6.6.4 STP Facts

To provide for fault tolerance, many networks implement redundant paths between multiple switches. However, providing redundant paths between segments could cause frames to be endlessly passed between the redundant paths. This condition is known as a *switching loop*.

To prevent switching loops, the IEEE 802.1d committee defined the Spanning Tree Protocol (STP). With STP, one switch for each route is assigned as the designated bridge. Only the designated bridge can forward packets. Redundant switches are assigned as backups.

The spanning tree protocol:

- Eliminates loops.
- Provides redundant paths between devices.
- Enables dynamic role configuration.
- Recovers automatically from a topology change or device failure.
- Identifies the optimal path between any two network devices.

The spanning tree protocol uses a spanning tree algorithm (STA) to calculate the best loop-free path through a network by assigning a role to each bridge or switch. The bridge role determines how the device functions in relation to other devices and whether the device forwards traffic to other segments. The following table describes the three types of bridge roles:

<table>
<tr><th>Role</th><th>Characteristics</th></tr>
<tr><td>Root bridge</td><td>The root bridge is the master, or controlling, bridge.

There is only one root bridge in the network. The root bridge is the logical center of the spanning tree topology in a switched network.
The root bridge is determined by the switch with the lowest bridge ID (BID):

The bridge ID is composed of two parts—a bridge priority number and the MAC address assigned to the switch.
The default priority number for all switches is 32,768. This means the switch with the lowest MAC address becomes the root bridge unless you customize the priority values.
You can manually configure the priority number to force a specific switch to become the root switch.

The root bridge periodically broadcasts configuration messages. These messages are used to select routes and reconfigure the roles of other bridges, if necessary.
All ports on a root bridge forward messages to the network.
</td></tr>
<tr><td>Designated bridge</td><td>A designated bridge is any other device that participates in forwarding packets through the network.

They are selected automatically by exchanging bridge configuration packets.
To prevent bridge loops, there is only one designated bridge per segment.
</td></tr>
<tr><td>Backup bridge</td><td>All redundant devices are classified as backup bridges.

They listen to network traffic and build the bridge database. However, they will not forward packets.
They can take over if the root bridge or a designated bridge fails.
</td></tr>
</table>

Devices send special packets called Bridge Protocol Data Units (BPDUs) out each port. BPDUs sent to and received from other bridges are used to determine bridge roles and port states, verify that neighbor devices are still functioning, and recover from network topology changes. During the negotiation process and normal operations, each switch port is in one of the following states:

Port State	Description
Disabled	A port in the disabled state is powered on but does not participate in forwarding or listening to network messages. A bridge must be manually placed in the disabled state.
Blocking	When a device is first powered on, its ports are in the blocking state. Backup bridge ports are always in the blocking state. Ports in a blocking state receive packets and BPDUs sent to all bridges, but they will not process any other packets.
Listening	The listening state is a transitory state between blocking and learning. The port remains in the listening state for a specific period of time. This time period allows network traffic to settle down after a change has occurred. For example, if a bridge goes down, all other bridges go into the listening state for a period of time. During this time the bridges redefine their roles.
Learning	A port in the learning state receives packets and builds the bridge database (associating MAC addresses with ports). A timer is also associated with this state. The port goes to the forwarding state after the timer expires.

Forwarding	The root bridge and designated bridges are in the forwarding state when they can receive and forward packets. A port in the forwarding state can learn and forward. All ports of the root switch are in the forwarding state.

During the configuration process, ports on each switch are configured as one of the following types:

Port type	Description
Root port	The port on a designated switch with the lowest port cost back to the root bridge is identified as the *root port*. - Each designated switch has a single root port (a single path back to the route bridge). - Root ports are in the forwarding state. - The root bridge does not have a root port.

Designated port	One port on each segment is identified as the *designated port*. The designated port identifies which port on the segment is allowed to send and receive frames.
	
	- All ports on the root bridge are designated ports (unless the switch port loops back to a port on the same switch).
	- Designated ports are selected based on the lowest path cost to get back to the root switch. Default IEEE port costs include the following:
	  - 10 Mbps = 1000
	  - 100 Mbps = 19
	  - 1 Gbps = 4
	  - 10 Gbps = 2
	- If two switches have the same cost, the switch with the lowest priority becomes the designated switch, and its port the designated port.
	- If two ports have the same cost, the port on the switch with the lowest port ID becomes the designated port.
	  - The port ID is derived from two numbers—the port priority and the port number.
	  - The port priority ranges from 0–255, with a default of 128.
	  - The port number is the number of the switch's port. For example, the port number for Fa0/3 is 3.
	  - With the default port priority setting, the lowest port number becomes the designated port.
	- Designated ports are used to send frames back to the root bridge.
	- Designated ports are in the forwarding state.

Blocking port	A blocking port is any port that is not a root or a designated port. A blocking port is in blocking state.

Devices participating in the spanning tree protocol use the following process to configure themselves:

1. At startup, switches send BPDUs out each port.
2. Switches read the bridge ID contained in the BPDUs to elect (identify) a single root bridge (the device with the lowest bridge ID). All the ports on the root bridge become designated ports.
3. Each switch identifies its root port (the port with the lowest cost back to the root bridge).
4. Switches on redundant paths identify a designated switch for each segment. A designated port is also identified on each designated switch.
5. Remaining switch ports that are not root or designated ports are put in the blocking state to eliminate loops.
6. After configuration, switches periodically send BPDUs to ensure connectivity and discover topology changes.

The following table lists commands you would use to configure spanning tree:

Command	Function
Switch(config)#spanning-tree mode {pvst | rapid-pvst}	Sets the spanning tree mode. - PVST+ (Per VLAN Spanning Tree Protocol), also known as PVSTP, is a Cisco proprietary protocol used on Cisco switches. - Rapid PVST+ is Cisco's proprietary version of Rapid STP, which is based on the 802.1w standard. PVST+ and Rapid PVST+ are the same except that Rapid PVST+ uses a rapid convergence based on the 802.1w standard. To provide rapid convergence, Rapid PVST+ deletes learned MAC address entries on a per-port basis after receiving a topology change.
Switch(config)#spanning-tree vlan *[1-4094]* root primary	Forces the switch to be the root of the spanning tree.
Switch(config)#spanning-tree vlan *[1-4094]* cost *[1 - 200000000]*	Manually sets the cost. The cost range value depends on the path-cost calculation method: - For the short method the range is 1 to 65536.

	For the long method the range is from 1 to 200000000.
Switch(config)#spanning-tree vlan *[1-4094]* priority *[0-61440]*	Manually sets the bridge priority number: - The priority value ranges between 0 and 61440. - Each switch has the default priority of 32768. - Priority values are set in increments of 4096. If you enter another number, your value will be rounded to the closest increment of 4096, or you will be prompted to enter a valid value. - The switch with the lowest priority number becomes the root bridge.
Switch(config)#no spanning-tree vlan *[1-4094]*	Disables spanning tree on the selected VLAN.
Switch#show spanning-tree	Shows spanning tree configuration information, including the following: - Root bridge priority and MAC address - The cost to the root bridge - Local switch bridge ID and MAC address - The role and status of all local interfaces - The priority and number for each interface To verify that spanning tree is working, look for an entry similar to the following for each VLAN: Spanning tree enabled protocol ieee
Switch#show spanning-tree vlan *[1-4094]* root	Shows information about the root bridge for a specific VLAN. Information shown includes: - The root bridge ID, including the priority number and the MAC address - The cost to the root bridge from the local switch - The local port that is the root port
Switch#show spanning-tree vlan *[1-4094]* bridge	Shows spanning tree configuration information about the local switch for the specified VLAN. Information includes the local bridge ID, including the priority and MAC address.

Even though STP is great at eliminating switching loops, it has a key weakness. It allows only a single active path between two switches at any given time. If that active link goes down, it can sometimes take 30 seconds or more for STP to detect that the link has gone down before it activates a redundant link. To address this weakness, a new protocol, *Shortest Path Bridging* (SPB), has been developed to eventually replace STP. SPB is a routing protocol defined in the IEEE 802.1aq standard that adds routing functions to Layer 2 switching. SPB uses a link-state routing protocol to allow switches to learn the shortest paths through a switched Ethernet network and to dynamically adjust those paths as the topology changes, just like a Layer 3 router does.

SPB addresses this issue by applying Layer 3 routing protocols to Layer 2 switches. This allows those switches to actually route Ethernet frames between switches, just as Layer 3 protocols route packets between routers. By doing this, SPB allows multiple links between switches to be active at the same time without creating a switching loop. This functionality is designed to eliminate the time lag associated with failed links managed by STP. If a link between switches goes down on a network that uses SPB, the frames can be immediately re-routed to the destination segment by using redundant links between switches that are already active and able to forward frames.