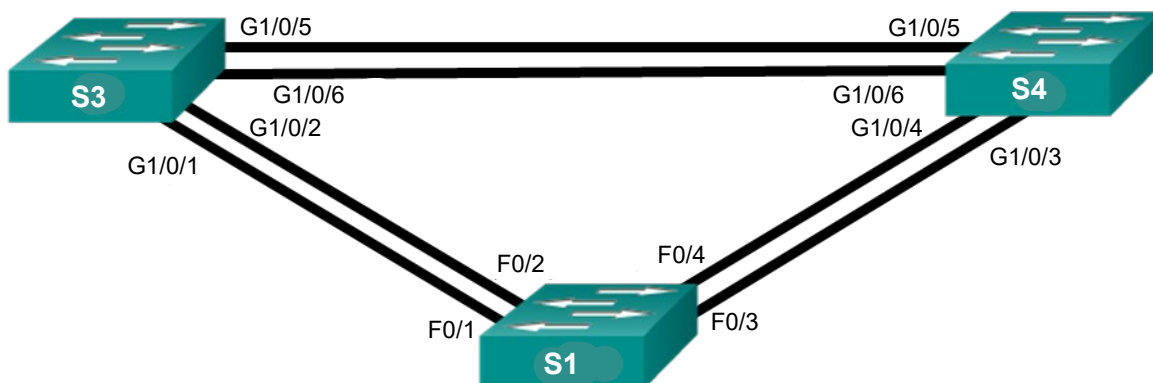


# Lab – Building a Switched Network with Redundant Links

## 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.

- Disable DNS lookup.
- Configure the device name as shown in the topology.
- Configure logging synchronous for the console line.
- Configure a message of the day (MOTD) banner to warn users that unauthorized access is prohibited.
- Configure the IP address listed in the Addressing Table for VLAN 1 on all switches.

### Step 4: Test connectivity.

Verify that 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**

- Deactivate (shutdown) all ports on the switches
- Configure all connected ports as trunk ports
- Activate (enable) ports **f0/2** and **f0/4** on S1
- Activate (enable) ports **G1/0/2** and **G1/0/6** on S3
- 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

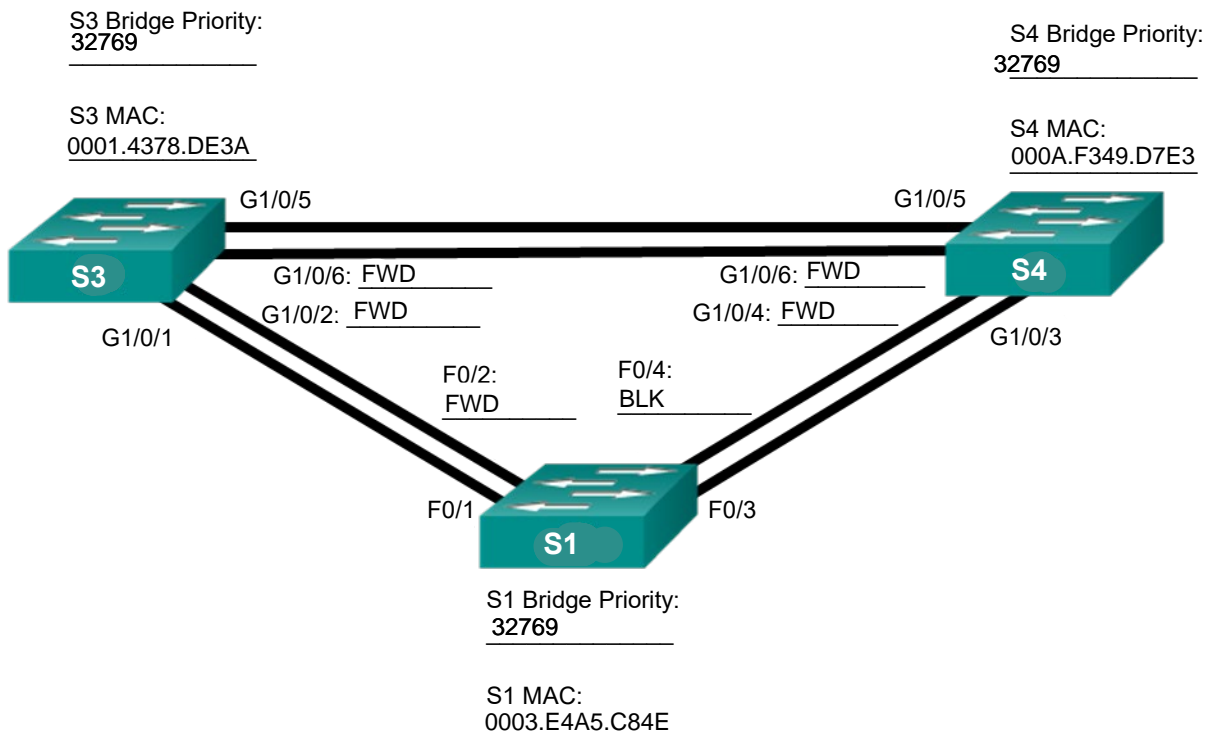
Spanning tree enabled protocol rstp

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? Switch 3

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

It has the Lowest MAC Address

Which ports are the root ports on the switches? S1: Fa0/2, S4: Gi1/0/6

Which ports are the designated ports on the switches? S3: All, S4: Gi1/0/4

What port is showing as an alternate port and is currently being blocked? S1: Fa0/4

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

this switch has a higher path cost to the root bridge (19>4)

### 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?

Because, comparing the costs of each port in Sw1 and Sw4 (non-root bridge switches), Sw1 now has a port that is lower in root cost (3 in Sw1 < 4 in Sw4)



**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.

- Activate ports F0/1 and F0/3 on S1.
- Activate ports G1/0/5 and Gi1/0/1 on S3
- Activate ports G1/0/5 and Gi1/0/3 on S4
- 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? Sw1: Fa0/1, Sw4: Gi1/0/5

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

For Sw1, the cost of all of the port are the same (19) hence, it will check the port with the lowest port ID.

For Sw4, the cost of Gi1/0/5 and Gi1/0/6 are the same (4) and the lowest, so they contest for the root port, and since Gi1/0/5 has the lower port ID, it will be granted the root port role.

## 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?

Since S3 is the root bridge, all of its port are still designated ports

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

One of the Altn port (lowest port ID) is now the root port and has FWD status

### 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

- After a root bridge has been selected, what is the first value STP uses to determine port selection?  
Lowest port cost
- If the first value is equal on the two ports, what is the next value that STP uses to determine port selection?  
Lowest bridge ID (priority + MAC)
- If both values are equal on the two ports, what is the next value that STP uses to determine port selection?  
Lowest port ID