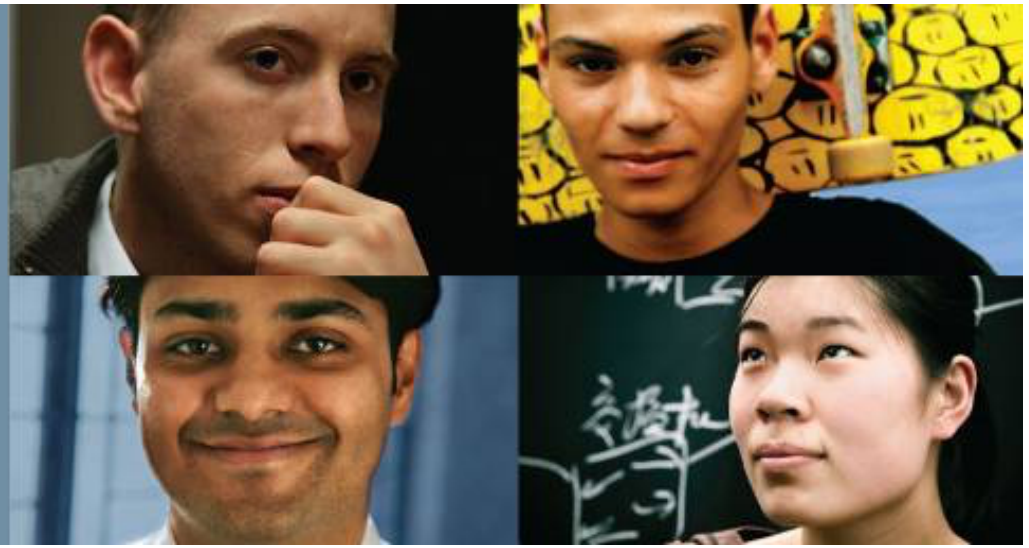
TNE10006/TNE60006: Networks and Switching



Spanning Tree Protocol (Basics)

Cisco | Networking Academy®
Mind Wide Open™

Outline

- Introduction to STP
- How STP implements a loop-free Layer 2 Network
- What is the Root Bridge
- Port roles in an STP network
- How port roles are decided
- Example STP network
- Verifying configuration
- STP Port States

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STP – Spanning Tree Protocol

Introduction

- 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
- A port is considered blocked when user data is prevented from entering or leaving that port. This does not include bridge protocol data unit (BPDU) frames that are used by STP to prevent loops
- The physical paths still exist to provide redundancy, but these paths are disabled to prevent the loops from occurring
- If the path is ever needed to compensate for a network cable or switch failure, STP recalculates the paths and unblocks the necessary ports to allow the redundant path to become active

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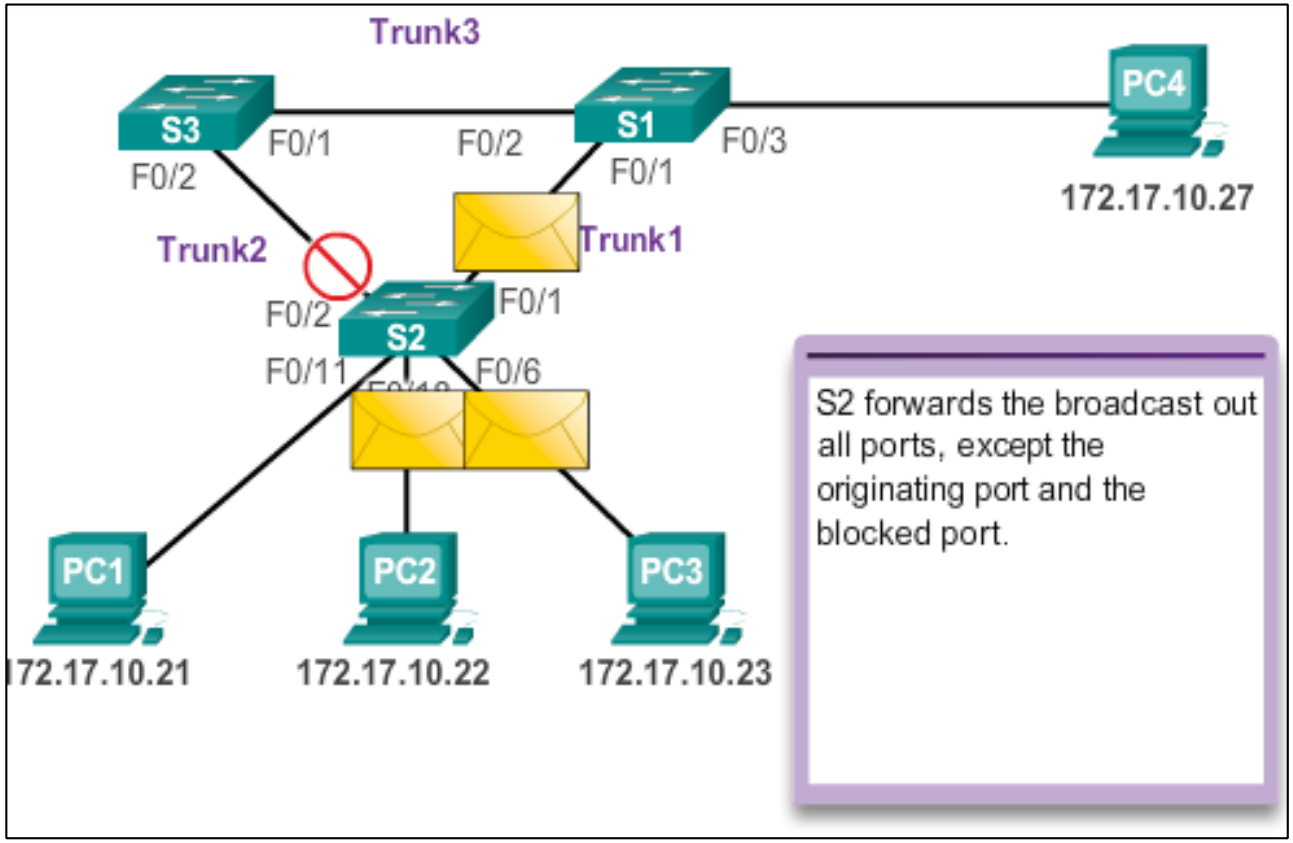
STP – Spanning Tree Protocol

Introduction



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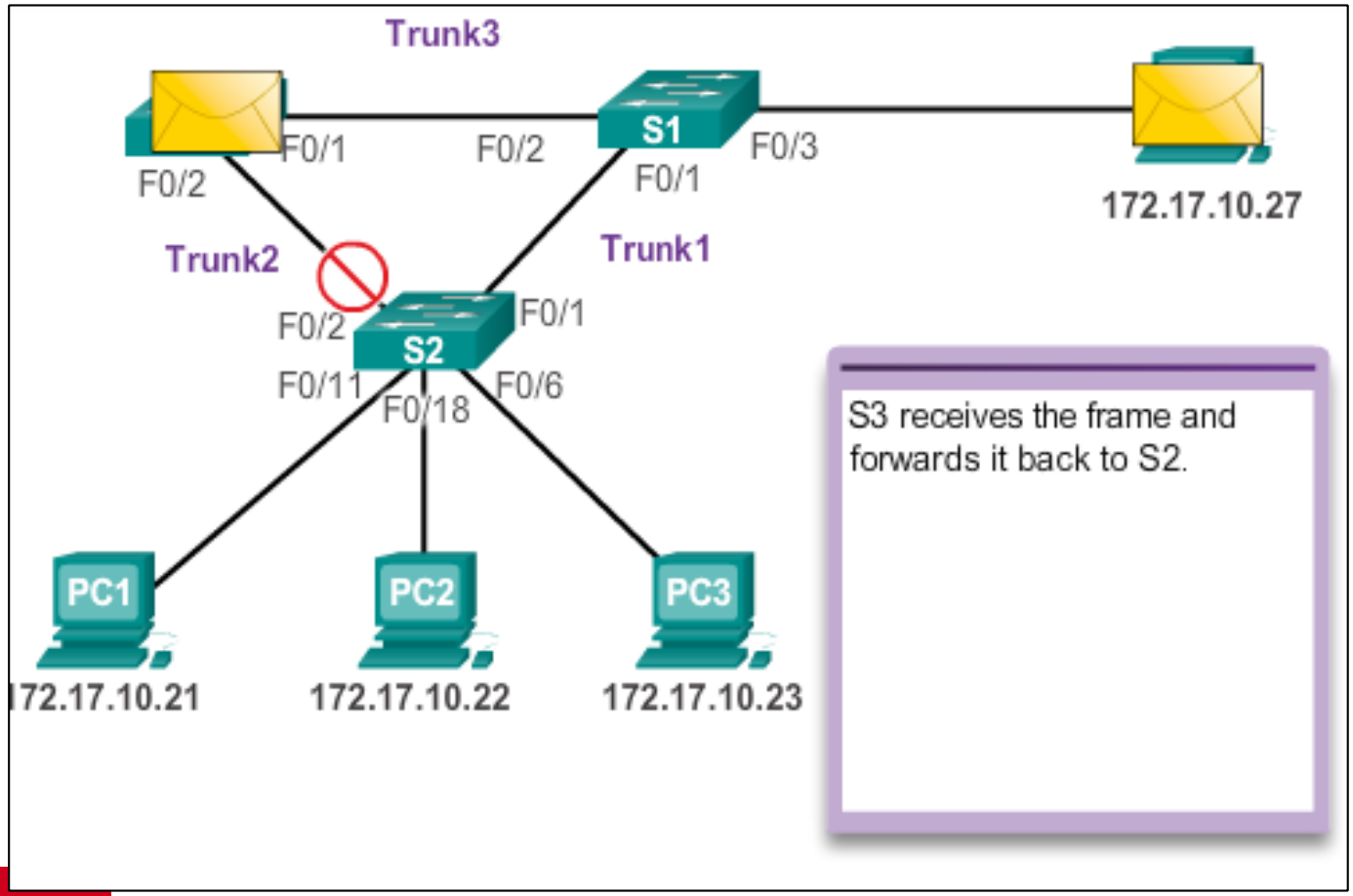
STP – Spanning Tree Protocol

Introduction



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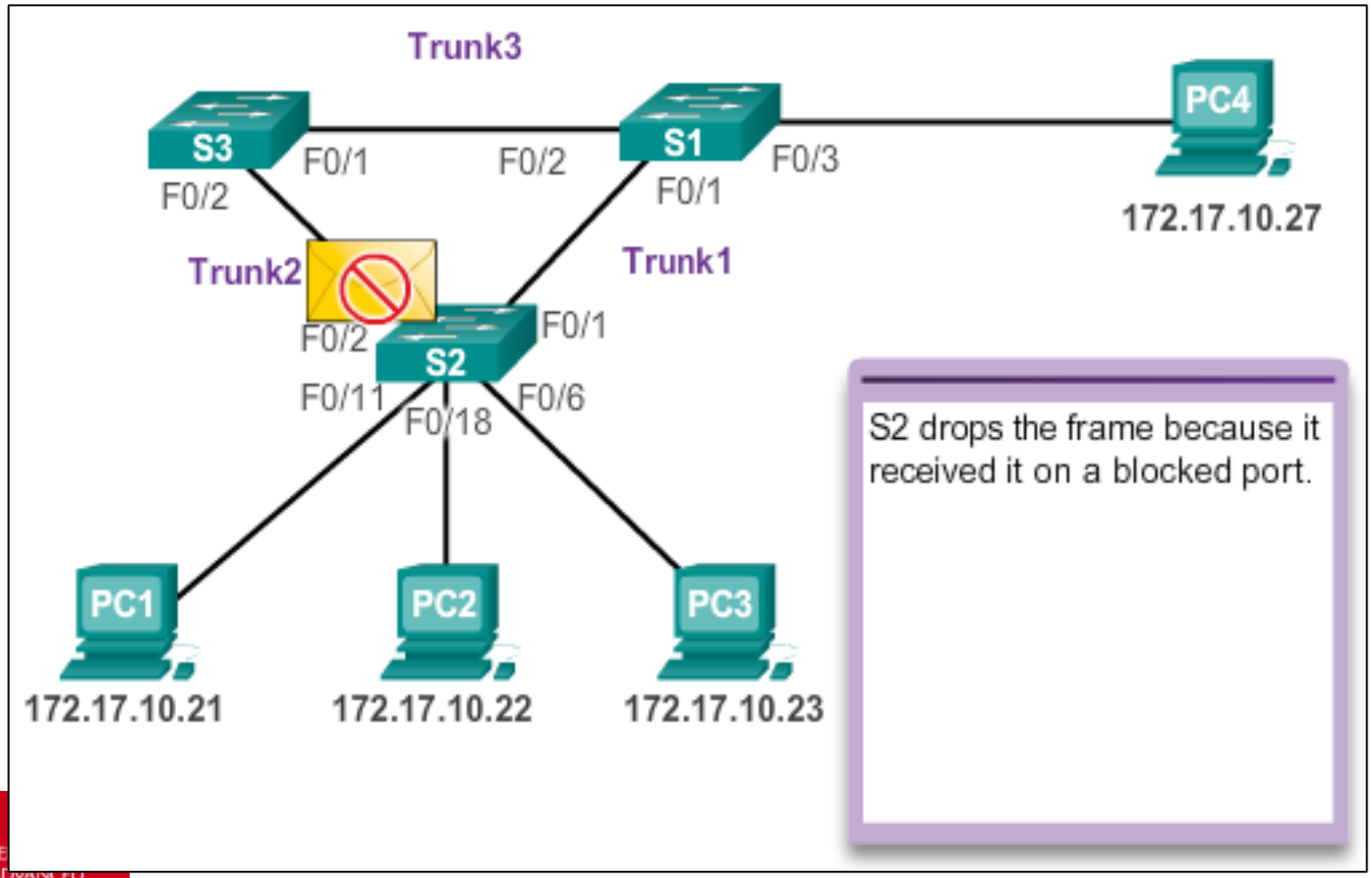
STP – Spanning Tree Protocol

Introduction



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CE ADVANCED INTERNET ARCHITECTURES

Introduction

- STP uses the Spanning Tree Algorithm (STA) to determine which switch ports on a network need to be blocked
- The algorithm selects a single switch as the root bridge and uses it as the reference point for all STA calculations
- Three steps:
  - Elect one root bridge
  - Elect the root port on all non-root bridges
  - Elect the designated and non-designated ports

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STP

Step 1 – Electing the Root Bridge

All switches in the broadcast domain participate in the election process:

- After a switch boots, it sends out BPDU frames containing the switch BID and the current root ID every 2 seconds
- Initially, each switch identifies itself as the root

As switches receive BPDU frames from adjacent switches:

- Update root ID based on information from other switches
- Forward new BPDU frames with the lower root ID to other adjacent switches
- Eventually, the switch with the lowest BID ends up being identified as the root bridge on all switches
- Regular BPDU frames ensures re-election if a switch fails

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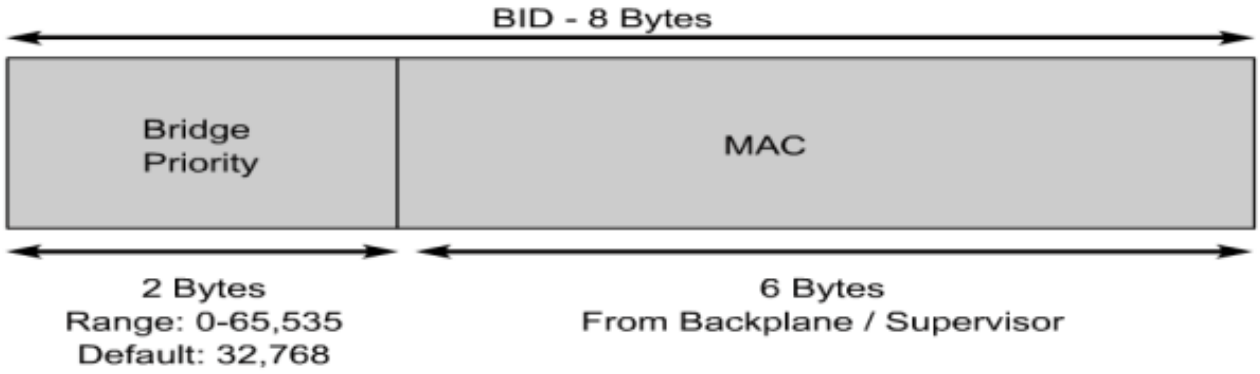
STP

Step 1 – Electing the Root Bridge



- **Bridge ID (BID)** is used to identify each bridge/switch
- The BID is used in determining the **root bridge**
- Consists of two components:

  A 2-byte Bridge Priority: Cisco switch defaults to **32,768** (decimal)

  A 6-byte MAC address (hexadecimal)
- **Lowest Bridge ID is the root.**
- If all devices have the same priority, the bridge with the lowest MAC address becomes the root bridge.

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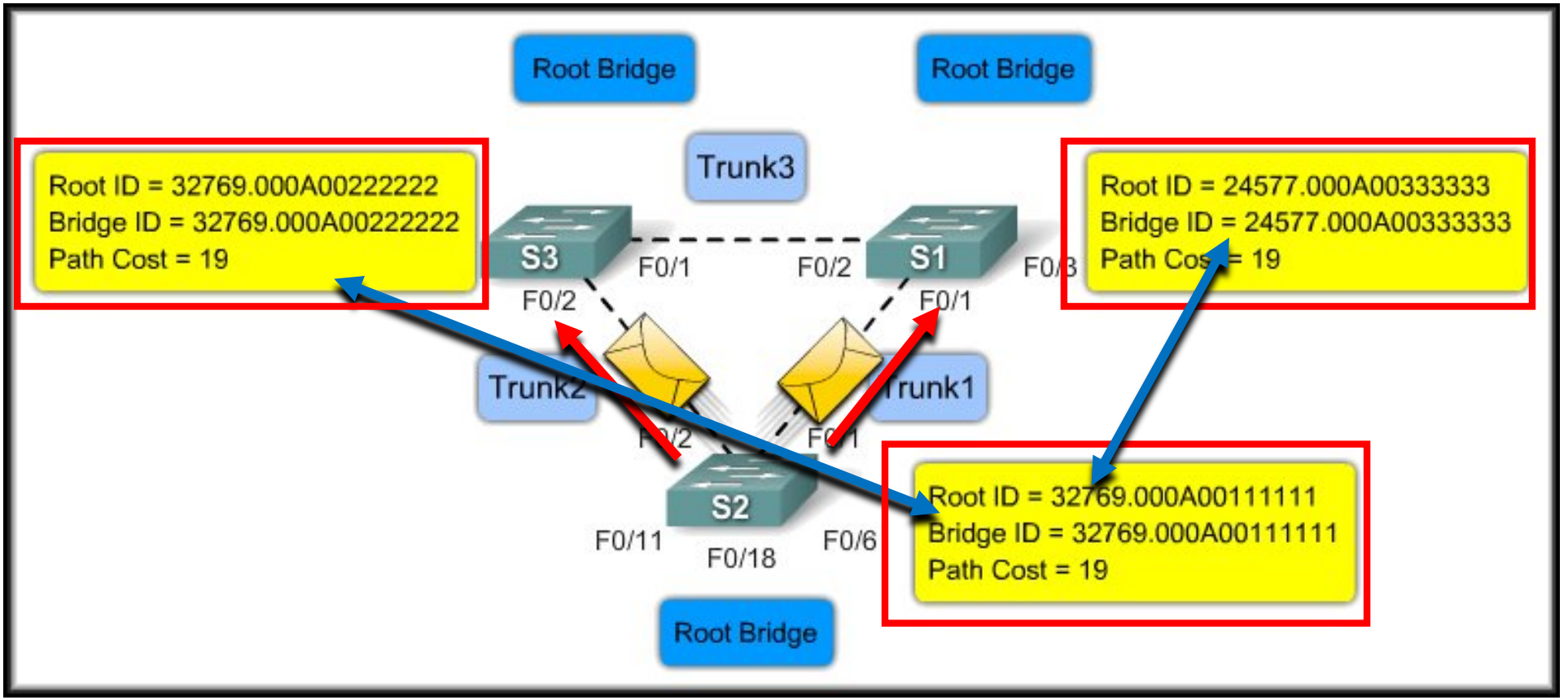
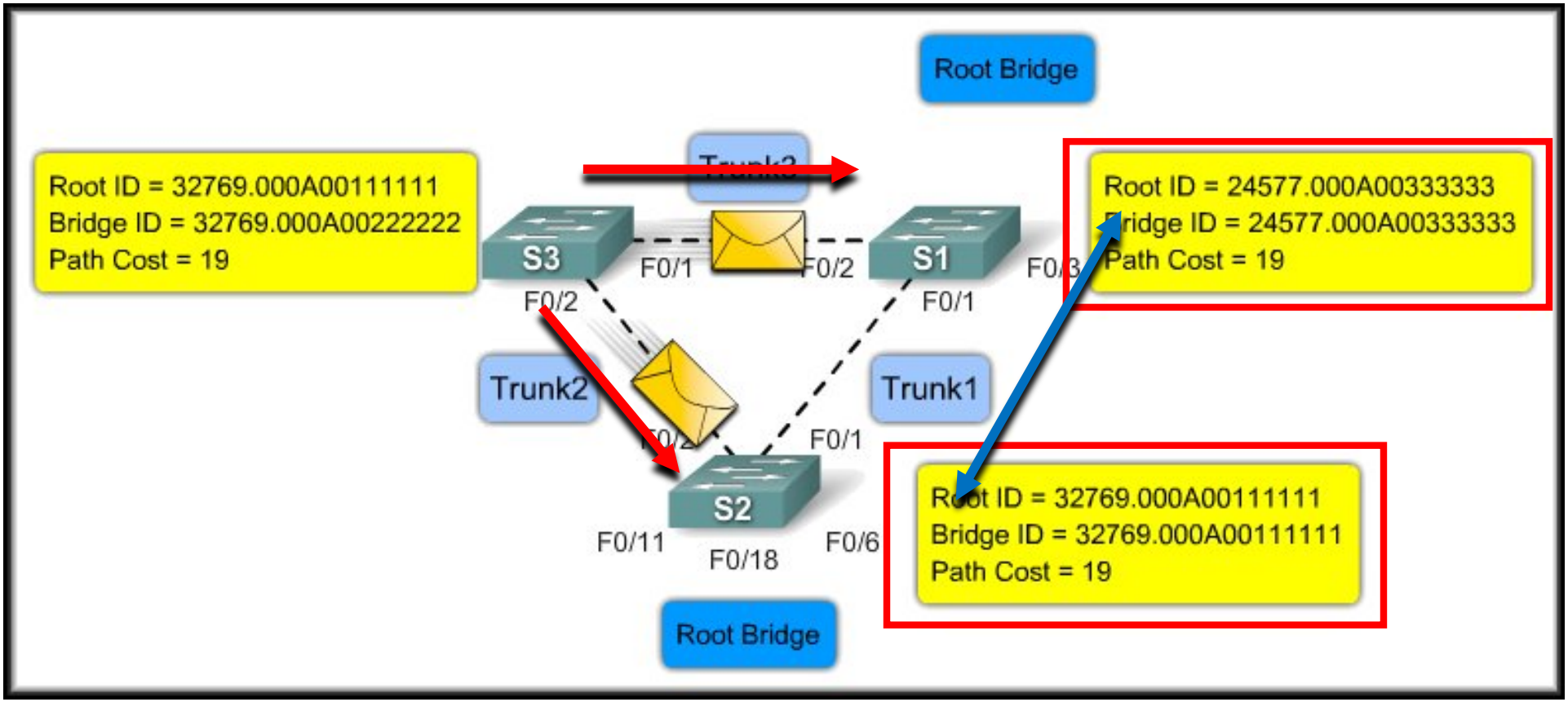
Step 1 – Electing the Root Bridge



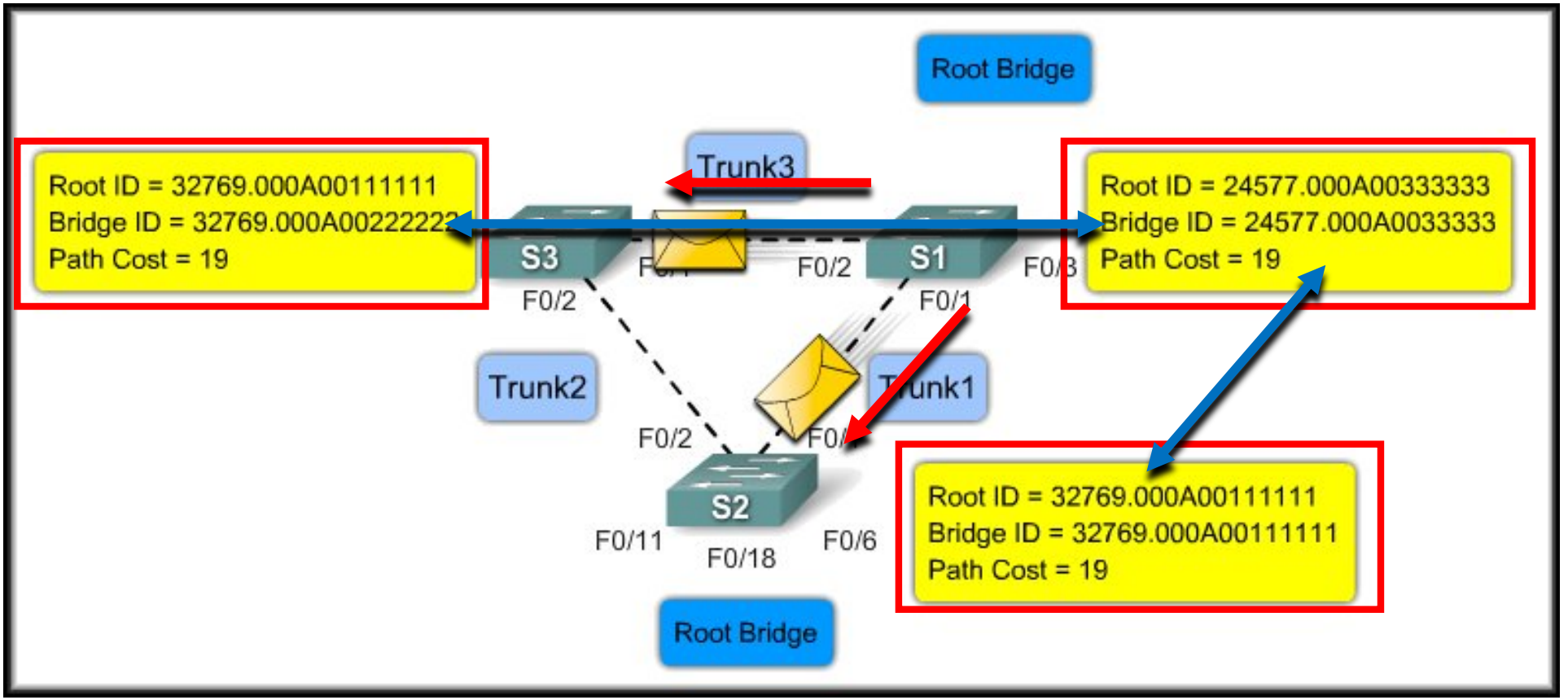
S3 believes S2 is the root bridge.
S1and S2 still think they are the root bridge.

Step 1 – Electing the Root Bridge



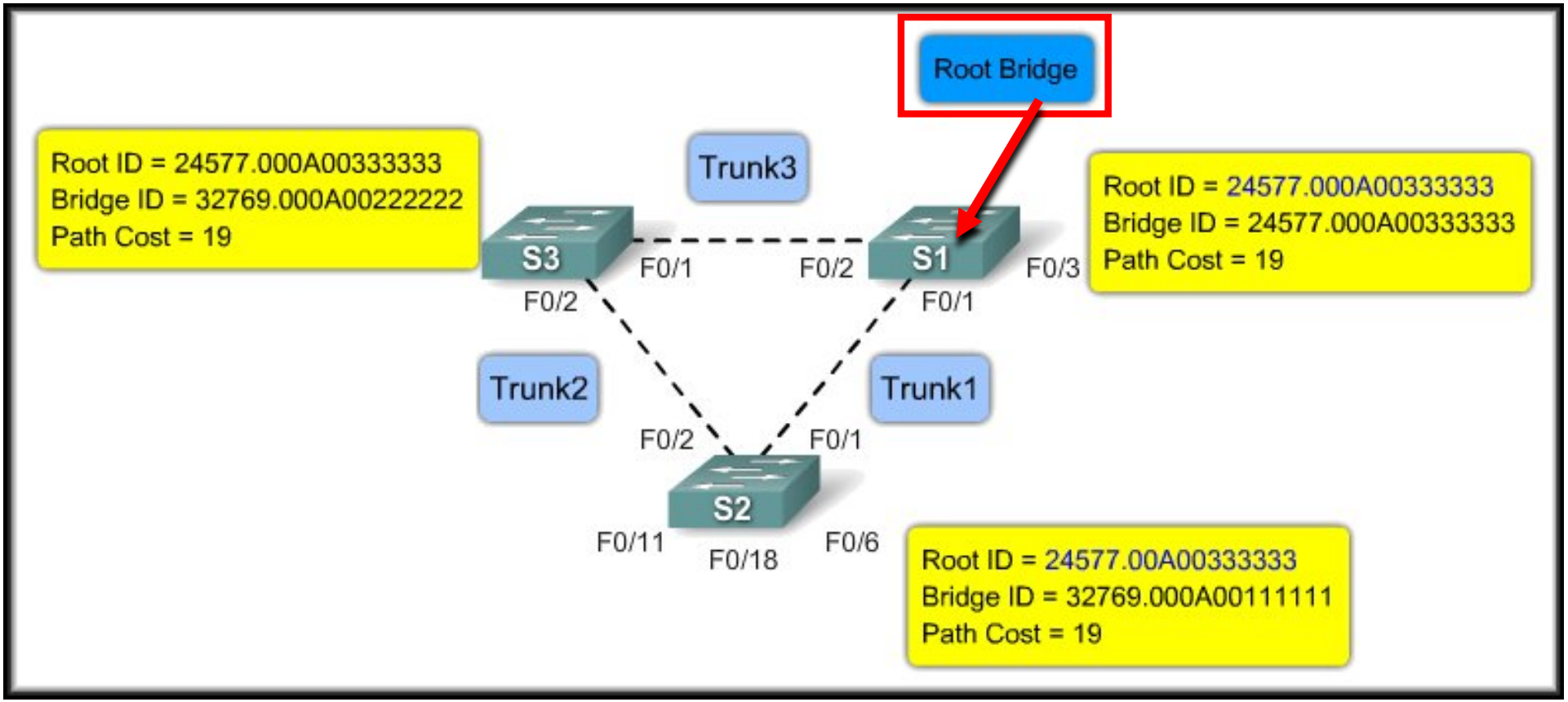
S2 and S1 both think that they are the root bridge.

Step 1 – Electing the Root Bridge



S3 recognizes S1 as the root.
S2 recognizes S1 as the root.

Step 1 – Electing the Root Bridge



If the root bridge fails, the election process begins again.

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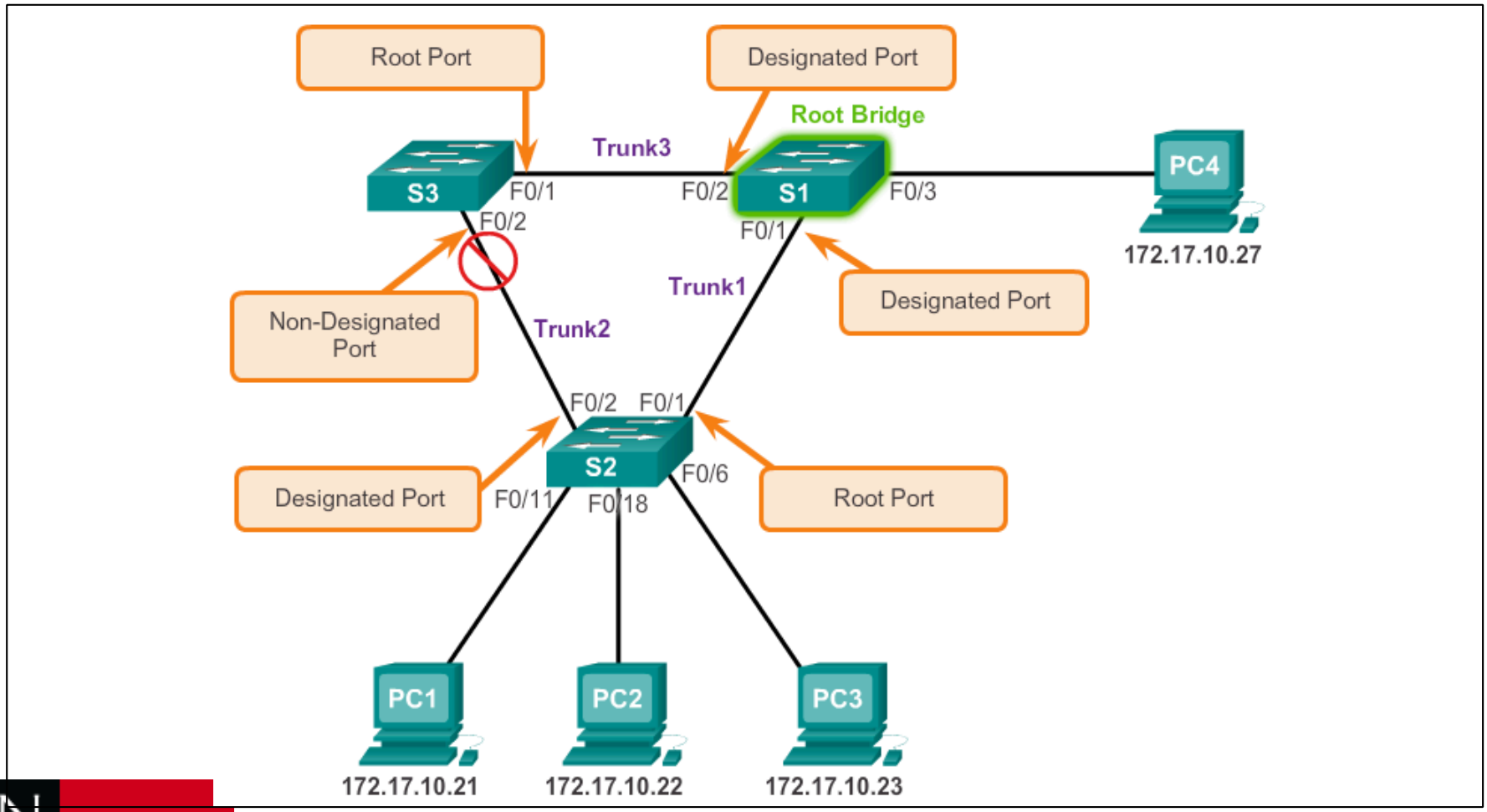
Port Roles in a Spanning Tree Network

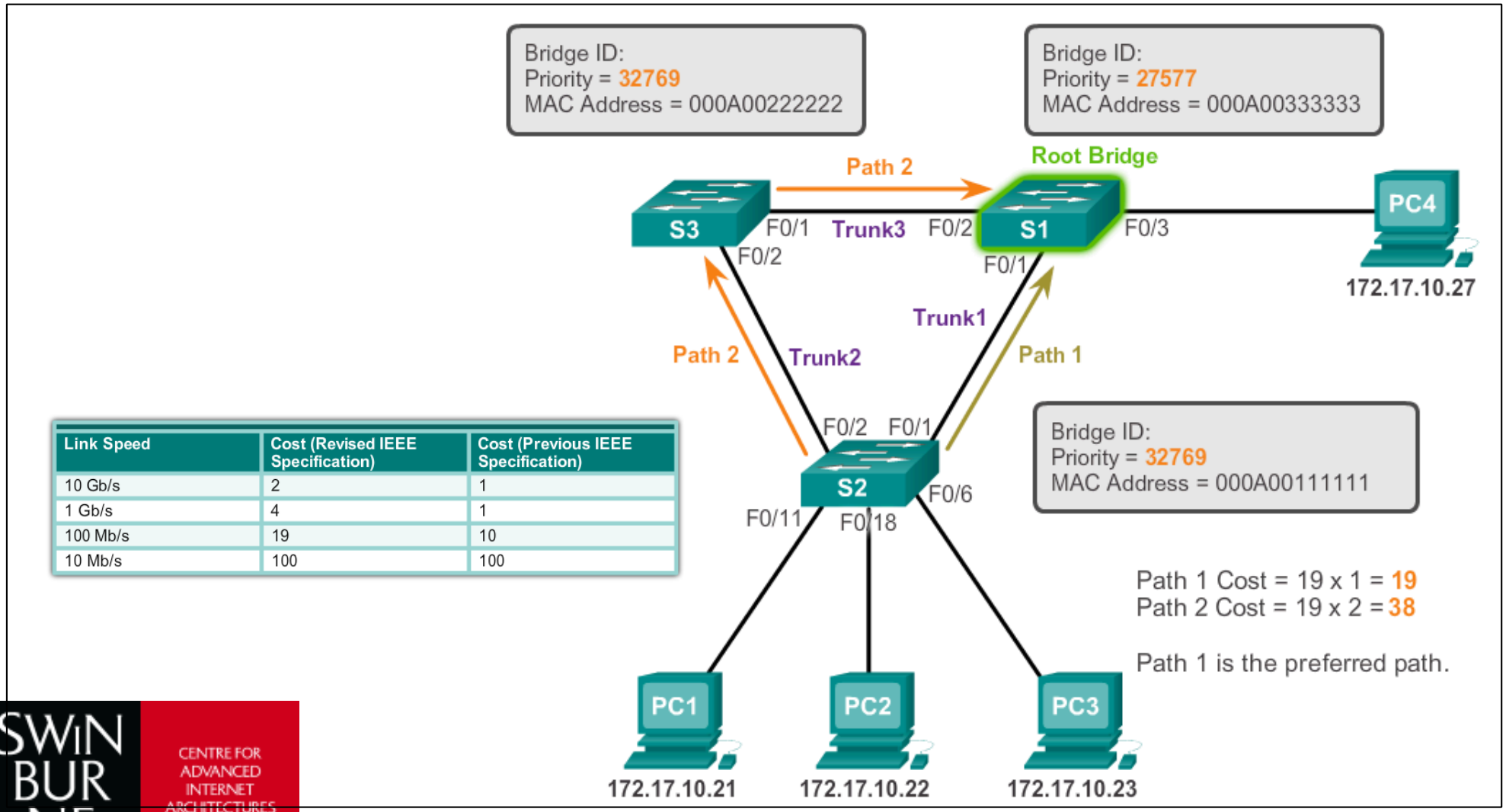
- Root port – port with cheapest path to root bridge
  - Lowest next hop's bridge ID and then port ID are tiebreakers
  - Only one root-port for each non-root bridge
  - Can send and receive traffic
- Designated ports – all other active ports
  - Each link **MUST** have one designated port
  - Other end of segment of root port, **OR**
  - end with cheapest path to root bridge (bridge ID is tiebreaker)
  - On the root bridge, all ports are designated ports
  - Can send and receive traffic
- Non-designated ports – all other ports
  - Sends no traffic (except BPDU)
  - Drops all received traffic (except BPDU)

Port Roles in a Spanning Tree Network



STP

Step 2 – Electing Root Ports



Link Speed	Cost (Revised IEEE Specification)	Cost (Previous IEEE Specification)
10 Gb/s	2	1
1 Gb/s	4	1
100 Mb/s	19	10
10 Mb/s	100	100

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Step 2 – Electing Root Ports

- After the root bridge has been elected, the STA starts the process of determining the best paths to the root bridge
- We sum the individual port costs along the path from the destination to the root bridge

Configure Port Cost

Configuring Port Costs

```
S2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
S2(config)#interface f0/1
S2(config-if)#spanning-tree cost 25
S2(config-if)#end
S2#
```

Reset Port Cost

```
S2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
S2(config)#interface f0/1
S2(config-if)#no spanning-tree cost
S2(config-if)#end
S2#
```

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Step 3 – Electing (Non-)Designated Ports

- All ports on the root bridge will be Designated ports
- All links connected to root ports will be Designated ports
- On other links, port with lowest path cost to the root bridge is designated, other side is Non-designated
- Lowest BID is used as a tie breaker

STP Example

Putting It All Together

- STP Convergence is the time it takes for the network to:
  - Determine which switch is going to assume the role of the root bridge.
  - Set switch ports to their final spanning-tree port roles where all potential loops are eliminated

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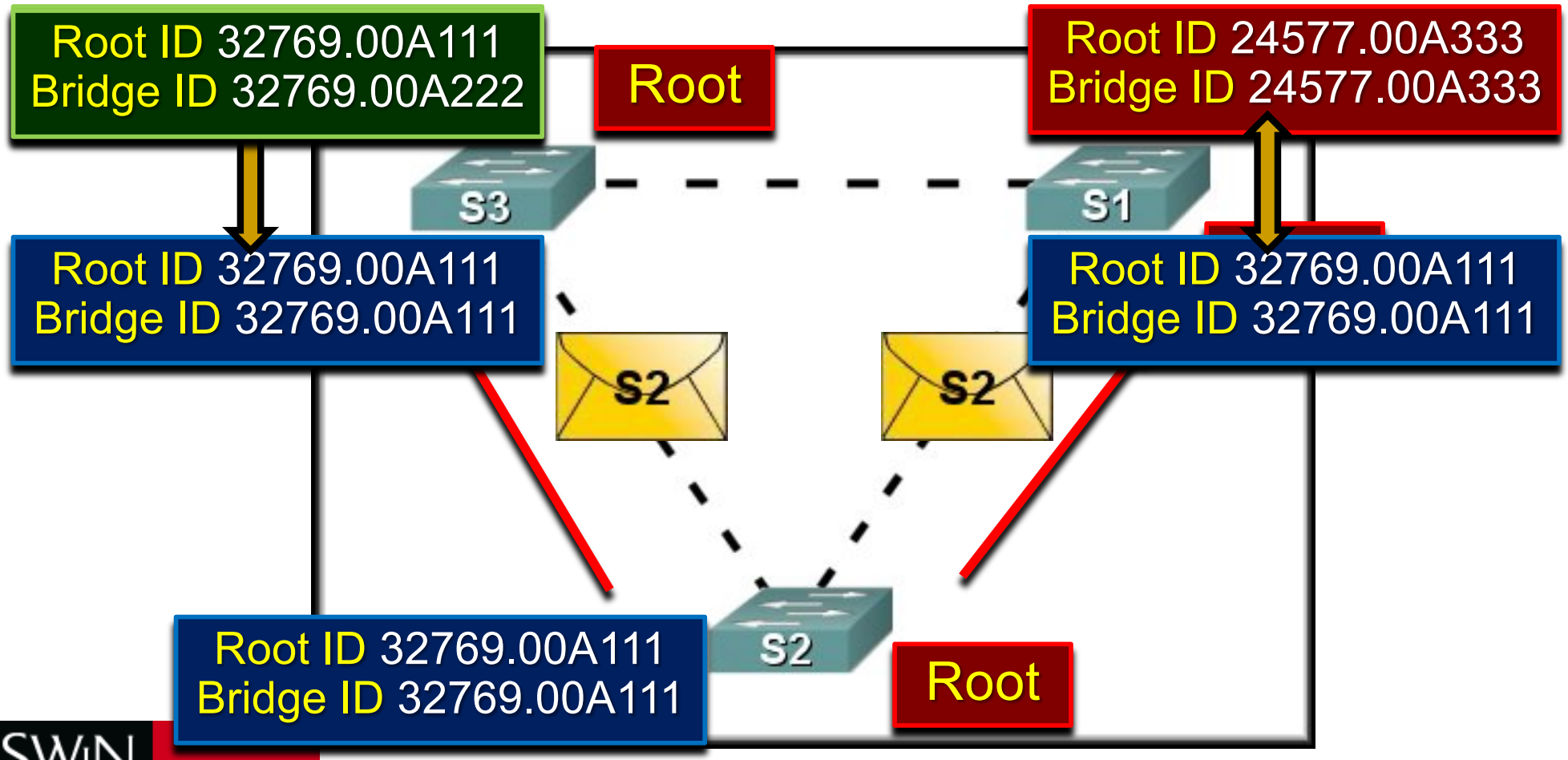
STP Example

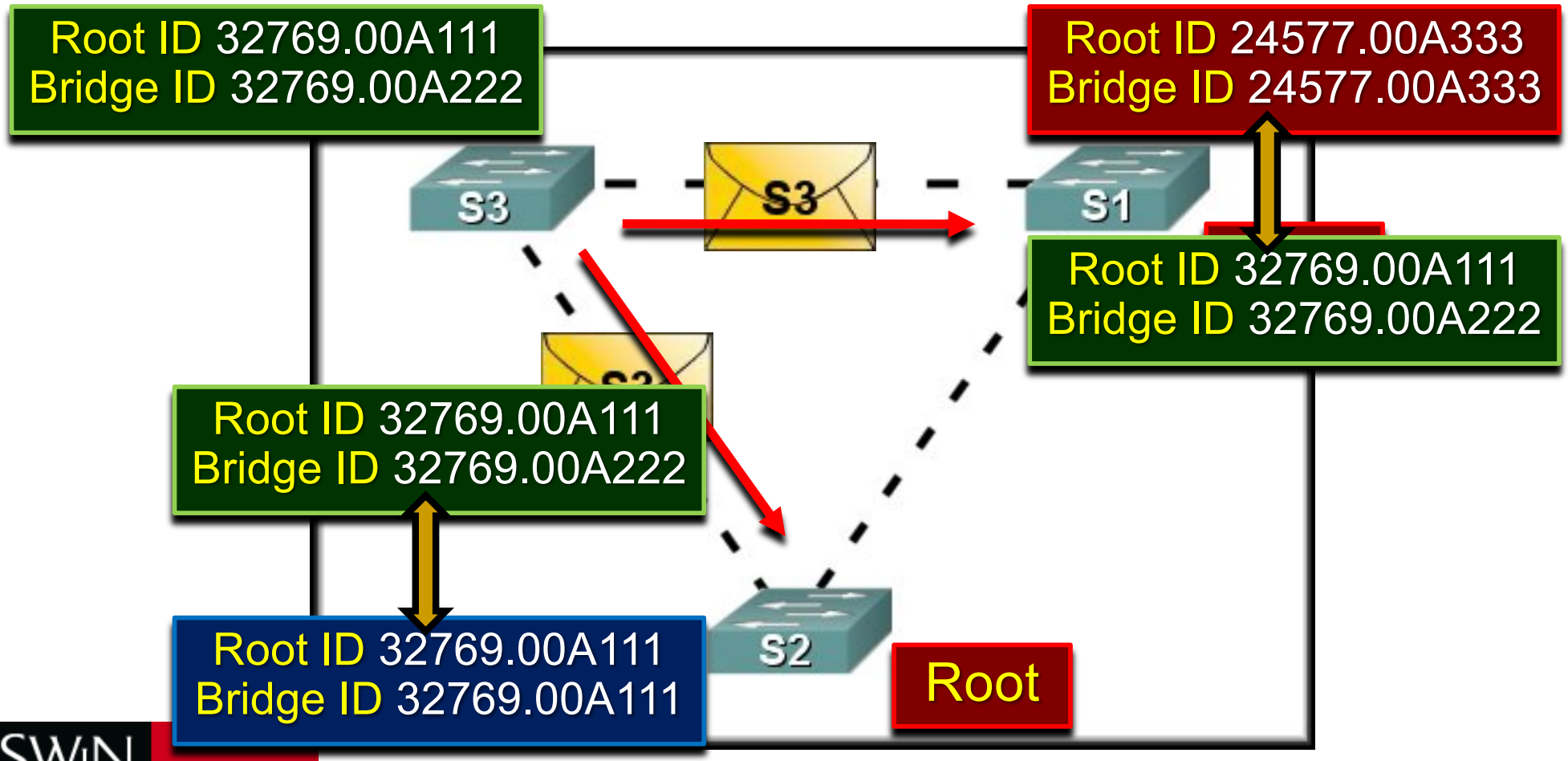
Step 1 – Root Bridge Election



SWINBURNE CENTRE FOR ADVANCED INTERNET ARCHITECTURES

STP Example

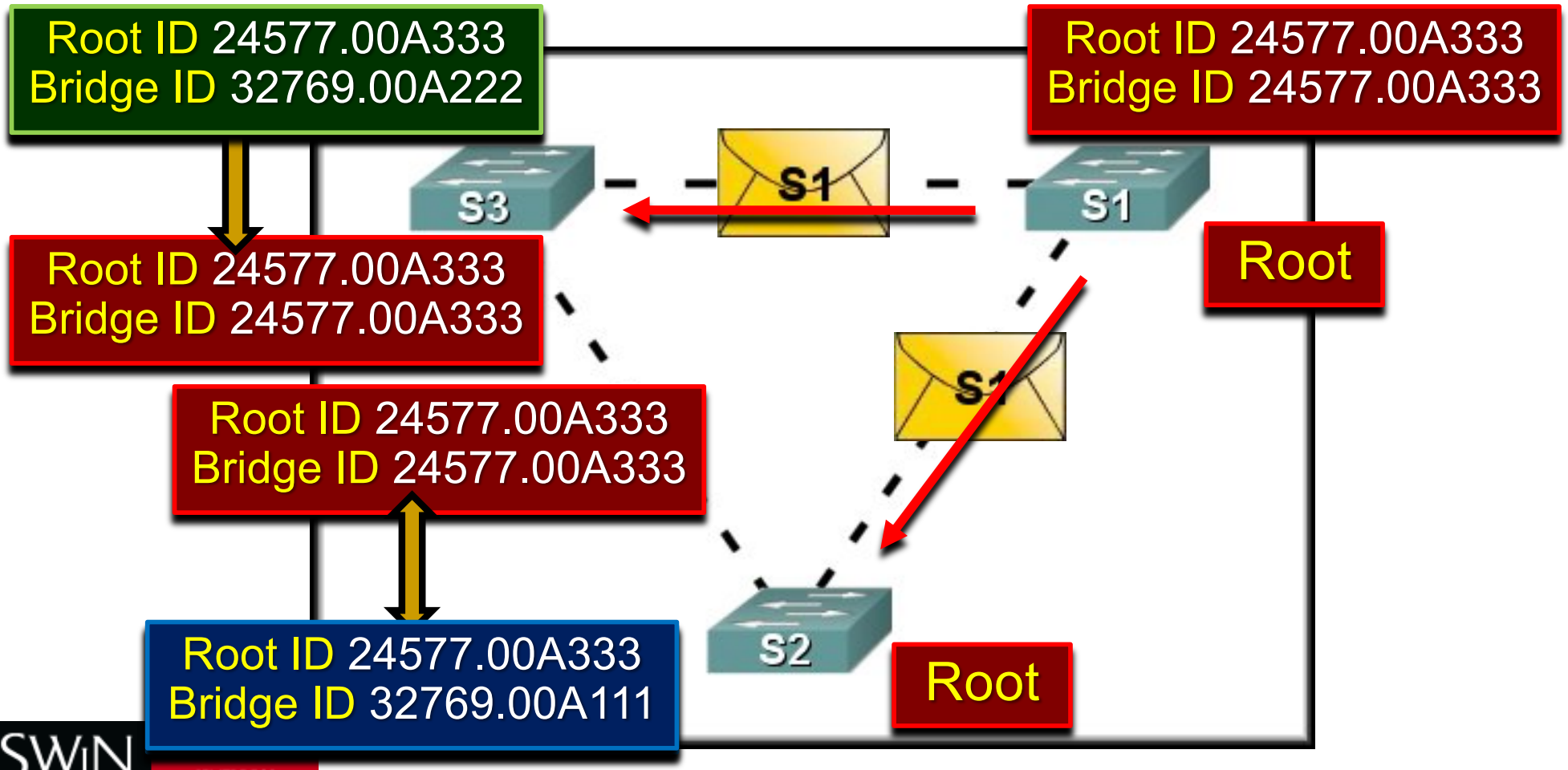
Step 1 – Root Bridge Election



SWINBURNE CENTRE FOR ADVANCED INTERNET ARCHITECTURES

STP Example

Step 1 – Root Bridge Election



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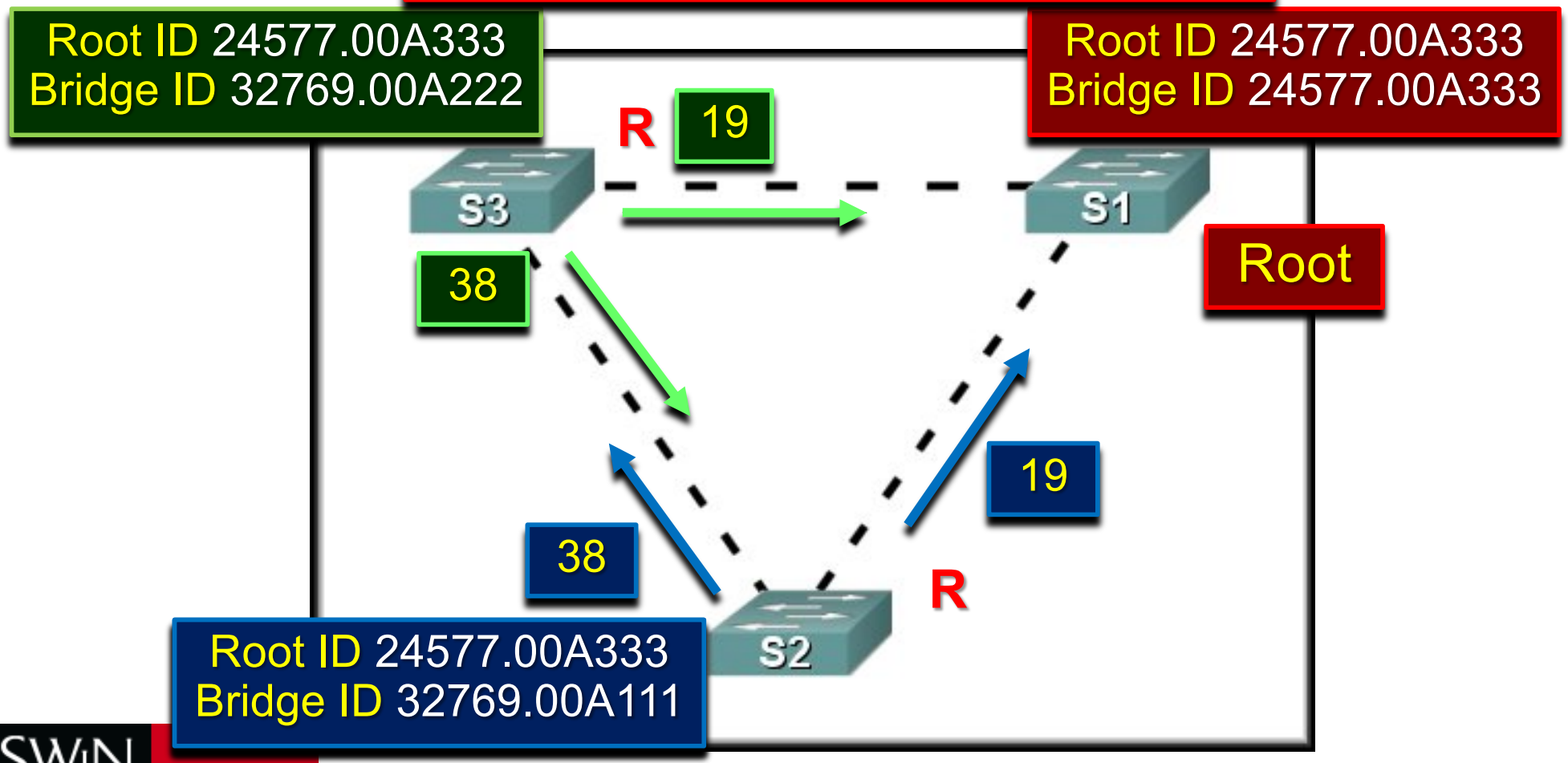
STP Example

Step 2 – Re

Throughout the root bridge election, the path cost has also been updated. All links are 100Mbps. Cost = 19



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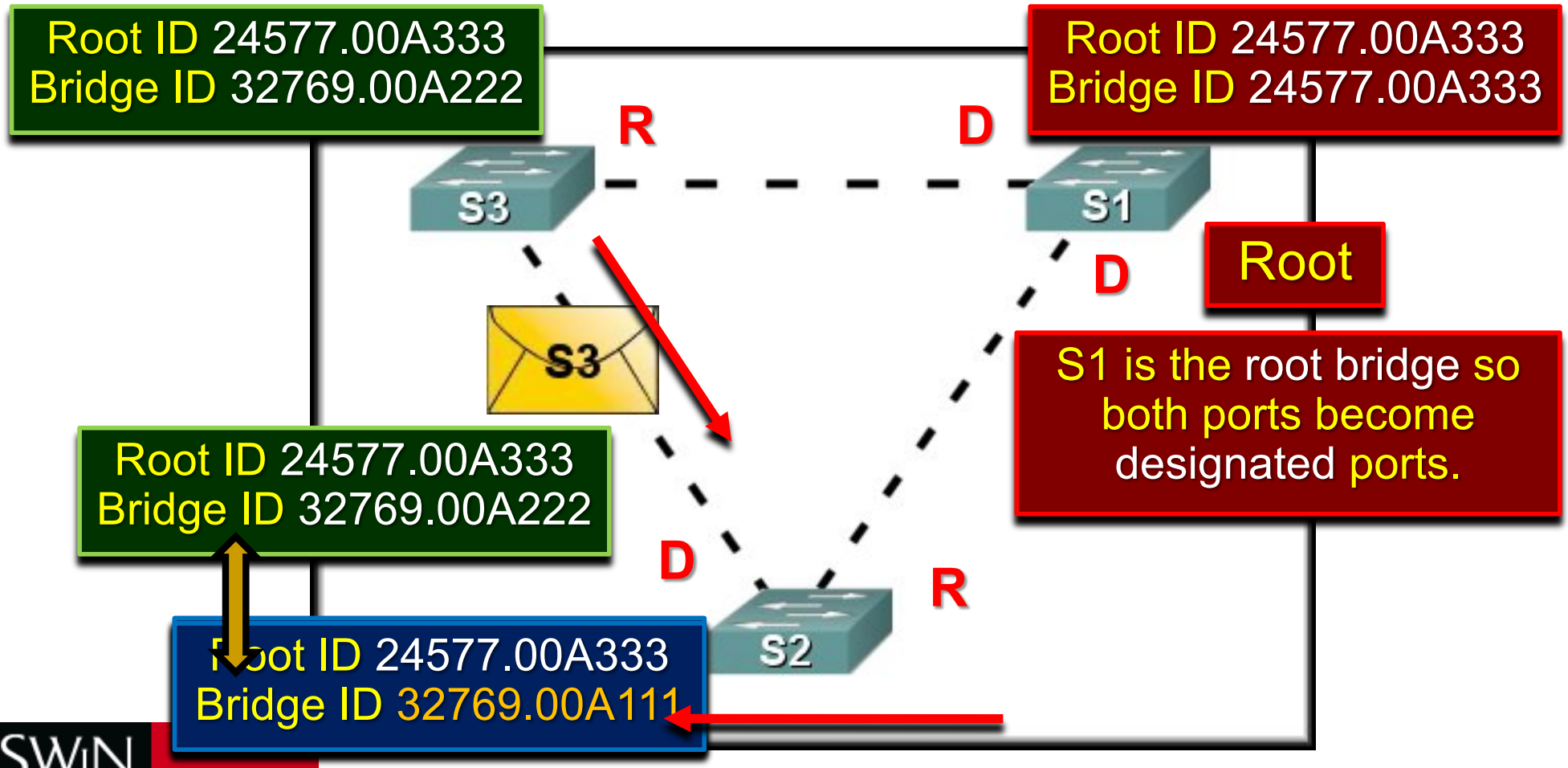
STP Example

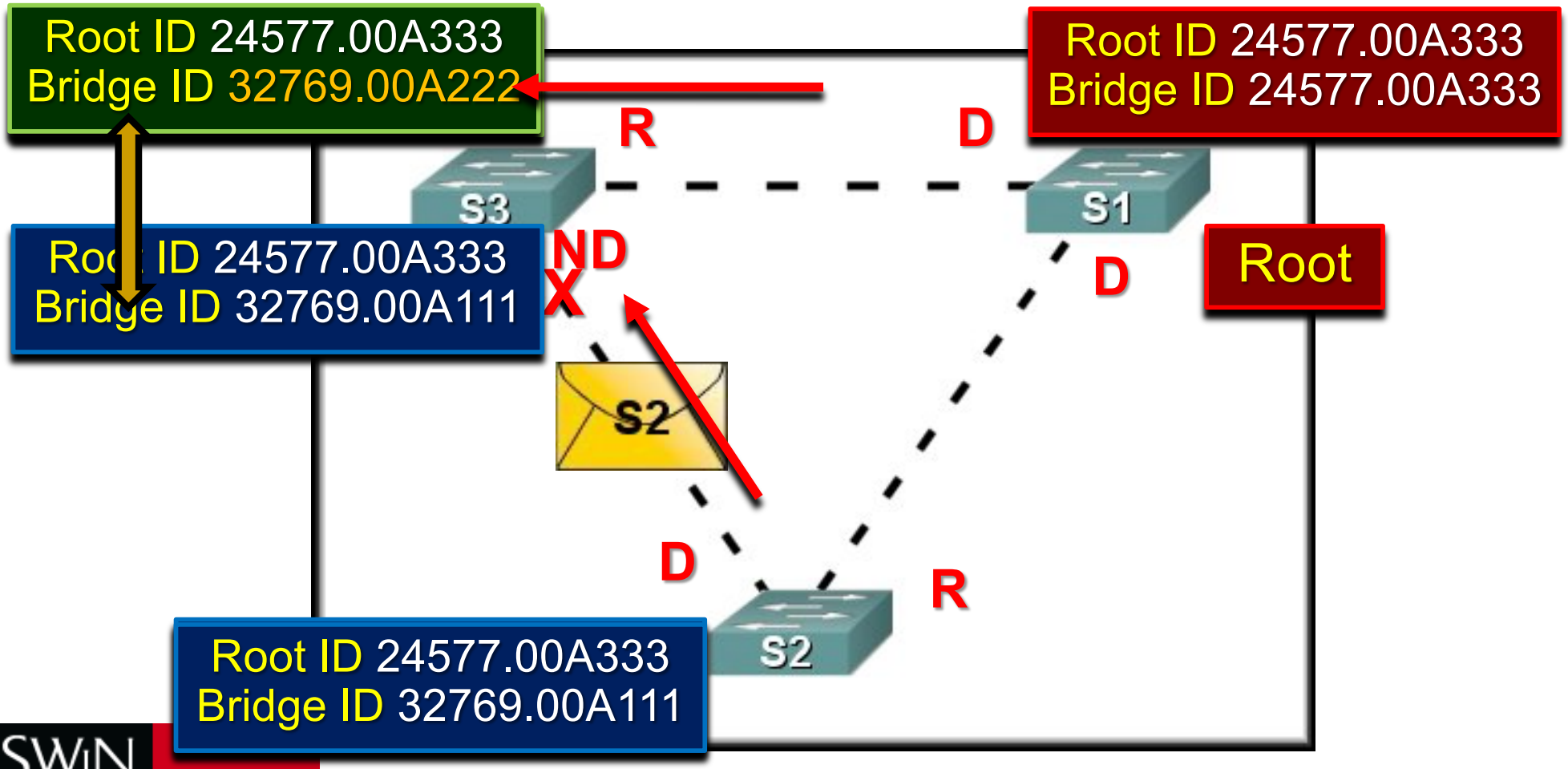
Step 3 – (Non-)Designated Ports



SWINBURNE CENTRE FOR ADVANCED INTERNET ARCHITECTURES

STP Example

Step 3 – (Non-)Designated Ports



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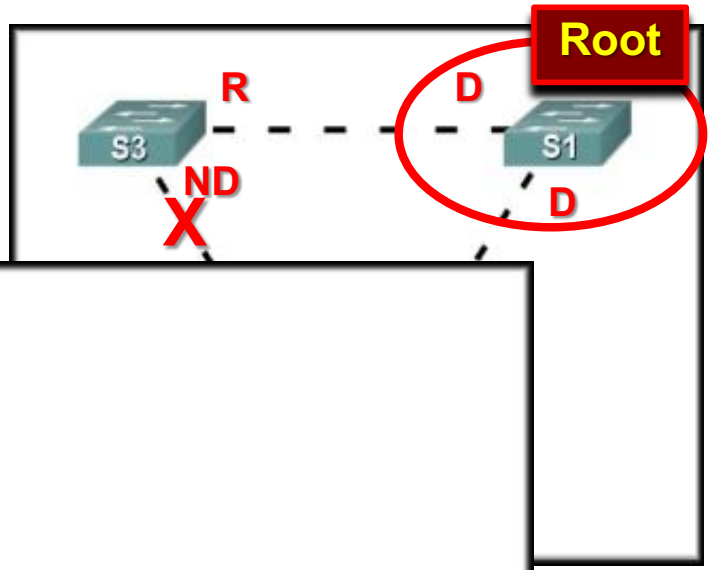
STP Example

Verification

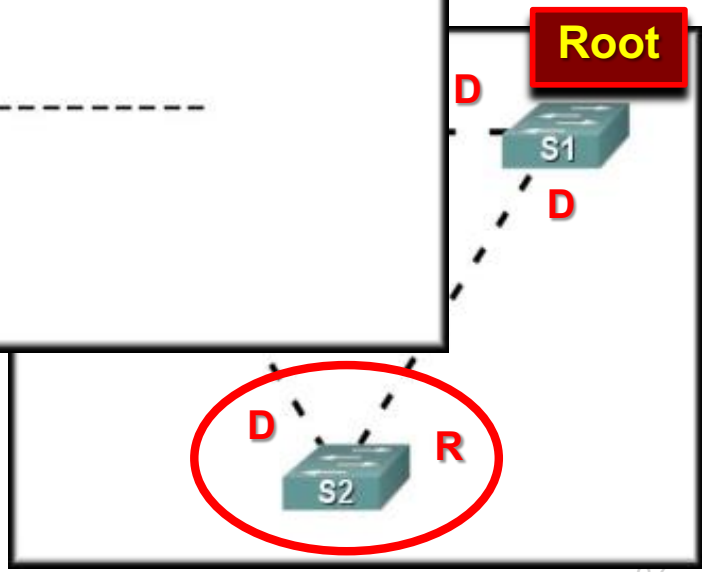



```
S1#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    24577
              Address     0060.47E0.3A67
              This bridge is the root
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    24577  (priority 24576 sys-id-ext 1)
              Address     0060.47E0.3A67
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  20

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------
Fa0/1            Desg FWD 19        128.1    P2p
Fa0/2            Desg FWD 19        128.2    P2p

S1#
```

STP Example

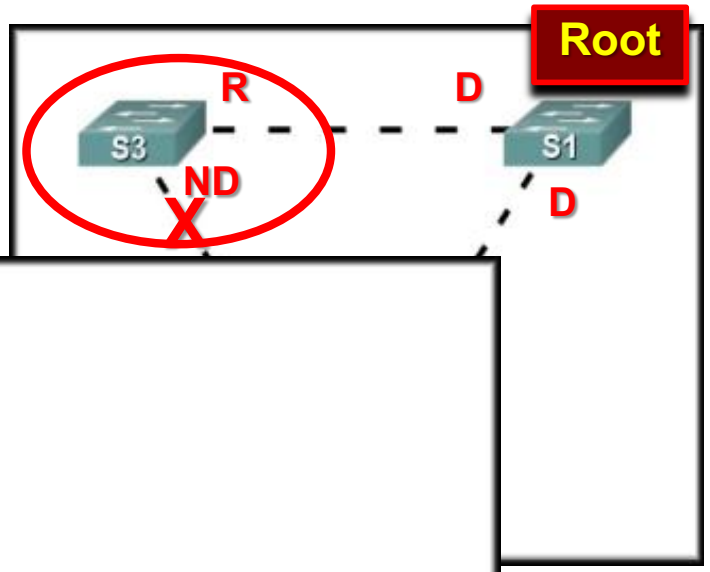
Verification

```
S2#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    24577
              Address     0060.47E0.3A67
              Cost        19
              Port        1(FastEthernet0/1)
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    28673  (priority 28672 sys-id-ext 1)
              Address     0030.A3AA.0268
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  20

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------
Fa0/1            Root FWD 19        128.1    P2p
Fa0/2            Desg FWD 19        128.2    P2p

S2#
```



STP Example

Verification




```
S3#show spanning-tree
VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    24577
              Address     0060.47E0.3A67
              Cost        19
              Port        1(FastEthernet0/1)
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     0001.636D.D150
              Hello Time  2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time  20

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------
Fa0/1            Root FWD 19        128.1    P2p
Fa0/2            Altn BLK 19        128.2    P2p

S3#
```

STP Operation

Port States

Port States

Processes	Blocking	Listening	Learning	Forwarding	Disabled
Processes received BPDUs	YES	YES	YES	YES	NO
Forward data frames received on interface	NO	NO	NO	YES	NO
Forward data frames switched from another interface	NO	NO	NO	YES	NO
Learn MAC addresses	NO	NO	YES	YES	NO

The spanning tree is calculated after a switch is finished booting up. Ports are initially blocked to prevent loops curing calculation

1. Blocking – The port is non-designated and does not forward frames

   The port continues to receive and process BPDU frames

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STP Operation

Port States

2. Listening – STP has determined that the port can participate in frame forwarding according to the BPDU frames that the switch has received thus far

   The switch port not only receives BPDU frames, it is also transmitts its own BPDU frames, informing adjacent switches that the switch port is preparing to participate in the active topology

3. Learning – Prepares to participate in frame forwarding

   We begin to populate the MAC address table

4. Forwarding – Full operation, both BPDU and data frames are forwarded

5. Disabled – Not participating in STP and does not forward frames

   The disabled state is set when the switch port is administratively disabled

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As Described by the Inventor

I think that I shall never see
A graph more lovely than a tree
A tree whose crucial property
Is loop-free connectivity
A tree that must be sure to span
So packets can reach every LAN
First the root must be selected
By ID, it is elected
Least-cost paths from root are traced
In the tree, these paths are placed
A mesh is made by folks like me
Then bridges find a spanning tree

Radia Perlman

SWINBURNE CENTRE FOR ADVANCED INTERNET ARCHITECTURES

Summary

In this lecture, we covered:

- Introduction to STP
- How STP implements a loop-free Layer 2 Network
- What is the Root Bridge
- Port roles in an STP network
- How port roles are decided
- Example STP network
- Verifying configuration
- STP Port States