD is 2682112
         via FE80::260:3EFF:FE77:E701 (2682112/2170112), Serial0/0/0
P ::/0, 1 successors, FD is 7289856
         via FE80::260:3EFF:FE77:E701 (7289856/6777856), Serial0/0/0
P 2001:DB8:ABCD::/127, 1 successors, FD is 2681856
         via FE80::260:3EFF:FE77:E701 (2681856/2169856), Serial0/0/0
```

Show IPv6 Access Lists

```
HQ# show ipv6 access-list
IPv6 access list WEB_ACCESS
    permit tcp host 2001:DB8:ACAD::1 host 2001:DB8:CAFE:1::3 eq www
    permit tcp host 2001:DB8:ACAD::1 host 2001:DB8:CAFE:1::3 eq 443
    permit tcp host 2001:DB8:ACAD::3 host 2001:DB8:CAFE:1::3 eq www
    permit tcp host 2001:DB8:ACAD::3 host 2001:DB8:CAFE:1::3 eq 443
    permit tcp host 2001:DB8:ACAD::5 host 2001:DB8:CAFE:1::3 eq www
    permit tcp host 2001:DB8:ACAD::5 host 2001:DB8:CAFE:1::3 eq 443
    permit tcp host 2001:DB8:ACAD::7 host 2001:DB8:CAFE:1::3 eq www
    permit tcp host 2001:DB8:ACAD::7 host 2001:DB8:CAFE:1::3 eq 443
    deny tcp any host 2001:DB8:CAFE:1::3 eq www
    deny tcp any host 2001:DB8:CAFE:1::3 eq 443
    permit ipv6 any any
```

```
Branch1# show ipv6 access-list
IPv6 access list NO_ACCESS
    permit tcp host 2001:DB8:ACAD::1 host 2001:DB8:ACAD:1:FFFF:FFFF:FFFF:FFFF eq
telnet
    permit tcp host 2001:DB8:ACAD::2 host 2001:DB8:ACAD:2:FFFF:FFFF:FFFF:FFFF eq
telnet
    deny tcp any host 2001:DB8:ACAD:2:FFFF:FFFF:FFFF:FFFF eq telnet
    deny tcp any host 2001:DB8:ACAD:1:FFFF:FFFF:FFFF:FFFF eq telnet
```

9.3.1.3 – OSPF Capstone Project (Instructor Version)

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

Objectives

- Configure basic OSPFv2 to enable internetwork communications in a small- to medium-sized IPv4 business network.
- Implement advanced OSPF features to enhance operation in a small- to medium-sized business network.
- Implement multiarea OSPF for IPv4 to enable internetwork communications in a small- to medium-sized business network.
- Configure basic OSPFv3 to enable internetwork communications in a small- to medium-sized IPv6 business network.

Instructor Notes:

- Students should be able to design, configure, and secure OSPF in a network.
- Documentation is a large factor of this project and students must be able to explain their network design and verification through the use of **`show`** commands.
- This activity is:
  - Best completed in groups of 2-3 students
  - Suggested to be a graded assignment after completing all of the OSPF Chapters

Scenario

Your company has made the decision to implement the OSPF routing protocol on its network. You have decided that you need to review the concepts related to OSPF in order to make a smooth transition to this protocol.

Create a network using Packet Tracer. Configure the network with these OSPF routing protocol options:

- Multiarea OSPFv2
- Single-area OSPFv3
- Bandwidth
- Cost
- Authentication
- Default routes
- DR and BDR elections for segments

Required Resources

- Packet Tracer
- Student/group-created rubric for assessment of the assignment

Step 1: Design and build a network from scratch.

a. Your design must include three routers connected to a multi-access network in area 0 for use with IPv4.
   1) Enable authentication.
   2) Establish the DR and BDR using the **`router id`** command.

Step 2: Add one additional router with two connections to area 0, representing another OSPF area.

Step 3: Configure the bandwidth or cost to favor one route.

Step 4: Add a network containing end devices and a passive OSPF interface.

Step 5: Add a route to a default network such as the Internet.

Step 6: Add an IPv6 addressing scheme on the routers and configure OSPFv3.

a. Enable IPv6 unicast routing.

b. Establish the DR and BDR using the `router id` command.

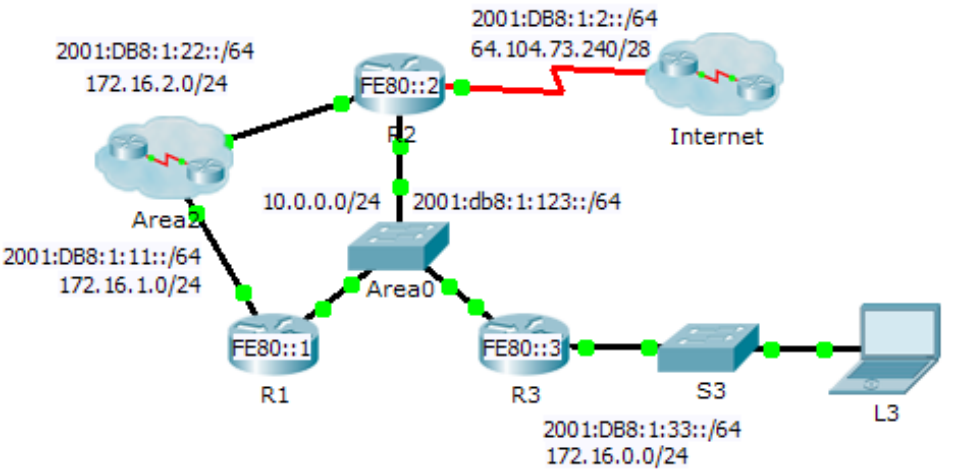
c. Do not configure timers, bandwidth, cost, default routes, or authentication.

Instructor-Sample Rubric

The example rubric includes a total of 100 points for the points earned category, if minimum standards are met. Instructors may wish to consider adding bonus points for additional/advanced work in any requirement category.

Requirement	Points Earned
Physical Topology • A minimum three routers are present in area 0. • One router exists in another area. • One Internet connection with one PC exists in the topology.	(10 suggested)
Logical Addressing and Connectivity • IPv4 and IPv6 networks should have full connectivity. Connectivity is verified with pings to every IP, including the Internet.	(20 suggested)
OSPF Requirement 1 • Two OSPFv2 areas exist. • Two OSPFv3 areas exist.	(20 suggested)
OSPF Requirement 2 • OSPF authentication and passive interfaces are used to secure the protocol.	(20 suggested)
OSPF Requirement 3 • Router IDs are used for the election of the DR and BDR.	(10 suggested)
OSPF Requirement 4 • The OSPF cost is changed to manipulate preferred routes.	(10 suggested)
OSPF Requirement 5 • Static routes and default information originate are used to reach the Internet.	(10 suggested)

Instructor Topology Example Solution



Suggested Addressing Table

Device	Interface	IPv4 Address	Subnet Mask	Default Gateway
		IPv6 Address/Prefix		Router ID
R1	G0/0	172.16.1.1	255.255.255.0	10.1.1.1
	G0/2	10.0.0.1	255.255.255.0	
	G0/0	2001:DB8:1:11::1/64		
	G0/2	2001:DB8:1:123::1/64		
	Link-local	FE80::1		
R2	G0/0	172.16.2.1	255.255.255.0	10.2.2.2
	G0/2	10.0.0.2	255.255.255.0	
	S0/0/0	64.104.73.242	255.255.255.240	
	G0/0	2001:DB8:1:22::1/64		
	G0/2	2001:DB8:1:123::2/64		
	S0/0/0	2001:DB8:1:2::1/64		
	Link-local	FE80::2		
R3	G0/0	172.16.0.1	255.255.255.0	10.3.3.3
	G0/2	10.0.0.2	255.255.255.0	
	G0/0	2001:DB8:1:33::1/64		
	G0/2	2001:DB8:1:123::3/64		
	Link-local	FE80::3		
A2	G0/0	172.16.2.2	255.255.255.0	2.2.2.2
	G0/2	172.16.1.2	255.255.255.0	
	G0/0	2001:DB8:1:22::2/64		
	G0/2	2001:DB8:1:11::2/64		
	Link-local	FE80::A		
L3	NIC	172.16.0.1	255.255.255.0	172.16.0.1
	NIC	2001:DB8:1:33::1/64		FE80::3

Device Configurations After Completion of the Activity

```
R1# show run
Building configuration...

Current configuration : 1291 bytes
!
version 15.1
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
!
hostname R1
!
ipv6 unicast-routing
!
license udi pid CISCO2911/K9 sn FTX1524UZ5Y
!
spanning-tree mode pvst
!
interface GigabitEthernet0/0
 ip address 172.16.1.1 255.255.255.0
 ip ospf message-digest-key 1 md5 Area2
 duplex auto
 speed auto
 ipv6 address FE80::1 link-local
 ipv6 address 2001:DB8:1:11::1/64
 ipv6 ospf 1 area 2
!
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
 shutdown
!
interface GigabitEthernet0/2
 ip address 10.0.0.1 255.255.255.0
 ip ospf message-digest-key 1 md5 Area0
 duplex auto
 speed auto
 ipv6 address FE80::1 link-local
 ipv6 address 2001:DB8:1:123::1/64
 ipv6 ospf 1 area 0
!
interface Serial0/0/0
 no ip address
 shutdown
```

```
!
interface Serial0/0/1
 no ip address
 shutdown
!
interface Vlan1
 no ip address
 shutdown
!
router ospf 1
 router-id 10.1.1.1
 log-adjacency-changes
 area 0 authentication message-digest
 area 2 authentication message-digest
 network 10.0.0.0 0.0.0.255 area 0
 network 172.16.1.0 0.0.0.255 area 2
!
ipv6 router ospf 1
 router-id 10.1.1.1
 log-adjacency-changes
!
ip classless
!
line con 0
!
line aux 0
!
line vty 0 4
 login
!
end

R2# show run
Building configuration...

Current configuration : 1494 bytes
!
version 15.1
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
!
hostname R2
!
ipv6 unicast-routing
!
```

```
license udi pid CISCO2911/K9 sn FTX1524GRRS
!
spanning-tree mode pvst
!
interface GigabitEthernet0/0
 ip address 172.16.2.1 255.255.255.0
 ip ospf message-digest-key 1 md5 Area2
 duplex auto
 speed auto
 ipv6 address FE80::2 link-local
 ipv6 address 2001:DB8:1:22::1/64
 ipv6 ospf 1 area 2
!
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
 shutdown
!
interface GigabitEthernet0/2
 ip address 10.0.0.2 255.255.255.0
 ip ospf message-digest-key 1 md5 Area0
 duplex auto
 speed auto
 ipv6 address FE80::2 link-local
 ipv6 address 2001:DB8:1:123::2/64
 ipv6 ospf 1 area 0
!
interface Serial0/0/0
 ip address 64.104.73.242 255.255.255.240
 ipv6 address FE80::2 link-local
 ipv6 address 2001:DB8:1:2::1/64
 ipv6 ospf 1 area 0
!
interface Serial0/0/1
 no ip address
 shutdown
!
interface Vlan1
 no ip address
 shutdown
!
router ospf 1
 router-id 10.2.2.2
 log-adjacency-changes
 area 0 authentication message-digest
```

```
 area 2 authentication message-digest
 passive-interface Serial0/0/0
 network 10.0.0.0 0.0.0.255 area 0
 network 172.16.2.0 0.0.0.255 area 2
 default-information originate
!
ipv6 router ospf 1
 router-id 10.2.2.2
 log-adjacency-changes
!
ip classless
ip route 0.0.0.0 0.0.0.0 Serial0/0/0
!
line con 0
!
line aux 0
!
line vty 0 4
 login
!
end

R3# show run
Building configuration...

Current configuration : 1291 bytes
!
version 15.1
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
!
hostname R3
!
ipv6 unicast-routing
!
license udi pid CISCO2911/K9 sn FTX15247W10
!
spanning-tree mode pvst
!
interface GigabitEthernet0/0
 ip address 172.16.0.1 255.255.255.0
 ip ospf message-digest-key 1 md5 Area0
 duplex auto
 speed auto
 ipv6 address FE80::3 link-local
```

```
 ipv6 address 2001:DB8:1:33::1/64
 ipv6 ospf 1 area 0
!
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
 shutdown
!
interface GigabitEthernet0/2
 ip address 10.0.0.3 255.255.255.0
 ip ospf message-digest-key 1 md5 Area0
 duplex auto
 speed auto
 ipv6 address FE80::3 link-local
 ipv6 address 2001:DB8:1:123::3/64
 ipv6 ospf 1 area 0
!
interface Serial0/0/0
 no ip address
 shutdown
!
interface Serial0/0/1
 no ip address
 shutdown
!
interface Vlan1
 no ip address
 shutdown
!
router ospf 1
 router-id 10.3.3.3
 log-adjacency-changes
 area 0 authentication message-digest
 passive-interface GigabitEthernet0/0
 network 10.0.0.0 0.0.0.255 area 0
 network 172.16.0.0 0.0.0.255 area 0
!
ipv6 router ospf 1
 router-id 10.3.3.3
 log-adjacency-changes
!
ip classless
!
line con 0
!
```

```
line aux 0
!
line vty 0 4
 login
!
end

A2# show run
Building configuration...

Current configuration : 1157 bytes
!
version 15.1
no service timestamps log datetime msec
no service timestamps debug datetime msec
no service password-encryption
!
hostname A2
!
ipv6 unicast-routing
!
license udi pid CISCO2911/K9 sn FTX1524DVBW
!
spanning-tree mode pvst
!
interface GigabitEthernet0/0
 ip address 172.16.2.2 255.255.255.0
 ip ospf message-digest-key 1 md5 Area2
 ip ospf cost 2000
 duplex auto
 speed auto
 ipv6 address FE80::A link-local
 ipv6 address 2001:DB8:1:22::2/64
 ipv6 ospf 1 area 2
!
interface GigabitEthernet0/1
 ip address 172.16.1.2 255.255.255.0
 ip ospf message-digest-key 1 md5 Area2
 ip ospf cost 1000
 duplex auto
 speed auto
 ipv6 address FE80::A link-local
 ipv6 address 2001:DB8:1:11::2/64
 ipv6 ospf 1 area 2
!
interface GigabitEthernet0/2
```

```
 no ip address
 duplex auto
 speed auto
 shutdown
!
interface Vlan1
 no ip address
 shutdown
!
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
 area 2 authentication message-digest
 network 172.16.2.0 0.0.0.255 area 2
!
ipv6 router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
!
ip classless
!
line con 0
!
line aux 0
!
line vty 0 4
 login
!
End
```

Show IP Route

```
R1>en
R1# show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is 10.0.0.2 to network 0.0.0.0

     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       10.0.0.0/24 is directly connected, GigabitEthernet0/2
L       10.0.0.1/32 is directly connected, GigabitEthernet0/2
```

```
     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
O       172.16.0.0/24 [110/2] via 10.0.0.3, 00:02:18, GigabitEthernet0/2
C       172.16.1.0/24 is directly connected, GigabitEthernet0/0
L       172.16.1.1/32 is directly connected, GigabitEthernet0/0
O IA    172.16.2.0/24 [110/2] via 10.0.0.2, 00:02:18, GigabitEthernet0/2
O*E2 0.0.0.0/0 [110/1] via 10.0.0.2, 00:02:18, GigabitEthernet0/2
```

Show IP Protocols

```
R1# show ip protocols

Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 10.1.1.1
  Number of areas in this router is 2. 2 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    10.0.0.0 0.0.0.255 area 0
    172.16.1.0 0.0.0.255 area 2
  Routing Information Sources:
    Gateway         Distance      Last Update
    10.1.1.1             110      00:08:18
    10.2.2.2             110      00:07:29
    10.3.3.3             110      00:07:38
  Distance: (default is 110)
```

Show IP OSPF Neighbor

```
R1# show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.3.3.3          1   FULL/DR         00:00:33    10.0.0.3        GigabitEthernet0/2
10.2.2.2          1   FULL/BDR        00:00:33    10.0.0.2        GigabitEthernet0/2
```

Show IP Interface Brief

```
R1# show ip int brief
Interface              IP-Address      OK? Method Status                Protocol

GigabitEthernet0/0     172.16.1.1      YES manual up                    up

GigabitEthernet0/1     unassigned      YES unset  administratively down down

GigabitEthernet0/2     10.0.0.1        YES manual up                    up

Serial0/0/0            unassigned      YES unset  administratively down down

Serial0/0/1            unassigned      YES unset  administratively down down

Vlan1                  unassigned      YES unset  administratively down down
```