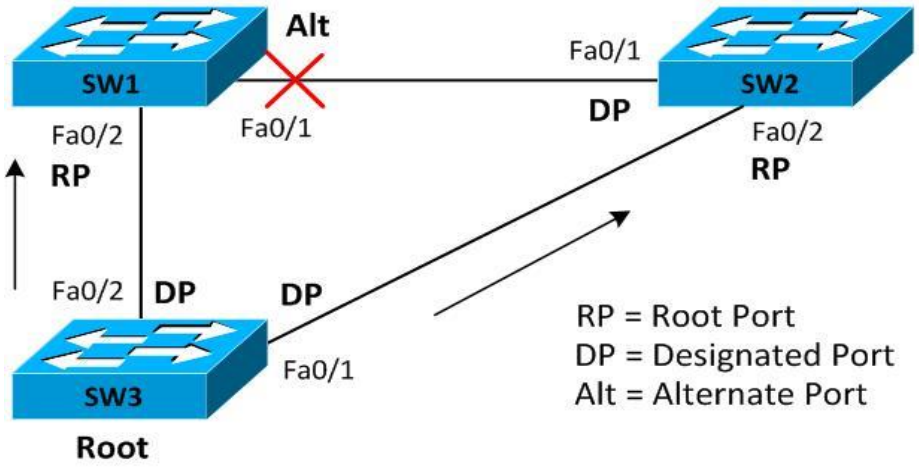
Layer 2 redundancy – Spanning Tree Protocol

Lecture 5



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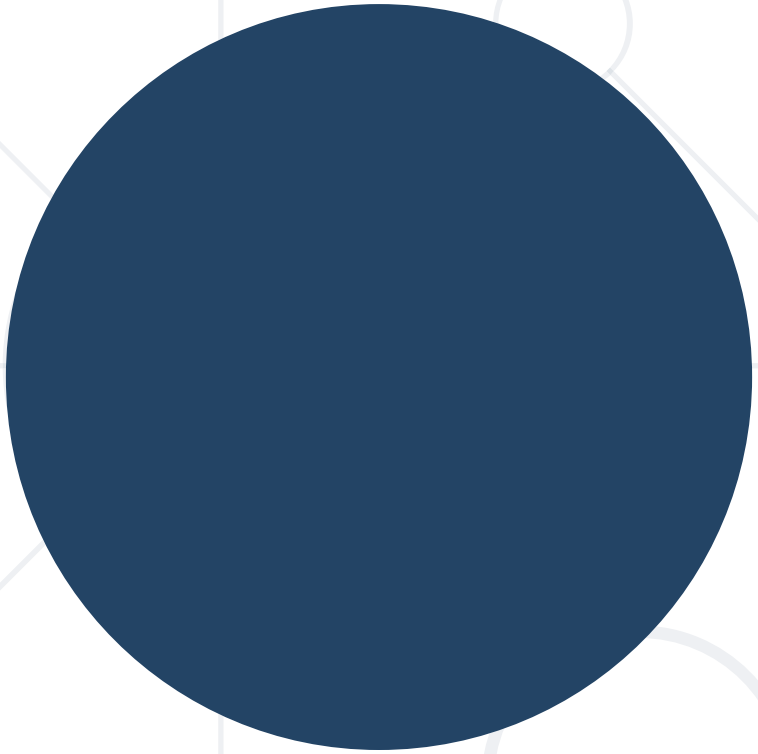
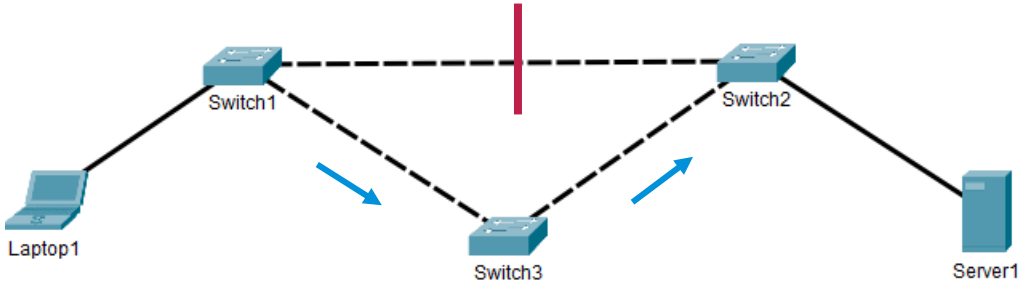


Spanning tree protocol (STP)

Layer 2 networks and redundancy

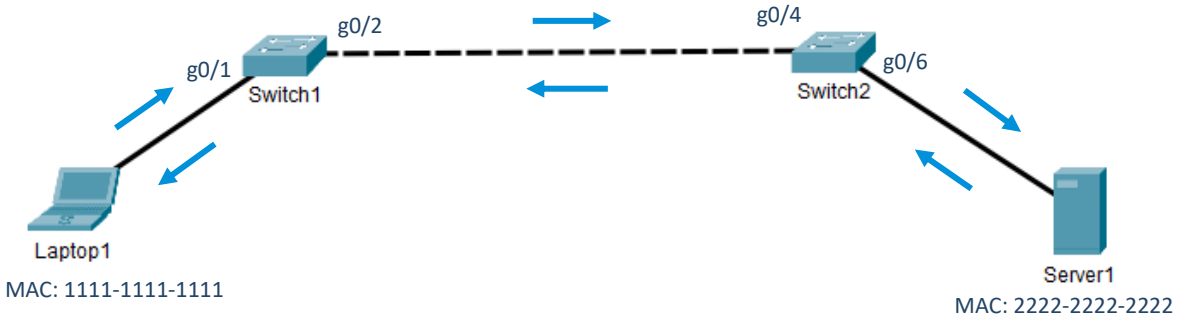
- No redundancy for the link between Switch1 and Switch2
  - If the link fails, the communication stops

- With redundancy - two paths between Switch1 and Switch2
  - If one path fails, the communication can continue over the other



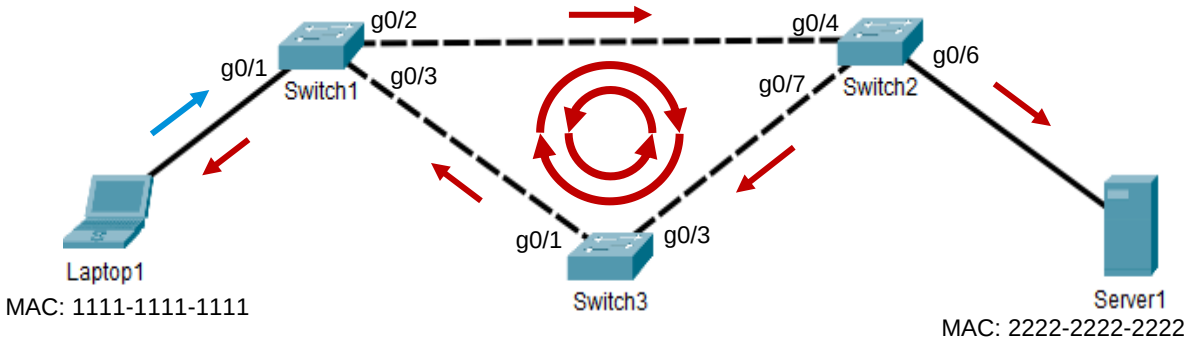
The problem with layer 2 network redundancy

- Normally, the switches will build and use MAC address tables to help them with the forwarding decisions
- When redundant paths are present, the switches are confused and will forward the received packet everywhere
  - Their MAC address tables become unstable
  - Multiple copies of the same frame (data) are received by all devices, endlessly
  - The links are overloaded
  - This is known as **Layer 2 loop and is very bad situation!**



Switch2 MAC Table

MAC address	Port
1111-1111-1111	g0/4
2222-2222-2222	g0/6

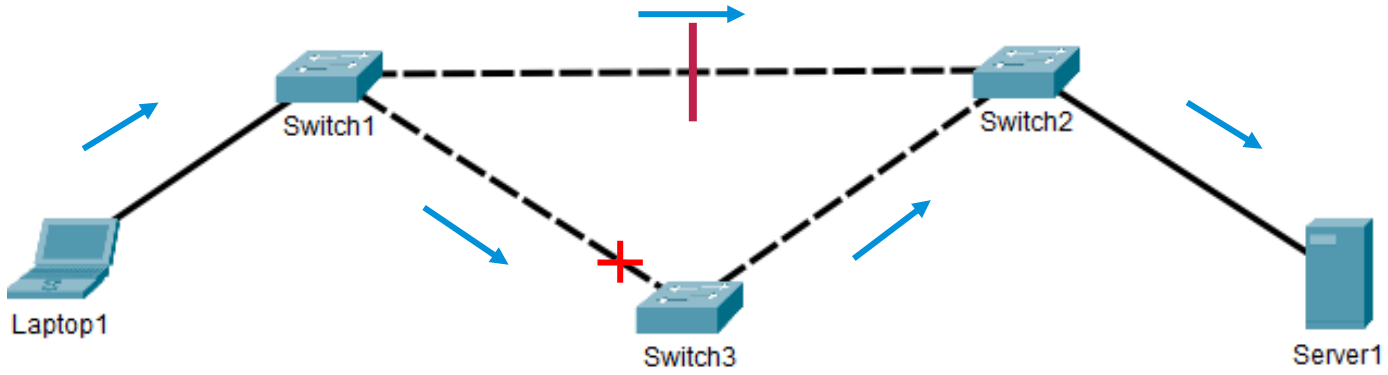


Switch2 MAC Table

MAC address	Port
1111-1111-1111	~~g0/4~~, ~~g0/7~~, ~~g0/4~~…**?**
2222-2222-2222	~~g0/6~~, ~~g0/7~~, ~~g0/4~~…**?**

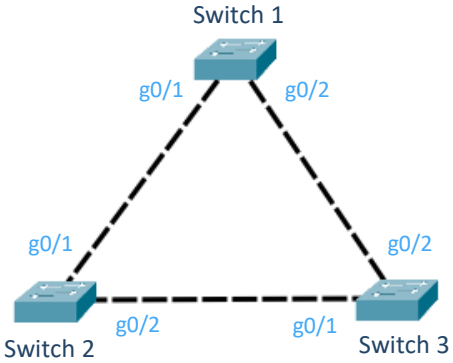
What is Spanning Tree Protocol (STP)?

- STP helps the network switches to deal with a problem which they can not handle alone – the Layer 2 loops
- STP will logically block a port (or multiple ports) in a redundant topology and will leave only one active path at a time
- If the active path is broken, STP will automatically unblock the port(s) to restore the connectivity



The STP algorithm

1. Elect the Root switch (a.k.a. Root bridge or just Root)
   - This is the switch with the lowest BID (Bridge ID)
   - BID = Switch Priority and MAC
   - Default priority = 32768
2. Select the root ports
   - They have the best (lowest) cost to the Root
   - Selected per switch – maximum one
   - Only the non-Root switches have root ports
3. Select the designated ports
   - They have the best (lowest) cost to the Root
   - Selected per segment (connection) – exactly one
4. All other ports go to blocking state
   - The role of these ports is called “alternate”



The STP tie-breakers

- If there is a tie situation - the same path cost via different paths, use the following tie-breakers:
  - When selecting Root port or Designated port, chose the neighboring switch which has the lowest Bridge ID
  - If the Bridge ID is the same, select the lowest Port ID (PID)
- Port ID = Port priority and port number

BPDUs, Bridge ID and Priority

- Switches communicate with each other by exchanging BPDUs (Bridge Protocol Data Units) - this is how they "talk the STP language"
- One piece of information that the BPDU contains is the Bridge ID (BID) = 8 byte value
- BID = Priority (2 bytes) and "system ID" / MAC address (6 bytes)
- STP Priority:
  - A number between 0 and 61440
  - Must be configured in increments of 4096
  - Default is 32768 (+ the VLAN ID)
  - The switch with the lowest priority will become the Root
- If equal values for priority -> lowest MAC address wins (BID = Priority and MAC)

The priority field

- Initially, the priority field allowed for 65536 different values (2^{16})

Priority (16 bits)															
(32768)	(16384)	(8192)	(4096)	(2048)	(1024)	(512)	(256)	(128)	(64)	(32)	(16)	(8)	(4)	(2)	(1)

- Later it was realized that some changes are required
- Nowadays, the priority field looks like this:

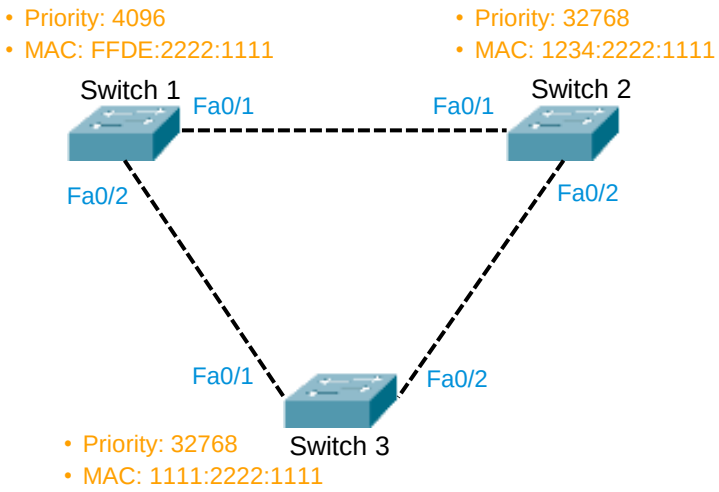
Priority (4 bits)				Extended system ID (12 bits)											
(32768)	(16384)	(8192)	(4096)	(2048)	(1024)	(512)	(256)	(128)	(64)	(32)	(16)	(8)	(4)	(2)	(1)	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	= 0
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	= 4096
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	= 8192 (2x4096)
.....																
																Default
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	= 32768 (8x4096)
.....																
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	= 61440 (15x4096)

Link costs (path costs)

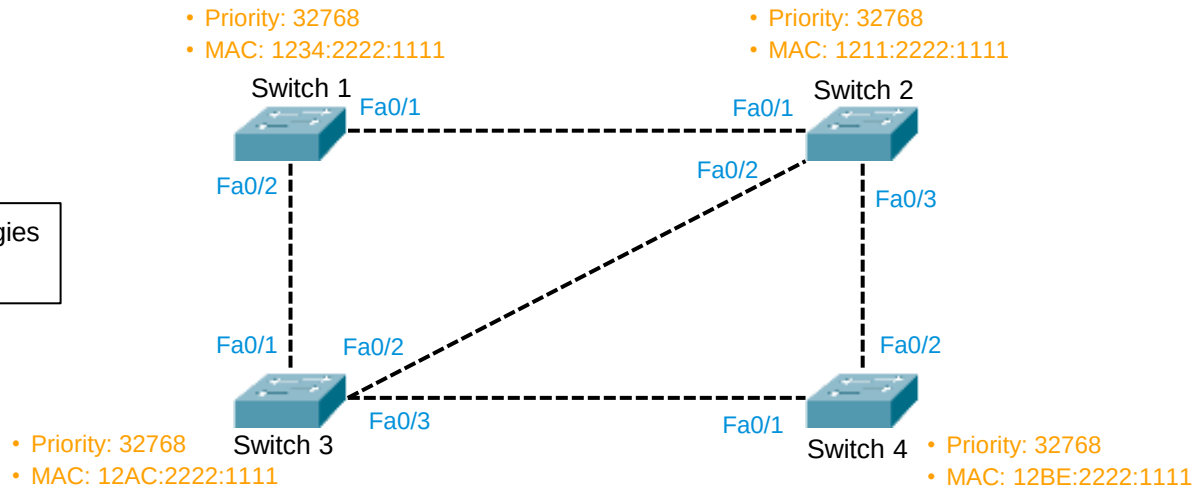
- This is the cost to get to the Root
- Calculated from the cost of a port and the number of links
- Higher port speed -> lower port cost
- The default values can be changed by administrator

Ethernet Speed	IEEE Cost: 1998	IEEE Cost: 2004
10 Mbps	100	2,000,000
100 Mbps	19	200,000
1 Gbps	4	20,000
10 Gbps	2	2,000
100 Gbps	N/A	200
1 Tbps	N/A	20

Examples – find the blocked ports



Note: All links on both topologies have the same costs!



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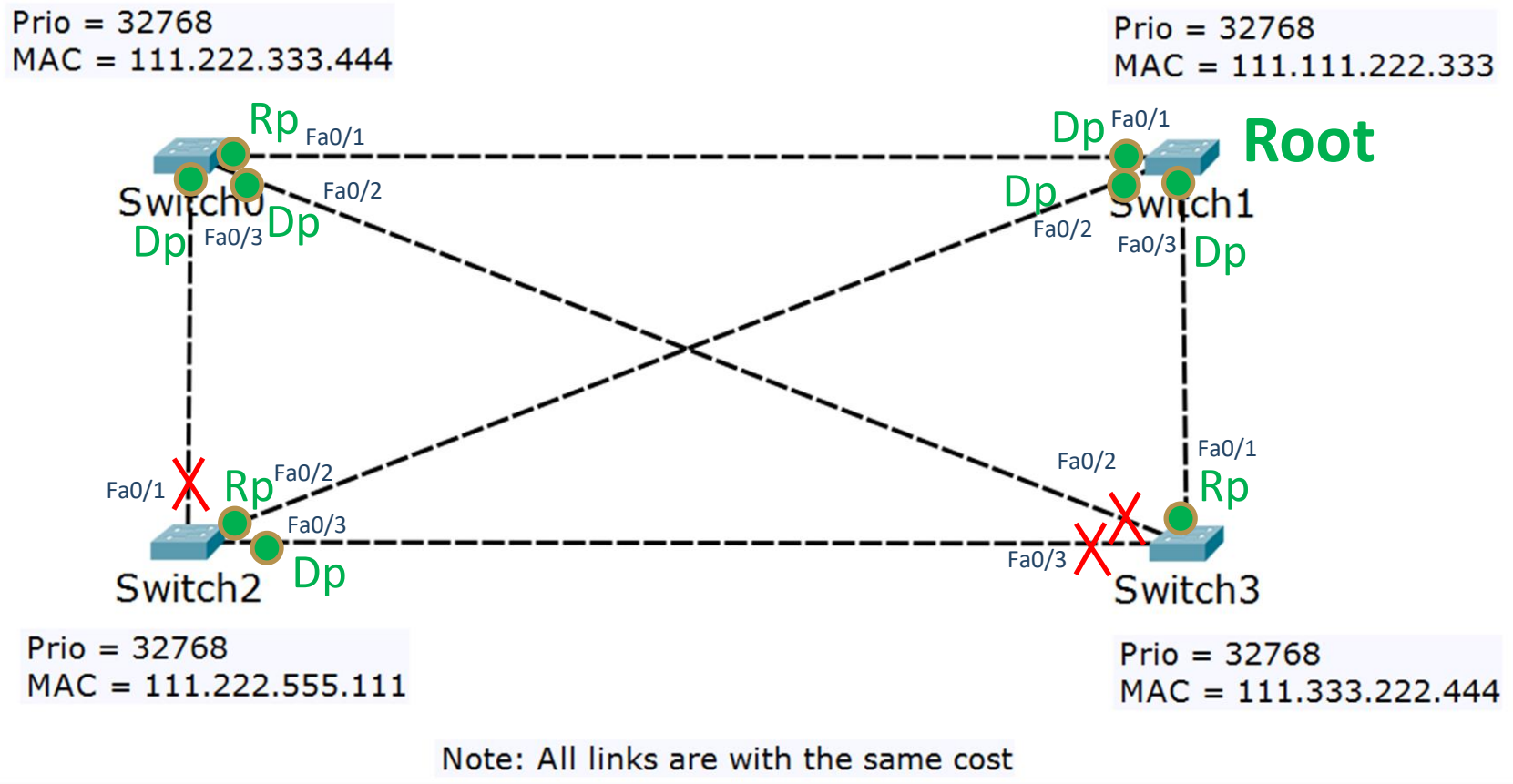
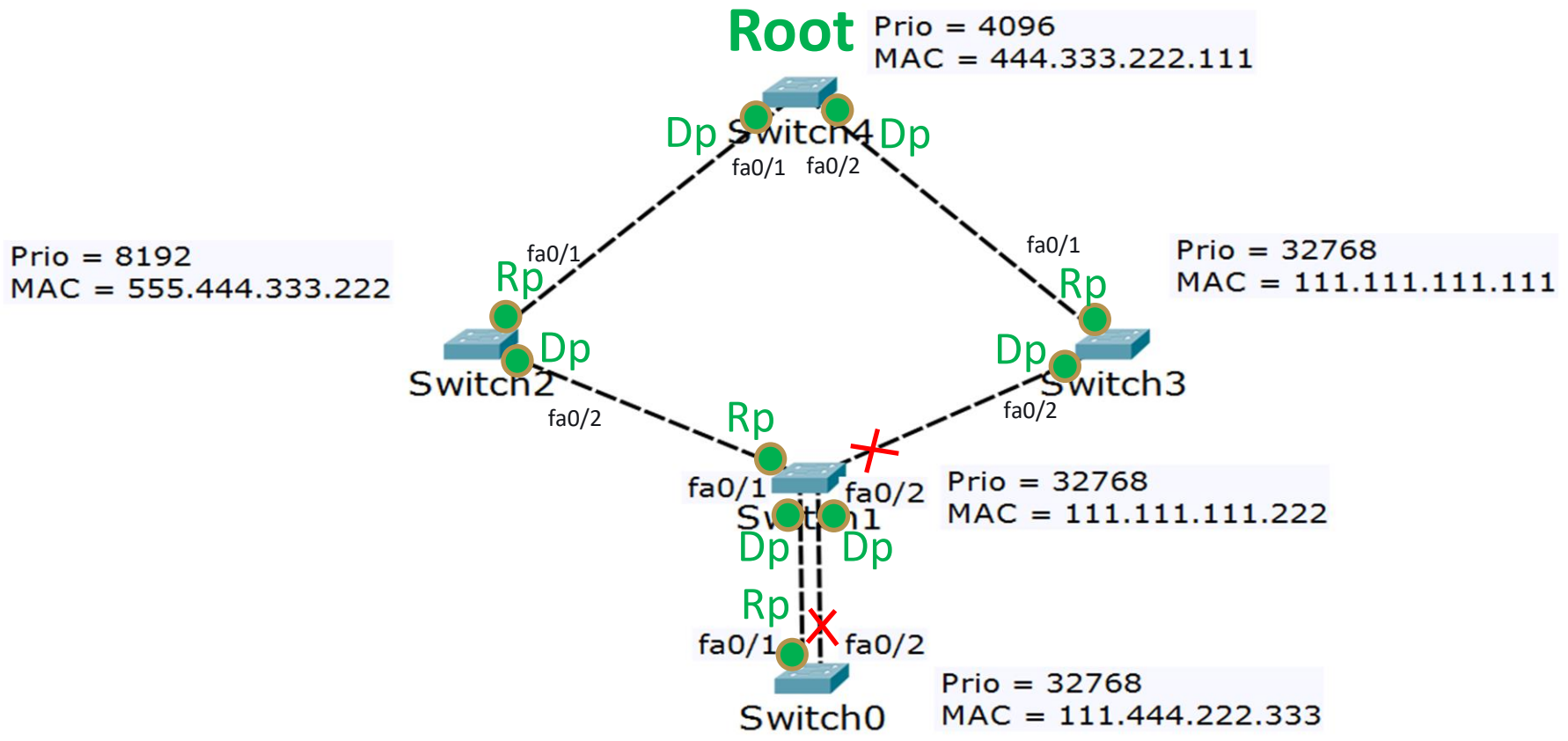
Additional example 1

Find the Root, the RP, the DP and the Blocking ports



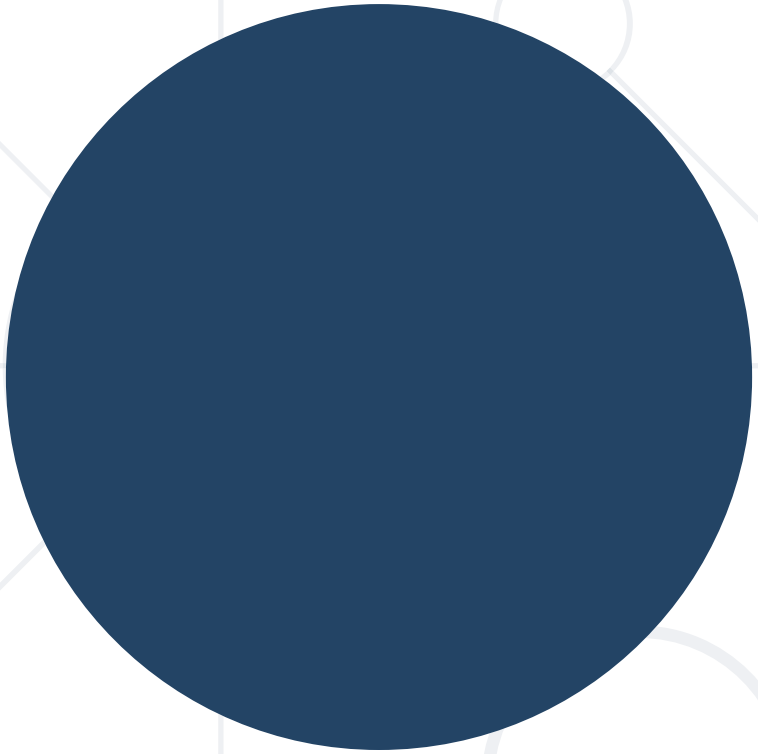
Additional example 2

Find the Root, the RP, the DP and the Blocking ports



History and flavors

- **STP** - The original Spanning Tree Protocol, IEEE 802.1D
  - Problem – very slow convergence (between 30 and 50 seconds)
  - Problem – single Root for the entire Layer 2 topology
- **RSTP** - Rapid STP, IEEE 802.1W
  - Much faster convergence (no more timers, introducing the concept of an “edge” port)
  - Still have the issue with single Root for the entire Layer 2 topology
- **PVST+** - Per-VLAN STP, Cisco proprietary
  - Calculates STP for each particular VLAN independently - can have multiple Roots
  - It is also “rapid”
- **MSTP** - Multiple STP, IEEE 802.1S
  - Calculates STP for each “instance” (group of VLANs) – can have multiple Roots
  - It is also “rapid”



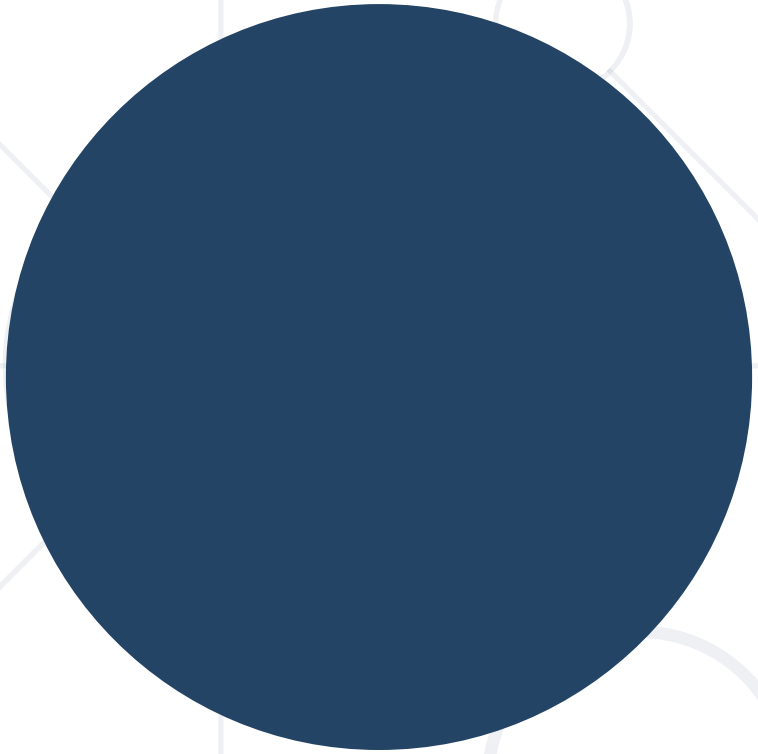
Rapid STP (RSTP)

STP (the good old Spanning Tree)

- Spanning Tree Protocol
- The industry standard name is IEEE 802.1D
- Slow convergence
- Port states:
  - Disabled
  - Blocking (up to 20 sec)
  - Listening (up to 15 sec)
  - Learning (up to 15 sec)
  - Forwarding

RSTP (the faster STP)

- Rapid STP
- The industry standard name is IEEE 802.1W
- Much faster convergence than STP
- Introducing Edge port – a port which is connected to an end device
- RSTP uses the same algorithm as STP
- Port states:
  - Discarding
  - Learning
  - Forwarding

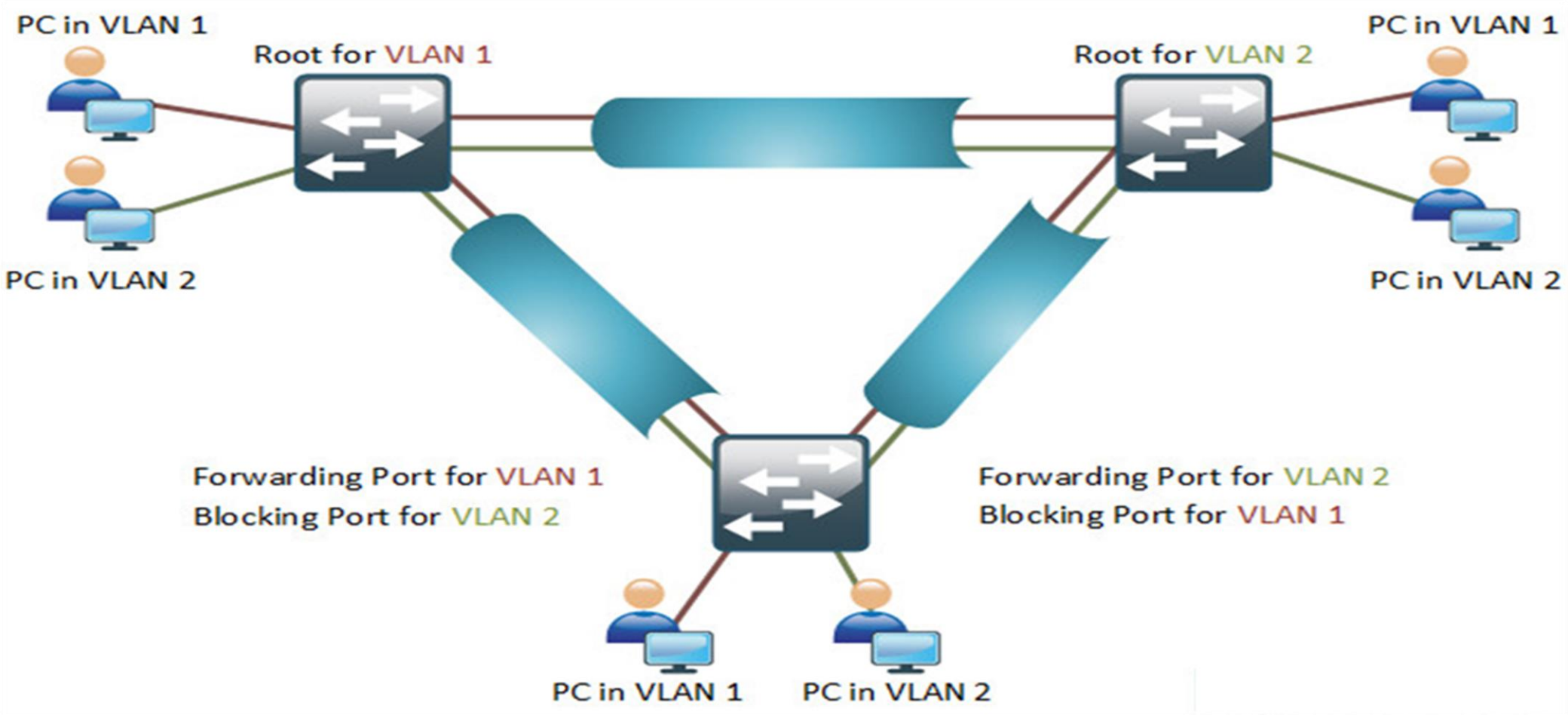


Per-VLAN STP plus (PVST+)

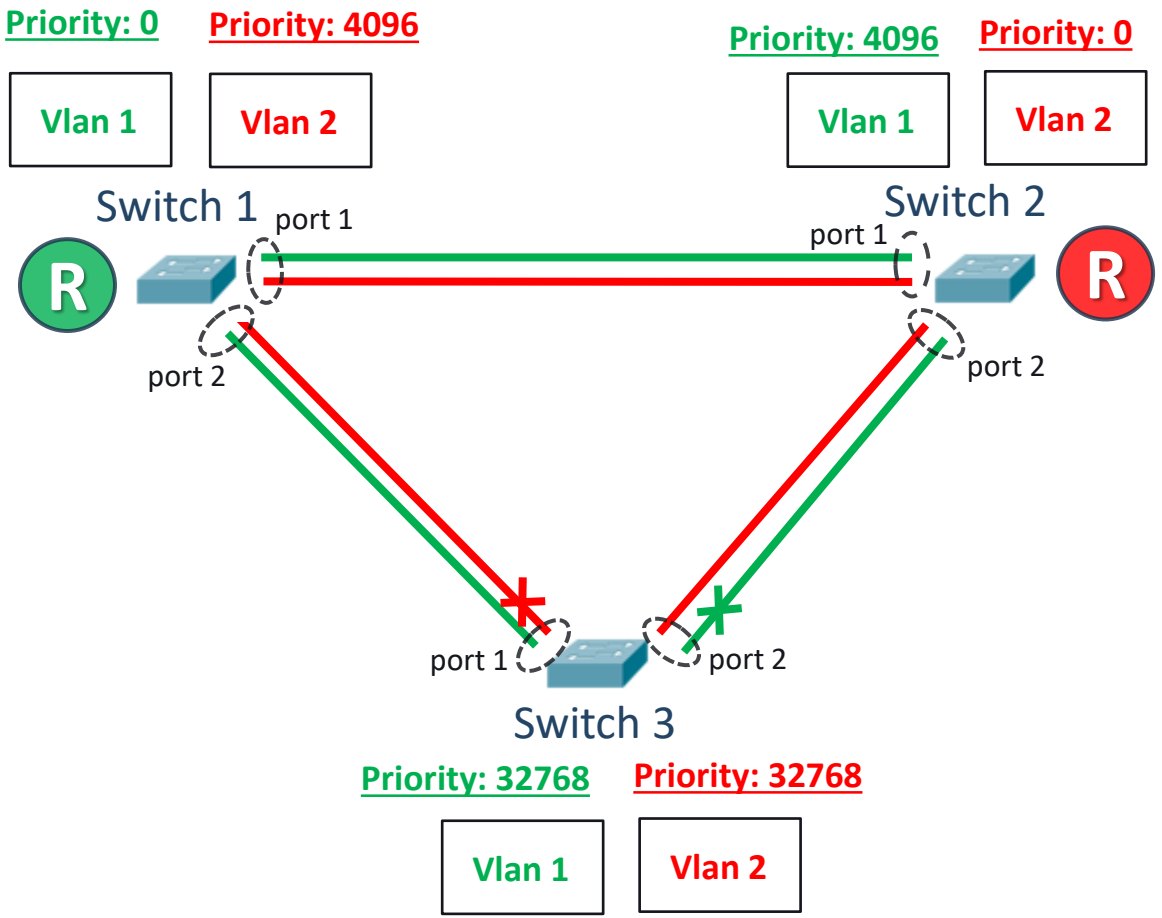
PVST+

- Per-VLAN Spanning Tree is Cisco protocol
- Why? It has a similar idea as MSTP - to distribute the load
- Creates a spanning tree topology for each VLAN separately
- PortFast in PVST+ is like Edge port in STP/RSTP

PVST+ (2)

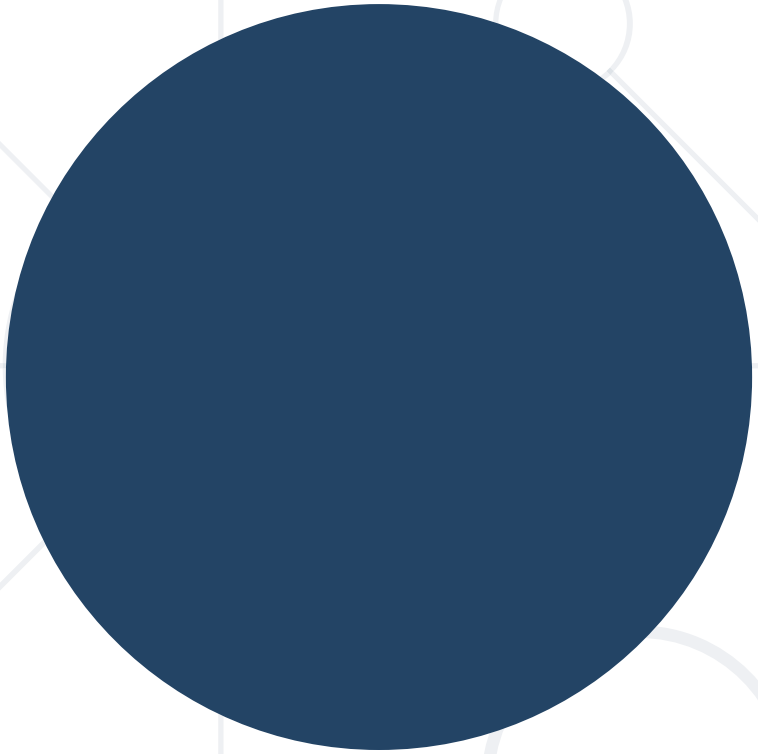

PC in VLAN 1
Root for VLAN 1
Root for VLAN 2
PC in VLAN 1
PC in VLAN 2
PC in VLAN 2
Forwarding Port for VLAN 1
Blocking Port for VLAN 2
Forwarding Port for VLAN 2
Blocking Port for VLAN 1
PC in VLAN 1
PC in VLAN 2

PVST+ (3)


Priority: 0
Priority: 4096
Vlan 1
Vlan 2
Switch 1
port 1
port 2
R
Priority: 4096
Priority: 0
Vlan 1
Vlan 2
Switch 2
port 1
port 2
R
port 1
port 2
Switch 3
Priority: 32768
Priority: 32768
Vlan 1
Vlan 2

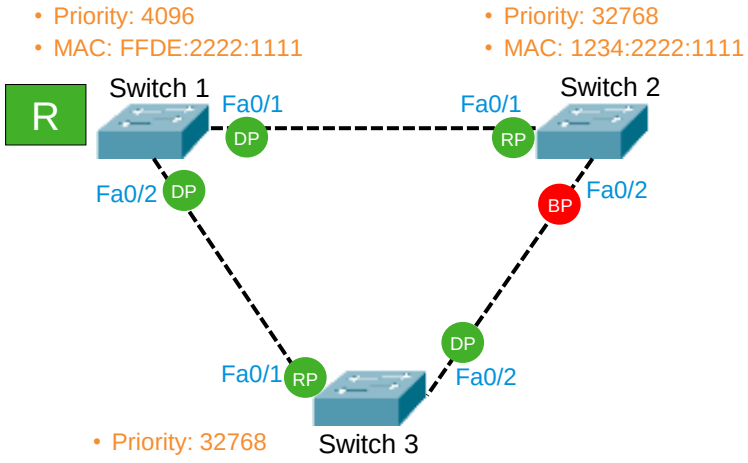
The good and the bad about PVST+

- PVST+ advantages:
  - triggers STP calculation only if there is a potential loop in a particular VLAN
  - detailed “look” of the network – does not block ports when there is no loop on the trunks for a given VLAN
- PVST+ disadvantages
  - generates a lot of overhead in the network
  - proprietary protocol



Demonstration

Examples - answers



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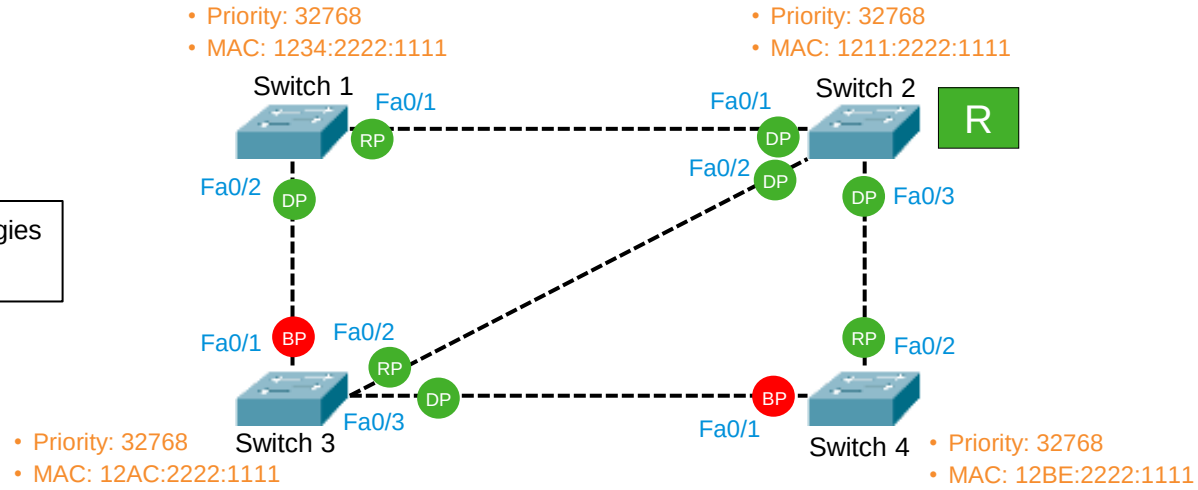

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The STP tie-breakers — Software University

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Summary

1. Spanning tree protocol (STP)
2. Rapid STP (RSTP)
3. Per-VLAN STP plus (PVST+)

Questions?

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SOFTWARE GROUP

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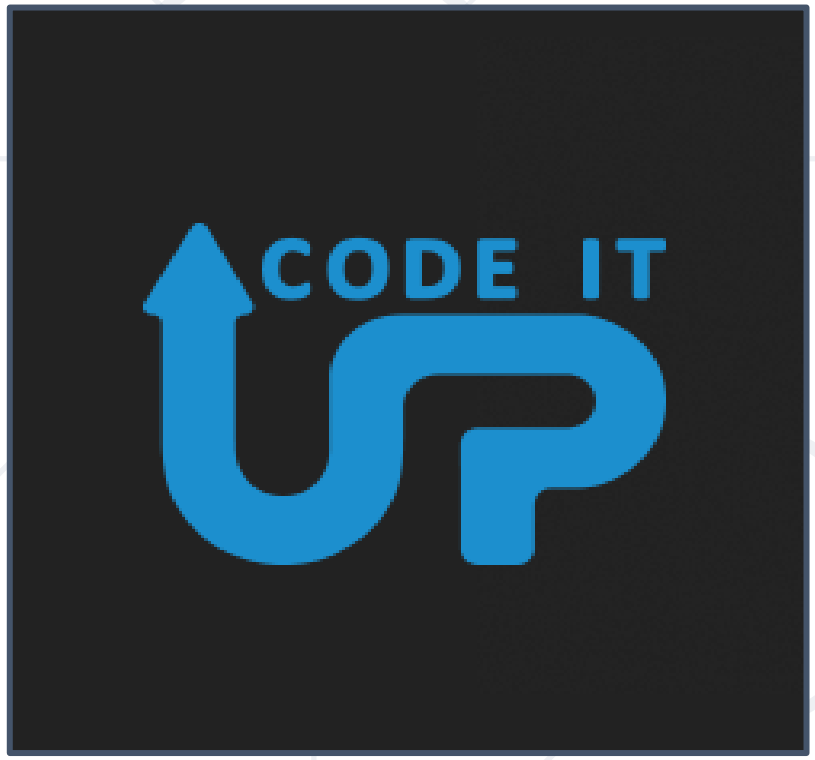

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