Spanning Tree Protocol (STP)

CCNA2v7 Module 5 STP Concepts + CCNA3v6 Chapter 3 STP

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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 redudant paths and recalculating in case of Link Failure.
- ⚠️ **STP enabled by default!!!**

STP

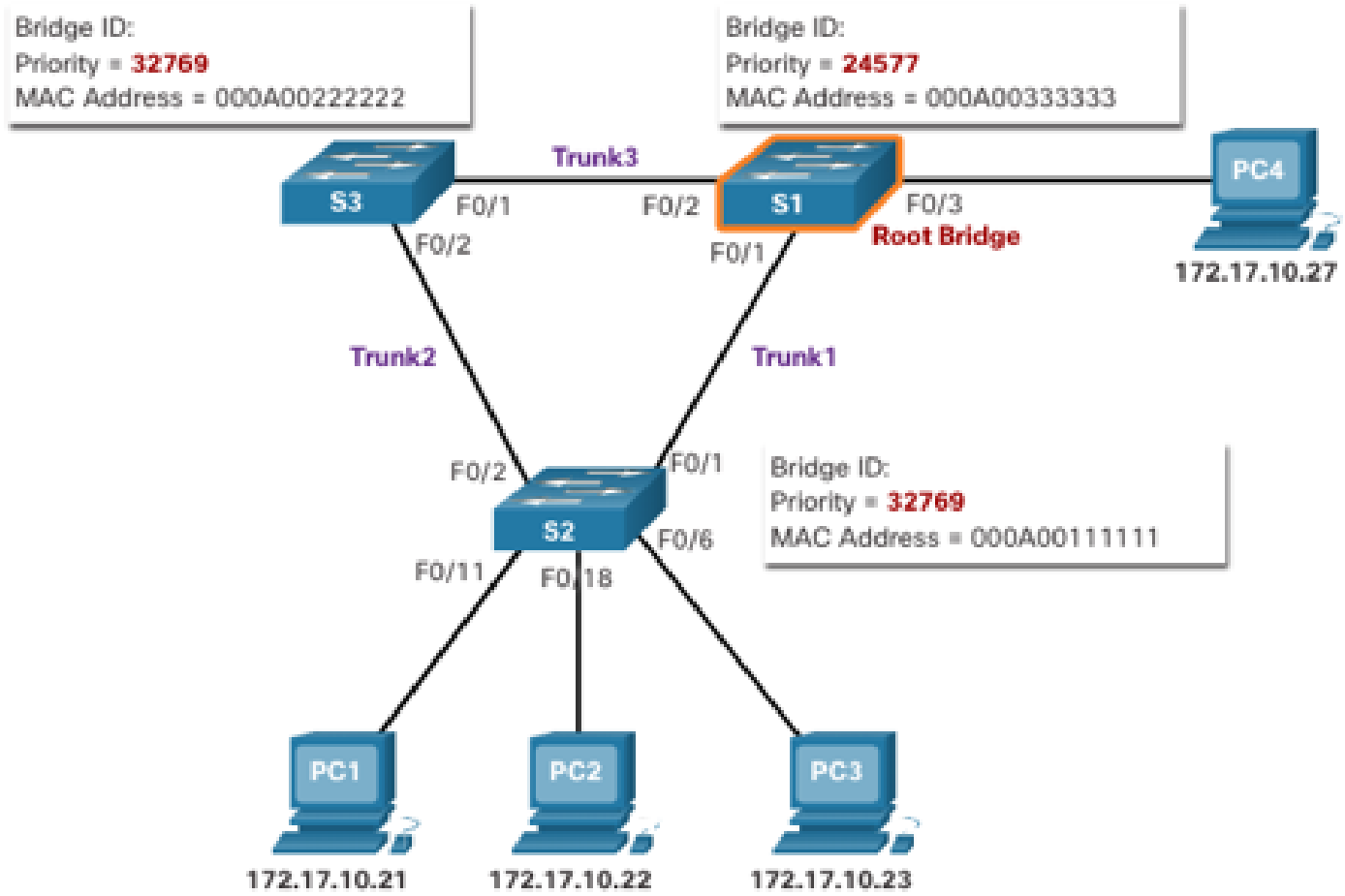
- **Problems solved:**
  - **MAC database instability**: MAC address table constantly changing from the broadcast frames -> High CPU -> Switch unable to forward frames
  - **Broadcast Storm**: high number of broadcasts overwhelming the network 🔥
  - **Duplicated unicast frames:** devices receive twice 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 Root Port.**
  - **Root port** (#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

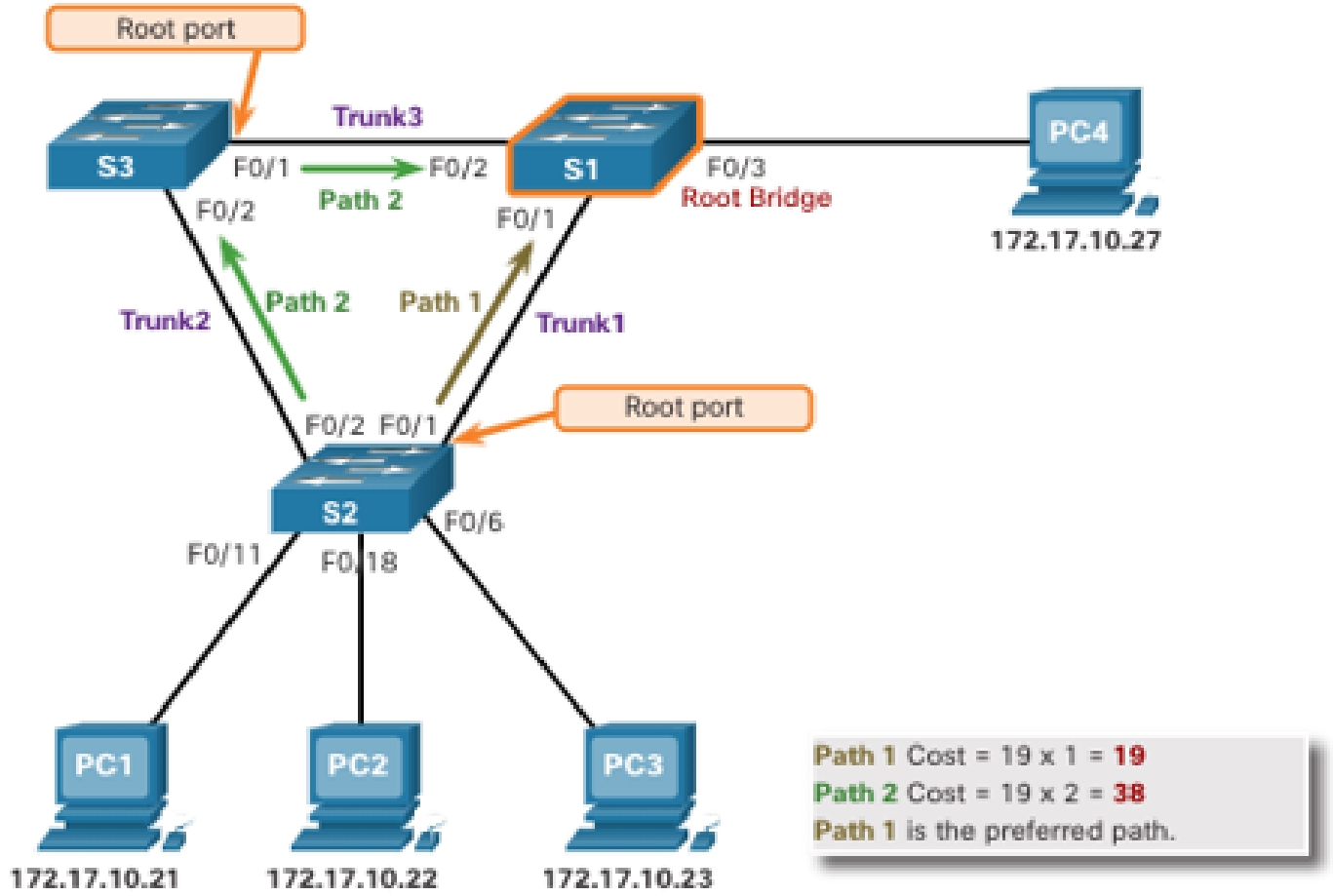
Defaults

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 Cost

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

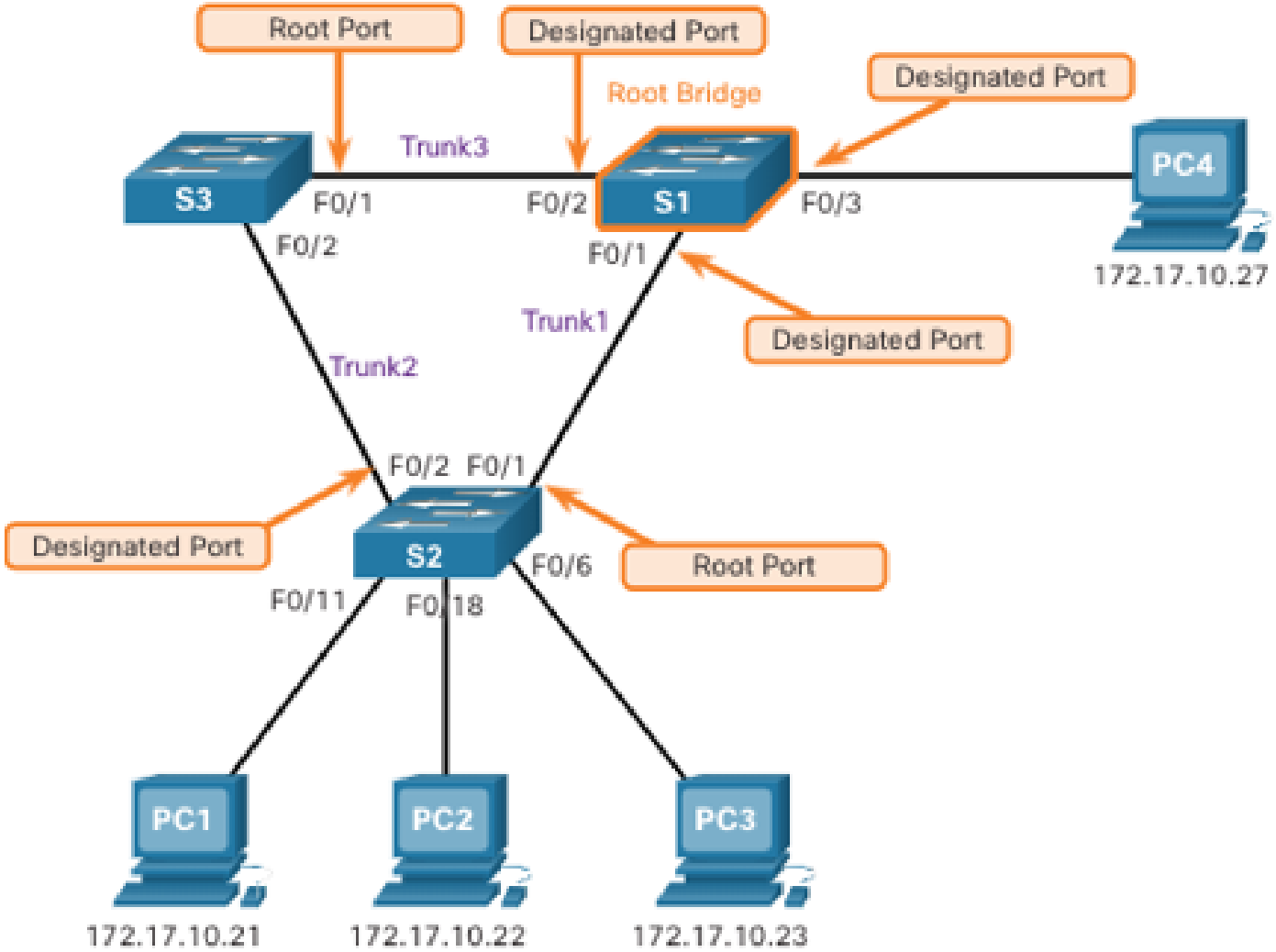
STP Step #2 - Elect the Root Ports



STP Step #3 - Elect Designated Ports (DP)

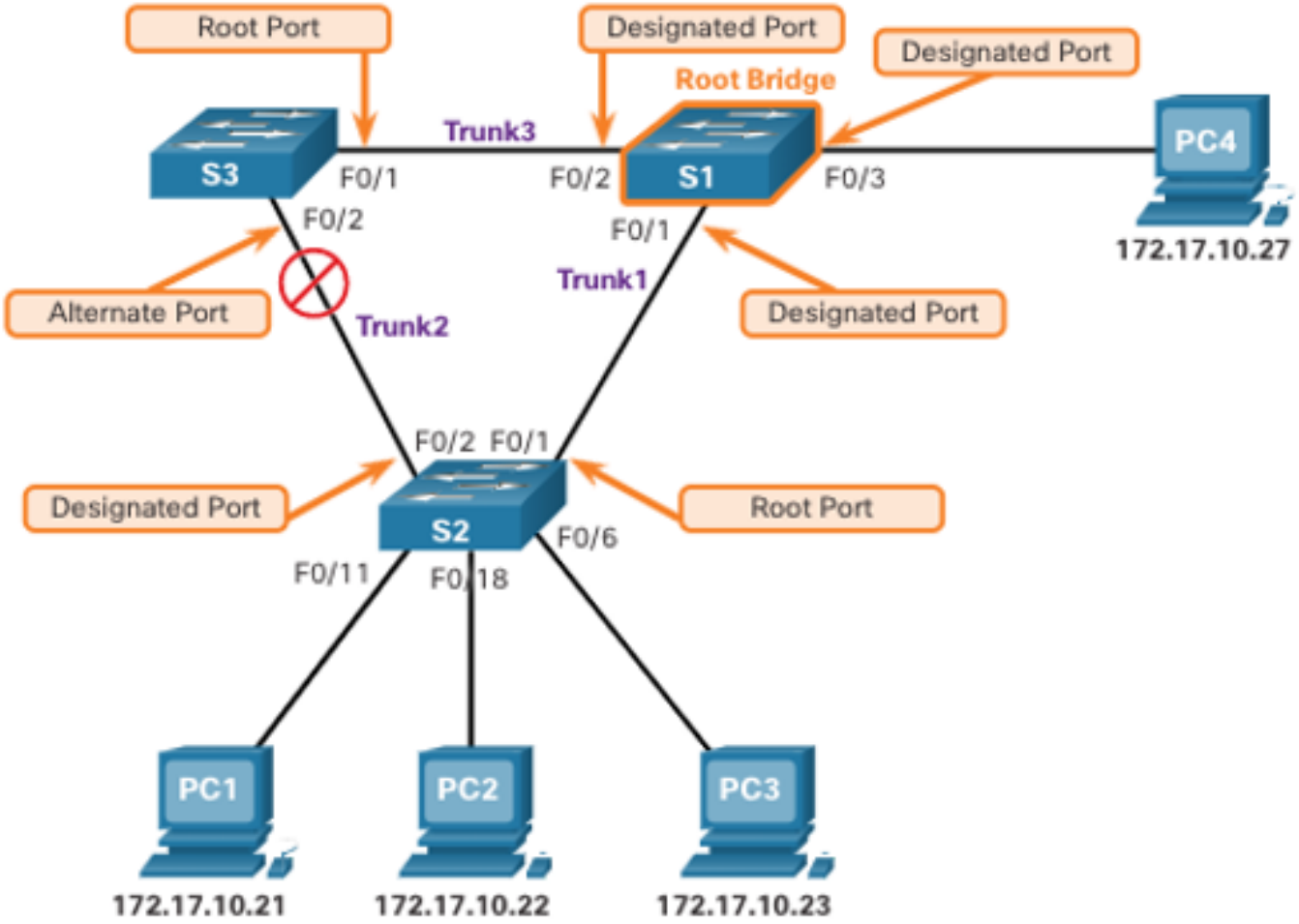
- **EVERY SEGMENT between 2 switches will have one Designated Port.**
  - All ports of Root Bridge ➡️ DP
  - One end of a segment is RP ➡️ Other end is DP
  - All ports attached to end devices ➡️ DP
  - Other segments without DP, one DP (#1, if equals then #2, ...):
    - #1 Port with overall lower cost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

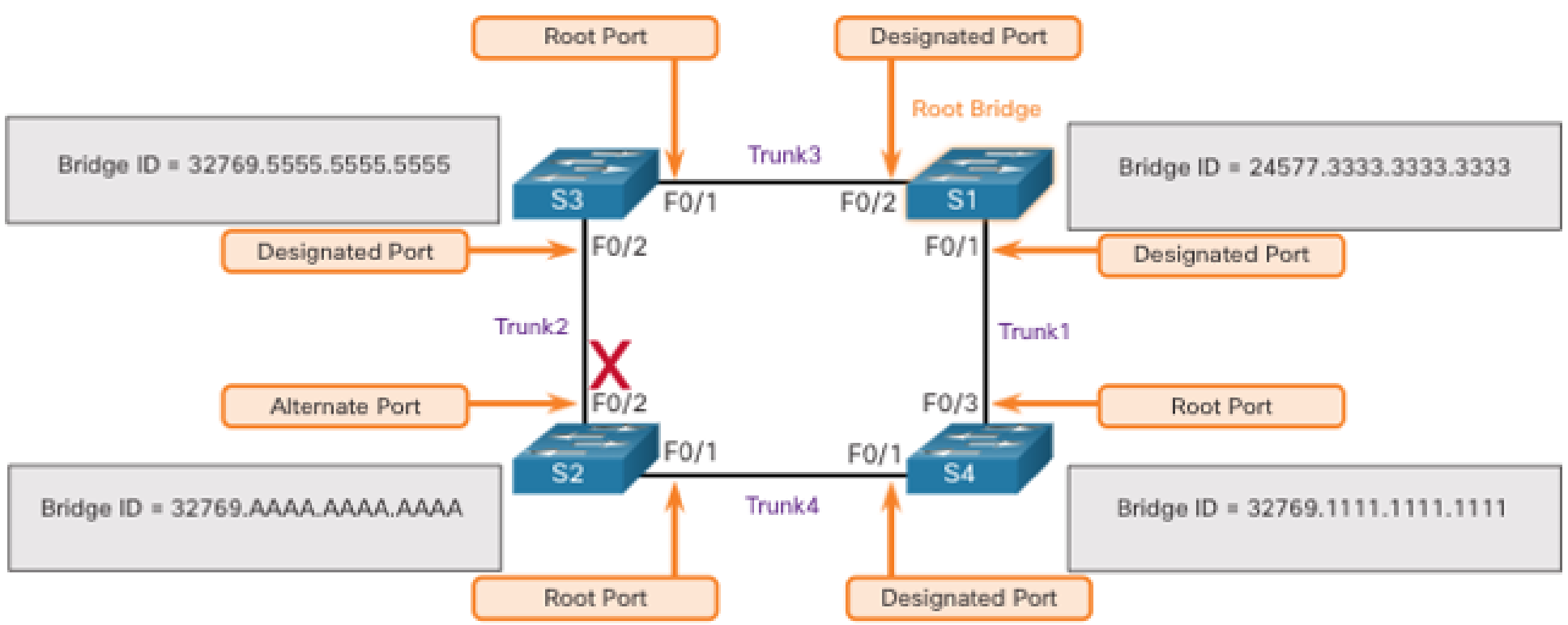


STP Step #4 - Elect Alternate/Blocked Ports (ALT/BLK)

- Block ports that are not RP or DP



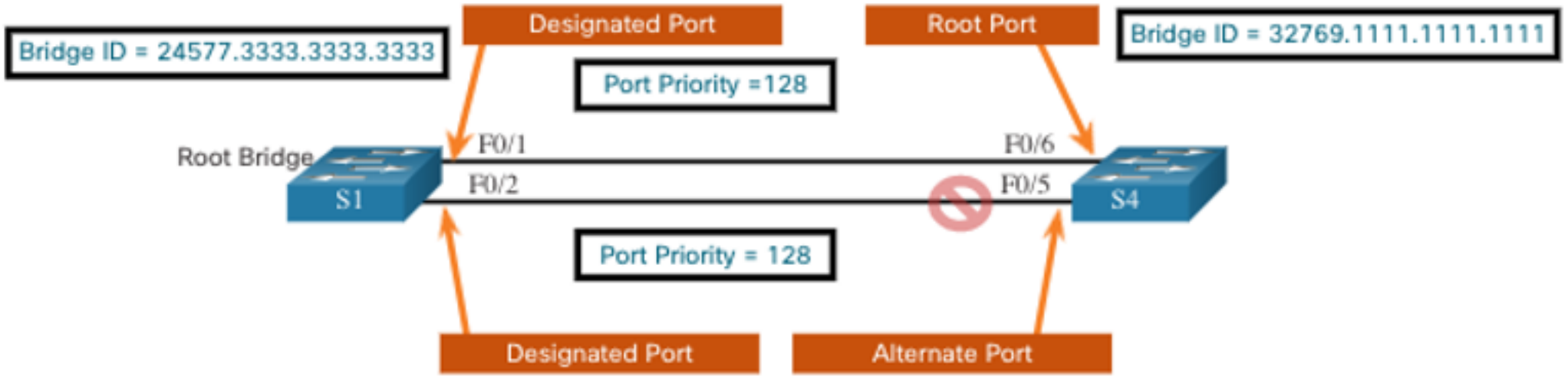
Multiple Equal-Cost Path: Lower Sender BID



S2: Root Port 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

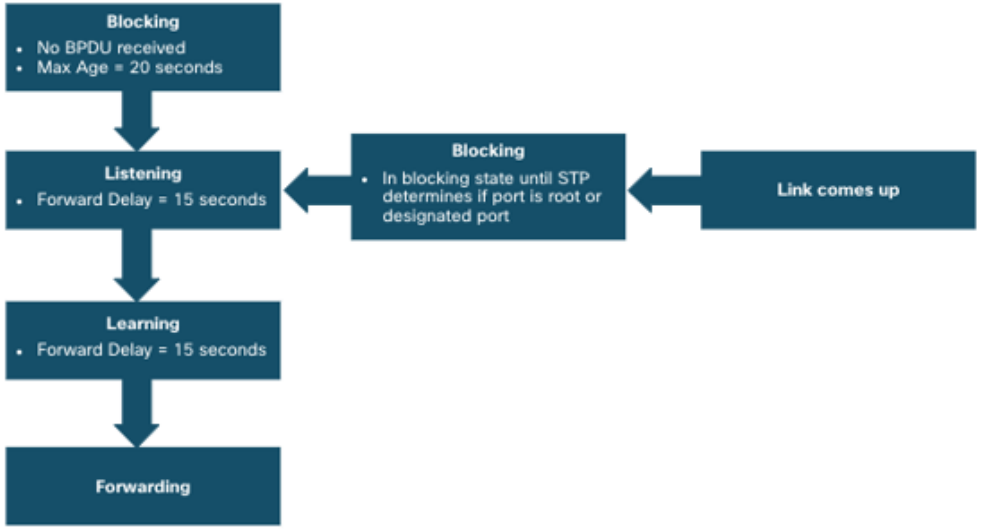


> S4: Root Port is F0/6, because S1 F0/1 has a lower sender Port ID than S1 F0/2
>
> Same cost > Same sender BID > Same Port Priority > Different Sender Port ID

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 stree instance/VLAN ➡️ Load Balancing

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

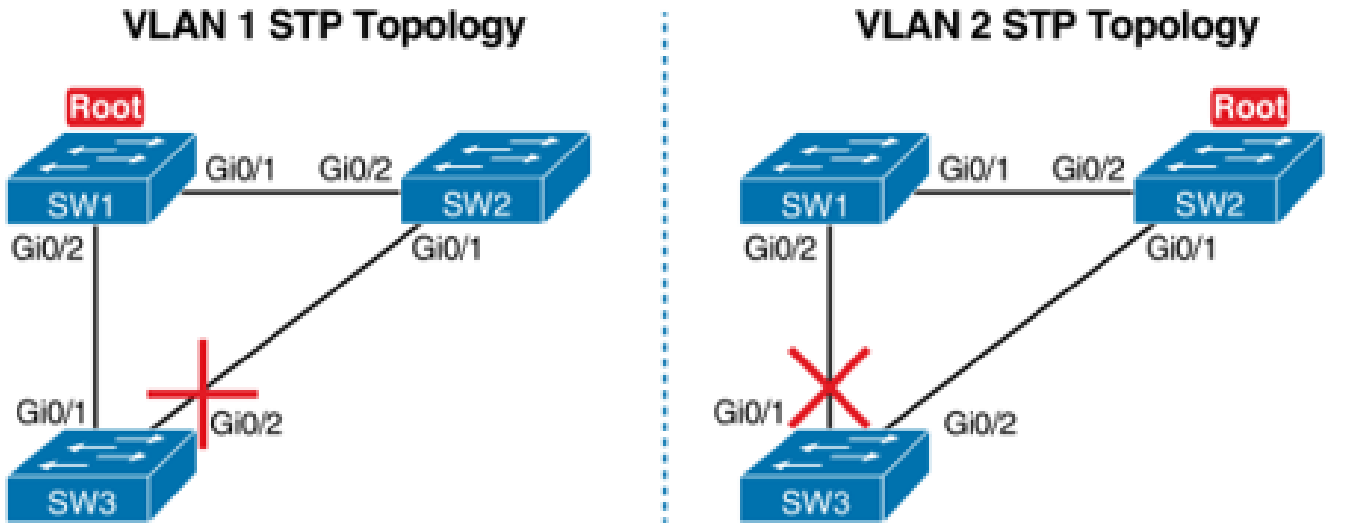
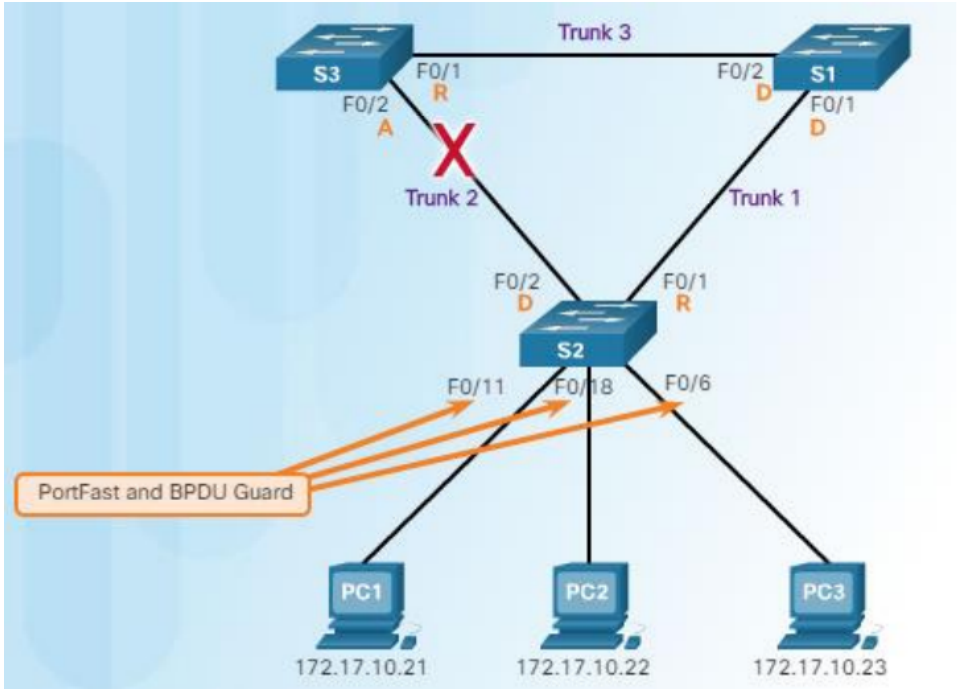


Figure 10-2 *Load Balancing with One Tree for VLAN 1 and Another for VLAN 2*

PVST Config: PortFast and BPDU Guard

- **PortFast**: Ports that have end devices (**Access Ports**). Port in FW 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 forwarding state without waiting the network to converge.
- **Backup Port**: backup to a shared medium (Hub). Less common!!