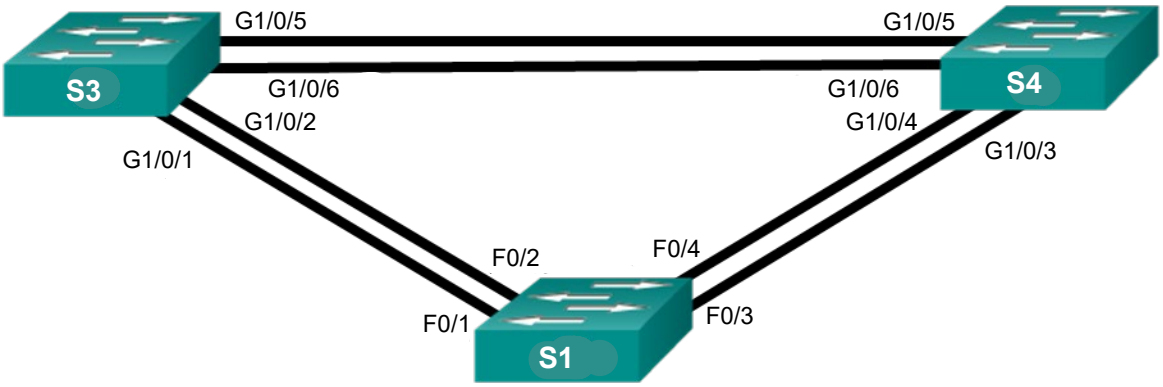
Lab – Building a Switched Network with Redundant Links

Topology



Addressing Table

Device	Interface	IP Address	Subnet Mask
S1	VLAN 1	192.168.1.1	255.255.255.0
S3	VLAN 1	192.168.1.3	255.255.255.0
S4	VLAN 1	192.168.1.4	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: Make sure that the switches have been erased and have no startup configurations. If you are unsure, contact your instructor.

Required Resources

- 3 Switches
- 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: Initialize and reload the switches as necessary.

On all switches, erase the startup-config file (write erase) the vlan.dat file (delete vlan.dat) and reload.

Step 2: Cable the network as shown in the topology.

Verify the devices are interconnected as shown in the topology diagram.

Step 3: Configure basic settings for each switch.

a. Disable DNS lookup.

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

c. Configure logging synchronous for the console line.

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

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

Step 4: Test connectivity.

Verify that the each of the switches can ping all the other switches. Troubleshoot until full connectivity is achieved

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.

In the spanning tree, ports are designated as a **root** port, a **designated** port, or an **alternate** port.

- **Root Port:** A port that is activated and following it will direct traffic towards the root bridge
- **Designated Port:** A port that is activated and following it will direct traffic away from the root bridge
- **Alternate Port:** A redundant port that is currently not activated

Note: If a link between two switches is disabled by STP, only one end of the link is physically blocked, the other end will be enabled and set to a **designated** port.

Note: If a port is a **root** port, the port at the other end of the link will always be a **designated** port. This statement is not true in the reverse direction.

Step 1: Configure switches for Spanning Tree operation over trunked interfaces

a. Deactivate (shutdown) all ports on the switches

b. Configure all connected ports as trunk ports

c. Activate (enable) ports **f0/2** and **f0/4** on S1

d. Activate (enable) ports **G1/0/2** and **G1/0/6** on S3

e. Activate (enable) ports **G1/0/4** and **G1/0/6** on S4

Step 2: 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).

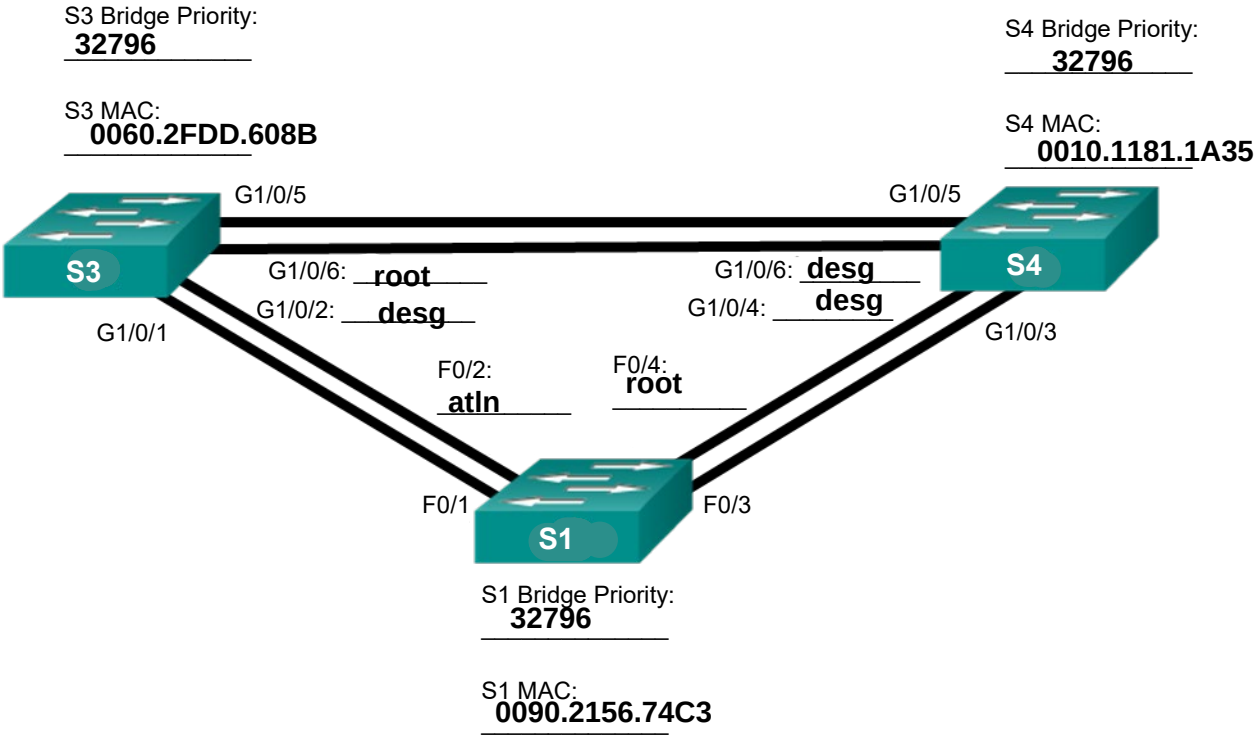
Note: In this example, S1 will be the root bridge. As your MAC addresses will be different to this example, you will have a different root bridge.

Note: The default STP mode on 2960 Cisco Switches is Per-VLAN Spanning Tree Protocol (PVST). The default STP mode on 3650 Cisco Switches is Rapid PVST.

```
S1# show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     247e.12c6.1300
              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     247e.12c6.1300
              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 rstp
  Root ID    Priority    32769
             Address     247e.12c6.1300
             Cost        19
             Port        2 (GigabitEthernet1/0/2)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     4c77.6d22.5c80
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/2             Root FWD 19        128.2    P2p Peer(STP)
Gi1/0/6             Altn BLK 4         128.6    P2p

S4# show spanning-tree

VLAN0001
  Spanning tree enabled protocol rstp
  Root ID    Priority    32769
             Address     247e.12c6.1300
             Cost        19
             Port        4 (GigabitEthernet1/0/4)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     4c77.6d16.af00
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/4             Root FWD 19        128.4    P2p Peer(STP)
Gi1/0/6             Desg FWD 4         128.6    P2p
```

In the diagram below, record the Bridge Priority and the MAC address of the switches and 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? **S4**

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

Spanning Tree Protocol (STP) selects the root bridge based on the lowest Bridge ID (BID). In this case, S4 has the same BID as the root ID (0010.1181.1A35), indicating it is the root bridge. The BID is determined by the priority and the MAC address, and since S4 has the lowest MAC address among the switches, it is selected as the root bridge.

Which ports are the root ports on the switches? **S1: Fa0/4 (Root Port) ; S3: Gi1/0/6 (Root Port)**

Which ports are the designated ports on the switches? **S1: Fa0/2 (Designated Port) ; S3: Gi1/0/2 (Designated Port) ; S4: Gi1/0/4 and Gi1/0/6 (Designated Ports)**

What port is showing as an alternate port and is currently being blocked? **S1: Fa0/2**

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

Spanning Tree Protocol blocks the alternate port (Fa0/2 on S1) because it has the same cost to the root bridge as the root port (Fa0/4) but is not the preferred path. The root port is the port with the lowest cost to the root bridge, while the alternate port is blocked to prevent loops in the network.

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 Gi1/0/5 on the switch with the highest BID (S3).

```
S3# show spanning-tree

VLAN0001
  Spanning tree enabled protocol rstp
  Root ID     Priority    32769
              Address     247e.12c6.1300
              Cost        19
              Port        2 (GigabitEthernet1/0/2)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     4c77.6d22.5c80
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/2             Root FWD 19        128.2    P2p Peer(STP)
Gi1/0/6             Altn BLK 4         128.6    P2p
```

```
S4# show spanning-tree

VLAN0001
  Spanning tree enabled protocol rstp
  Root ID    Priority    32769
             Address     247e.12c6.1300
             Cost        19
             Port        4 (GigabitEthernet1/0/4)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     4c77.6d16.af00
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/4             Root FWD 19        128.4    P2p Peer(STP)
Gi1/0/6             Desg FWD 4         128.6    P2p
```

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

After locating the switch with the blocked port, you should confirm that this switch has a higher path cost to the root bridge or the highest BID.

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 by issuing the **spanning-tree cost** interface configuration mode command.

If **S1** is the root bridge in your topology, change the cost to **18**.

If **S3** or **S4** is the root bridge in your topology, change the cost to **3**.

```
S3(config)# interface g1/0/2
S3(config-if)# spanning-tree cost 3
```

Step 3: Observe spanning tree changes.

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

```
S3# show spanning-tree

VLAN0001
  Spanning tree enabled protocol rstp
  Root ID     Priority    32769
              Address     247e.12c6.1300
              Cost        3
              Port        2 (GigabitEthernet1/0/2)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     4c77.6d22.5c80
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/2             Root FWD 3         128.2    P2p Peer(STP)
Gi1/0/6             Desg FWD 4         128.6    P2p

S4# show spanning-tree

VLAN0001
  Spanning tree enabled protocol rstp
  Root ID     Priority    32769
              Address     247e.12c6.1300
              Cost        19
              Port        4 (GigabitEthernet1/0/4)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     4c77.6d16.af00
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/4             Root FWD 19        128.4    P2p Peer(STP)
Gi1/0/6             Altn BLK 4         128.6    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?

Spanning Tree Protocol (STP) changed the previously blocked port to a designated port and blocked the designated port on the other switch due to adjustments in port costs. When the cost of the root port on S3 was lowered, it became the preferred path to the root bridge. Consequently, the previously designated port on S4 was blocked because it had a higher cost. This reassignment ensures a loop-free topology by maintaining only one active path to the root bridge from each switch.

Step 4: Remove port cost changes.

a. Issue the **default spanning-tree cost** interface configuration mode command to remove the cost statement that you created earlier.

```
S1(config)# interface g1/0/2
S1(config-if)# default spanning-tree cost
```

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 S1.

b. Activate ports G1/0/5 and Gi1/0/1 on S3

c. Activate ports G1/0/5 and Gi1/0/3 on S4

d. 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 port linked to the lower numbered port on the root switch, and blocked the previous root port. Also observe that all secondary links between the switches have become redundant and have been disabled.

```
S3# show spanning-tree

VLAN0001
  Spanning tree enabled protocol rstp
  Root ID    Priority    32769
             Address     247e.12c6.1300
             Cost        19
             Port        1 (GigabitEthernet1/0/1)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     4c77.6d22.5c80
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/1             Root FWD 19        128.1    P2p Peer(STP)
Gi1/0/2             Altn BLK 19        128.2    P2p Peer(STP)
Gi1/0/5             Desg FWD 4         128.5    P2p
Gi1/0/6             Desg FWD 4         128.6    P2p

S4# show spanning-tree

VLAN0001
  Spanning tree enabled protocol rstp
  Root ID    Priority    32769
             Address     247e.12c6.1300
             Cost        19
             Port        3 (GigabitEthernet1/0/3)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

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

```
              Address     4c77.6d16.af00
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  300 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/3             Root FWD 19        128.3    P2p Peer(STP)
Gi1/0/4             Altn BLK 19        128.4    P2p Peer(STP)
Gi1/0/5             Altn BLK 4         128.5    P2p
Gi1/0/6             Altn BLK 4         128.6    P2p
```

What port did STP select as the root port on each non-root switch? **S1: Fa0/3**

S3: Gi1/0/5

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

Path Cost: The root port is the port on a non-root switch that has the lowest cost to reach the root bridge. For S1, Fa0/3 has a cost of 19, which is the lowest among its available ports. For S3, Gi1/0/5 has a cost of 4, making it the most efficient path to the root bridge (S4). If multiple ports have the same cost, STP uses the Bridge ID (BID) and port priority to break ties. S3's Gi1/0/5 is selected due to its lower cost. Topology: The overall network topology also influences the selection. The ports selected as root ports provide the most direct and efficient paths to the root bridge, ensuring optimal data flow and minimizing potential loops in the network.

Part 5: Test redundancy

Shutdown the link between **G1/0/1** on S3 and **F0/1** on S1. Wait 30 seconds for STP to reconfigure itself.

Step 1: Verify that the alternate link between S3 and S1 has become active

Execute **show spanning-tree** to examine the port state on both switches

What is the state of the alternate port connecting S3 to S1 on S3?

forwarding

What is the state of the alternate port connecting S1 to S3 on S1?

forwarding

Step 2: Verify replacing the link resets the STP configuration

Re-enable the link between **G1/0/1** on S3 and **F0/1** on S1

After waiting for STP to reconfigure, re-execute **show spanning-tree** on both switches and confirm that all ports have returned to their normal state.

Reflection

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

Path Cost: STP first evaluates the cost of the path to the root bridge. The port with the lowest path cost is selected.

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

Bridge ID (BID) of the upstream switch: STP compares the Bridge ID of the switches connected to the ports. The port connected to the switch with the lower BID is selected.

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

Port Priority: STP uses the port priority value. The port with the lower priority value is selected.