

# Spanning Tree Protocol (STP)


# Redundancy in Layer 2 Switched Networks

- Redundancy ➡ eliminating single points of failure.
- Path redundancy ➡ physical and logical Layer 2 loops (frame has not TTL) ➡ 🔥
- STP logically blocks physical loops, preventing frames circling the network forever.
- STP compensates for a failure by recalculating and opening up previously blocked ports.
- STA: Spanning Tree Algorithm
  - Creates a loop-free topology by selecting a single root bridge where all the other switches determine a single least-cost path, blocking redundant paths and recalculating in case of Link Failure.
- ⚠️ STP enabled by default!!!

# STP

- Problems solved:
  - 🧐 **MAC database instability:** MAC address table constantly changing from the broadcast frames ➡ High CPU ➡ Switch unable to forward frames
  - ⚡ **Broadcast Storm:** high number of broadcasts overwhelming the network 🔥
  - 🤖 **Duplicated unicast frames:** devices receive twice the same frame from different paths.
- Usages:
  - ♻️ Solves L2 looping problems
  - 🛣️ Provides alternative paths in case of failure
  - ⚖️ Provides VLAN Load Balancing between trunks

# STP Step **1** - Elect the Root Bridge (RB)

- STA designates a single switch as root bridge
- Root Bridge = Switch with the lowest BID (Bridge ID)
- BID = (Bridge Priority + VLAN ID) . Bridge MAC
  - Bridge Priority = 32768 (default). Range: 0...61440 (increments of 4096)
    -  Can be changed to elect another root bridge
  - VLAN ID = Extended System ID
  - Bridge ID = Switch MAC Address

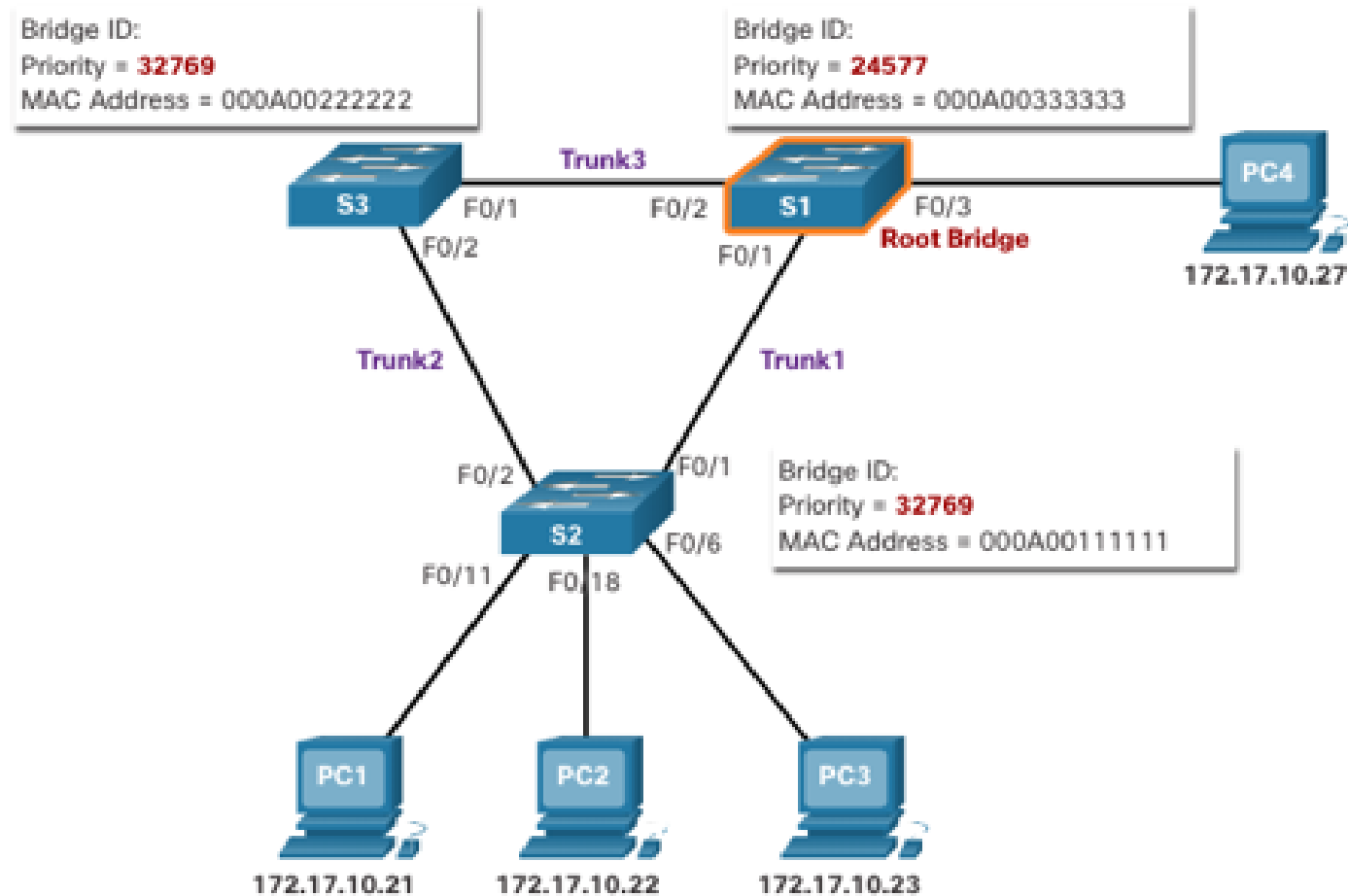
Example:

S1 BID: 32768.00A0.1101.V001

S2 BID: 32768.00A0.FF01.6689

S3 BID: 32767.0010.FF32.991B  Lowest  BID  Root Bridge

# STP Step **1** - Elect the Root Bridge



# STP Step **1** - Changing and verify Root Bridge

Option **1**: Select root bridge manually

```
S1(config)# spanning-tree VLAN 1 root primary
...
S2(config)# spanning-tree VLAN 1 root secondary
```







Option **2**: Change the priority value

```
S1(config)# spanning-tree VLAN 1 priority 24576
```

Verify Bridge ID and Root Bridge election

```
S1# show spanning-tree
```

## STP Step **2** - Elect the Root Ports (RP)

- EVERY NON-ROOT SWITCH will select one  RP.
  -  RP (**1**, if equals then **2**, ...):
    - **1** Port with overall lower  cost to the Root Bridge
    - **2** Port with lower  Sender Bridge ID
    - **3** Port with lower  Sender Port Priority
    - **4** Port with lower  Sender Port ID

# Root Path Cost

## Defaults

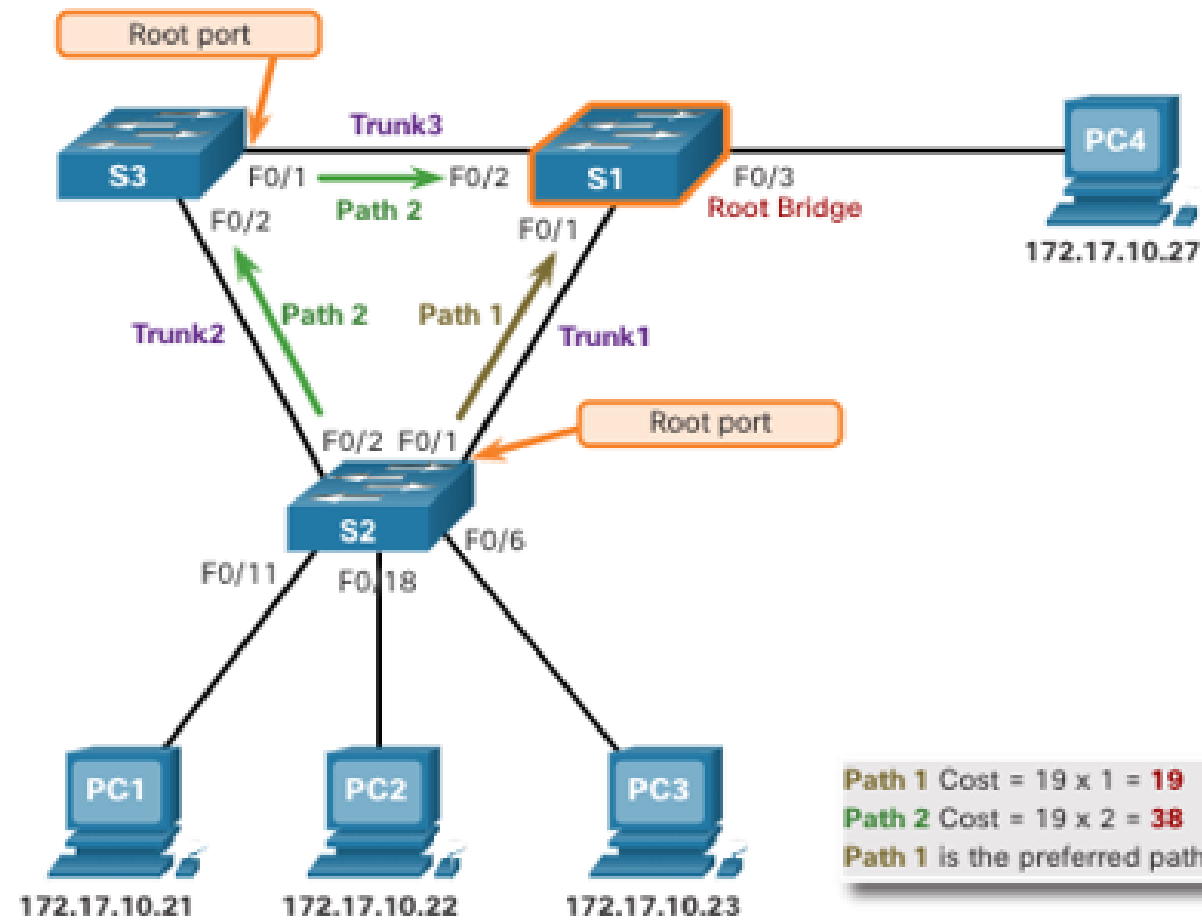
Link Speed	STP Cost: IEEE 802.1D-1998	RSTP Cost: IEEE 802.1w-2004
10 Gbps	2	2,000
1 Gbps	4	20,000
100 Mbps	19	200,000
10 Mbps	100	2,000,000

## Modify Path Cost

```
S1(config)# interface f0/1
S1(config-if)# spanning-tree cost 25
```



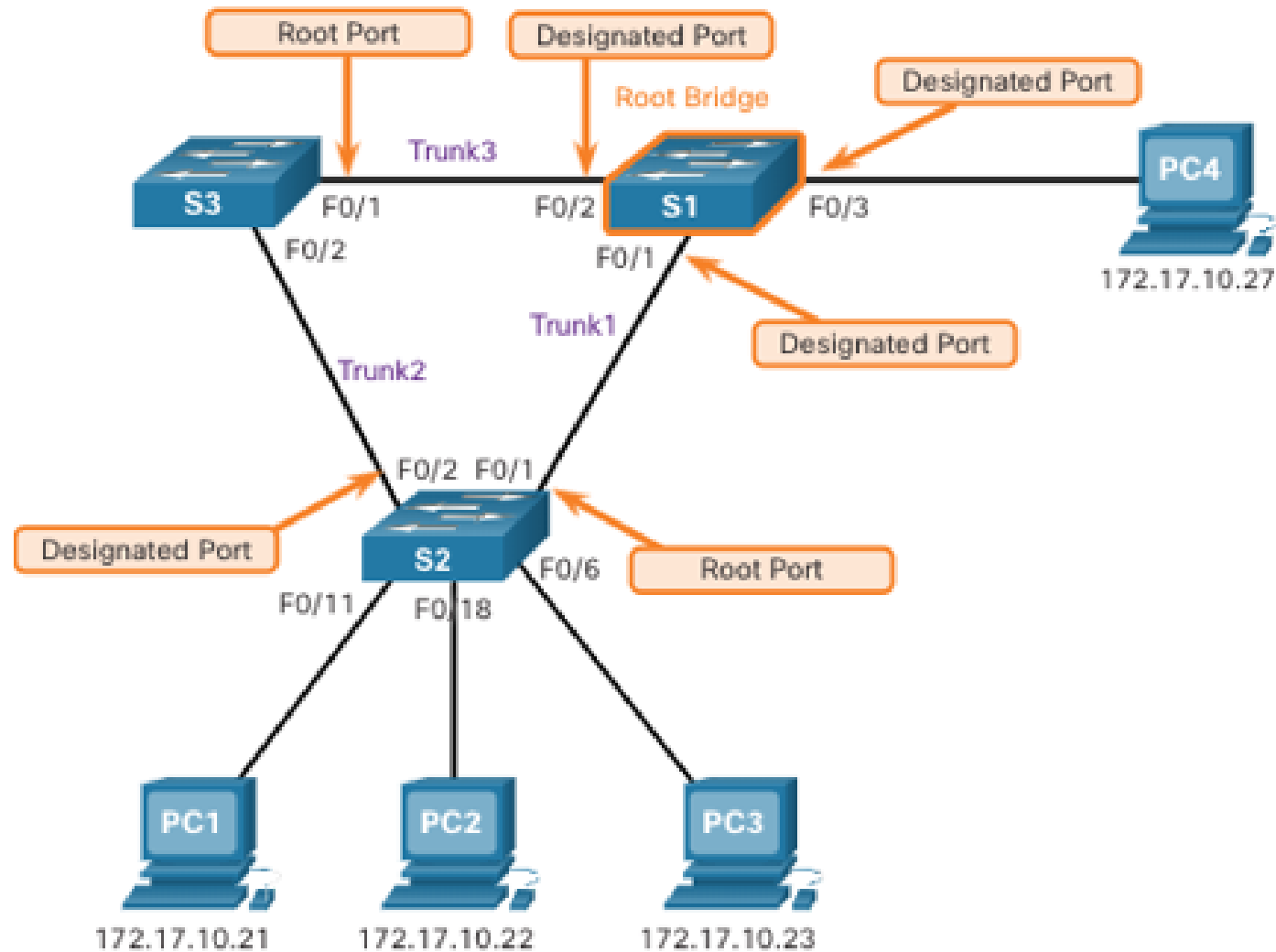
## STP Step **2** - Elect the Root Ports



## STP Step **3** - Elect Designated Ports (DP)

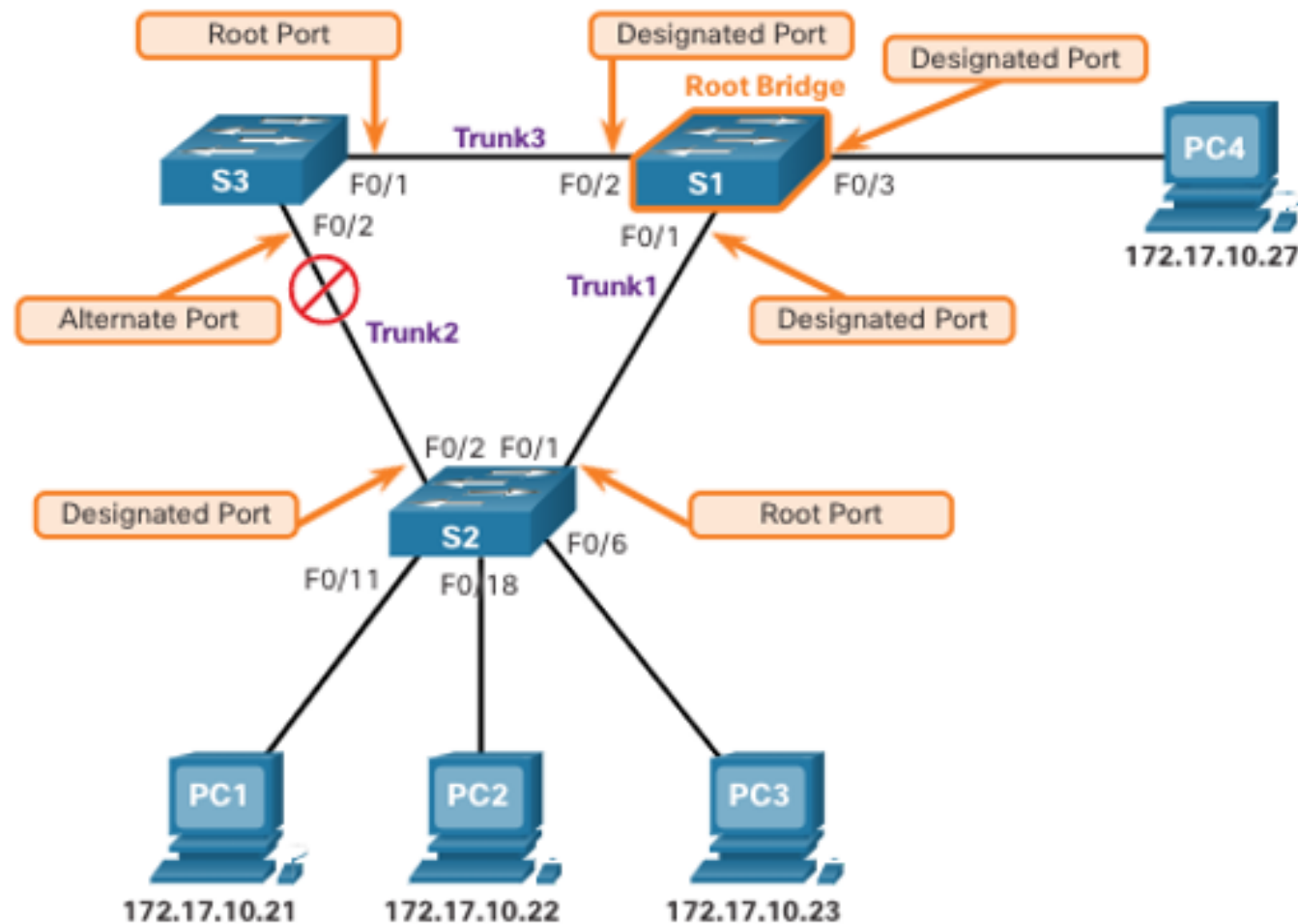
- EVERY SEGMENT between 2 switches will have one ● DP.
  - All ports of Root Bridge ➡ ● DP
  - One end of a segment is ● RP ➡ Other end is ● DP
  - All ports attached to end devices ➡ ● DP
  - Other segments without ● DP, one ● DP (**1**, if equals then **2**, ...):
    - **1** Port with overall lower ⬇ cost to the Root Bridge
    - **2** Port with lower ⬇ Sender Bridge ID
    - **3** Port with lower ⬇ Sender Port Priority
    - **4** Port with lower ⬇ Sender Port ID

## STP Step 3 - Elect Designated Ports

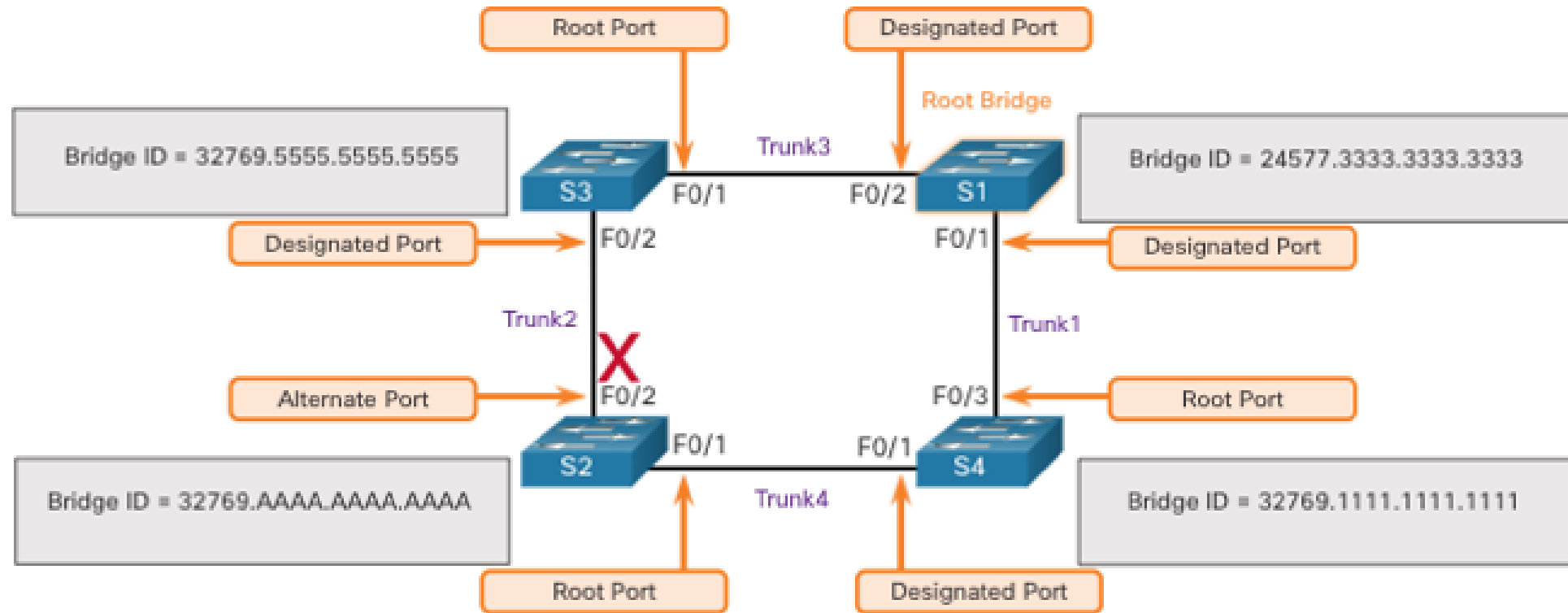


# STP Step 4 - Elect Alternate/Blocked Ports (ALT/BLK)

- Block ports that are not ● RP or ● DP ➡ ● ALT/BLK



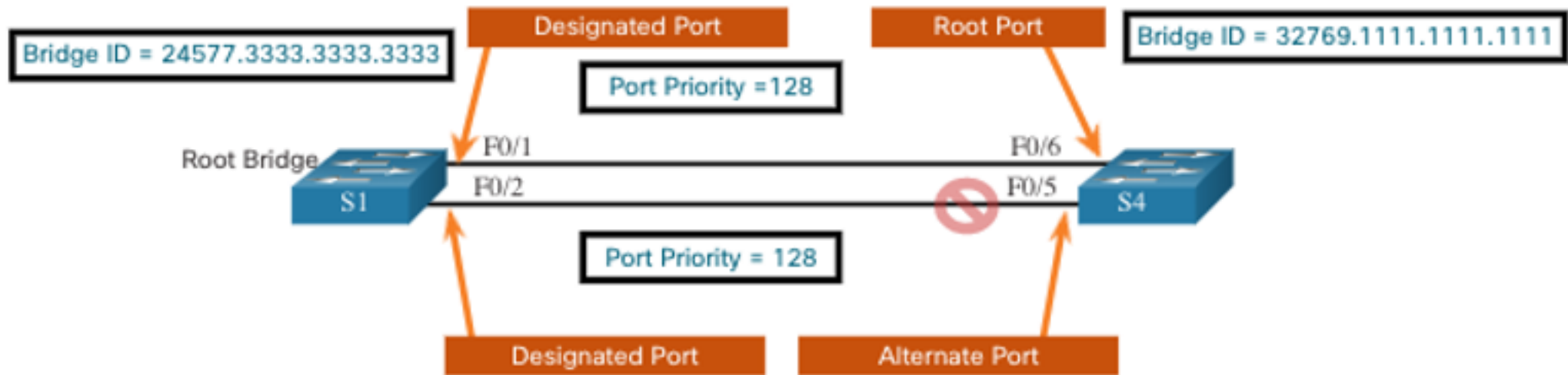
# Multiple Equal-Cost Path: Lower Sender BID



S2: ● RP is F0/1, because S4 has a lower ↓ sender BID than S3.

Same cost → Different Sender BID

# Multiple Equal-Cost Path: Lower Sender Port ID



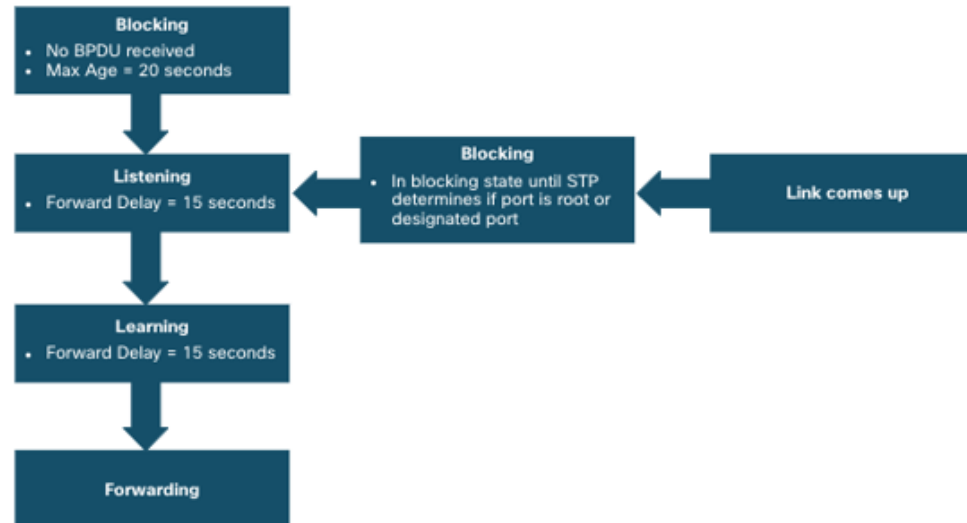
S4: ● RP is F0/6, because S1 F0/1 has a lower ↓ sender Port ID than S1 F0/2.

Same cost ➡ Same sender BID ➡ Same Port Priority ➡ Different Sender Port ID

# STP Timers and Port States

STP convergence requires 3 timers, defined in Root Bridge (changeable):

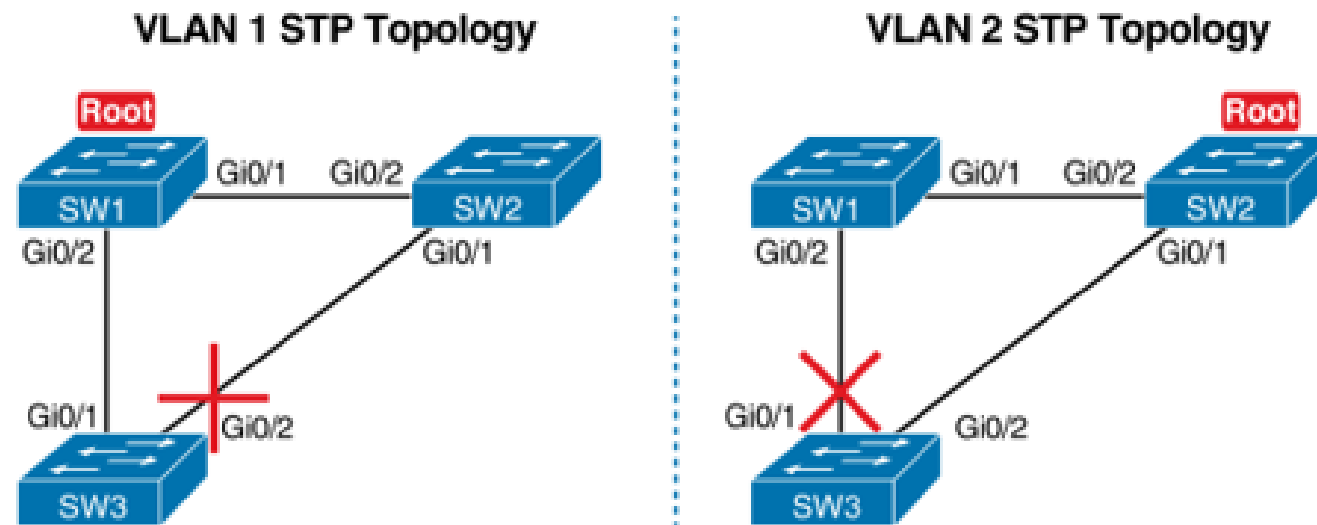
- 🙌 **Hello Timer**: Interval between PDUS. Default = **2 seconds** (range: 1...10 seconds)
- ↶ **Forward Delay Timer**: Time that is spent in the listening and learning state. Default = **15 seconds** (range: 4...30 seconds)
- 👤 **Max Age Timer**: Maximum length of time that a switch waits before attempting to change the STP Topology. Default = **20 seconds** (range: 6...40 seconds)



# Per-VLAN Spanning Tree (PVST)

A Root Bridge is elected for EACH spanning tree instance/VLAN ➡ Load Balancing

- Cisco switches running IOS 15.0+ run PVST+ by default



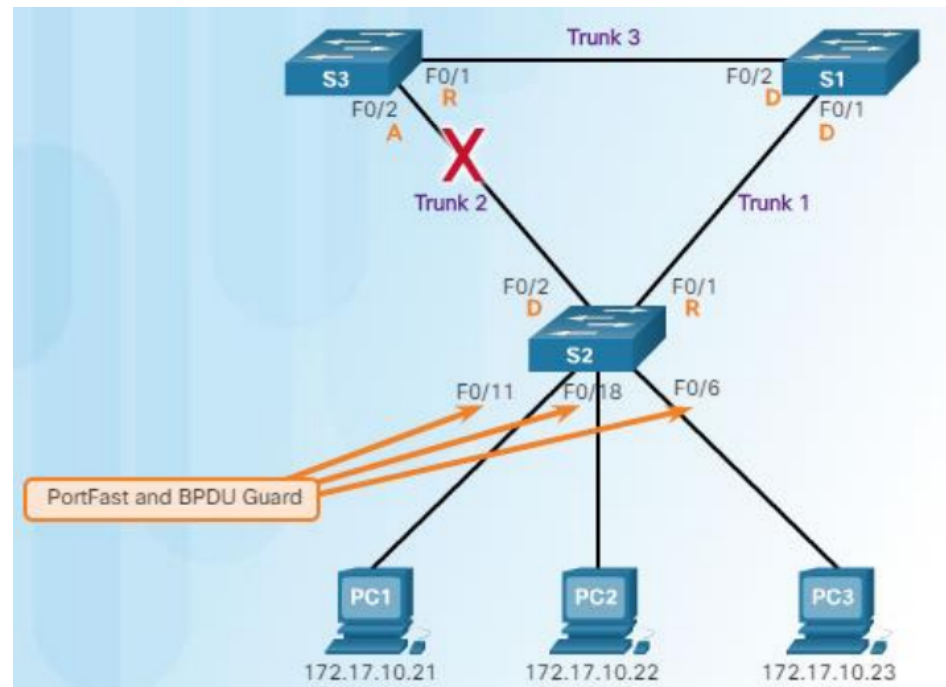
**Figure 10-2** Load Balancing with One Tree for VLAN 1 and Another for VLAN 2



# PVST Config: PortFast and BPDU Guard

- **PortFast:** Ports that have end devices (**Access Ports**). Port in ● FWD state.
- **BPDU Guard:** Disables a PortFast port if a BPDU is received ➡ Port in errdisabled

```
S2(config)# interface range f0/11,f0/18,f0/6
S2(config-if-range)# spanning-tree portfast
S2(config-if-range)# spanning-tree bpduguard enable
```



# Different Versions of STP

- **Common STP (CST/STP/802.1D):** 1998. 1 instance regardless number of VLANs.
- **Per-VLAN STP (PVST+):** Cisco enhanced STP. 1 instance per VLAN. PortFast, BPDU Guard.
- **Rapid STP (RSTP/802.1w):** Evolution of STP that provides faster convergence
- **Rapid PVST+:** Cisco enhanced RSTP. 1 instance per VLAN.
- **Multiple STP (MSTP/802.1s):** Maps multiple VLANs into the same spanning tree instance.
- **Multiple Spanning Tree (MST):** Cisco enhanced MSTP. Provides up to 16 instances of RSTP.

# RSTP

- **Alternate Port** (alternate path to the Root Bridge) ➡ change to FWD state without waiting the network to converge.
- **Backup Port**: backup to a shared medium (Hub). Less common!!

