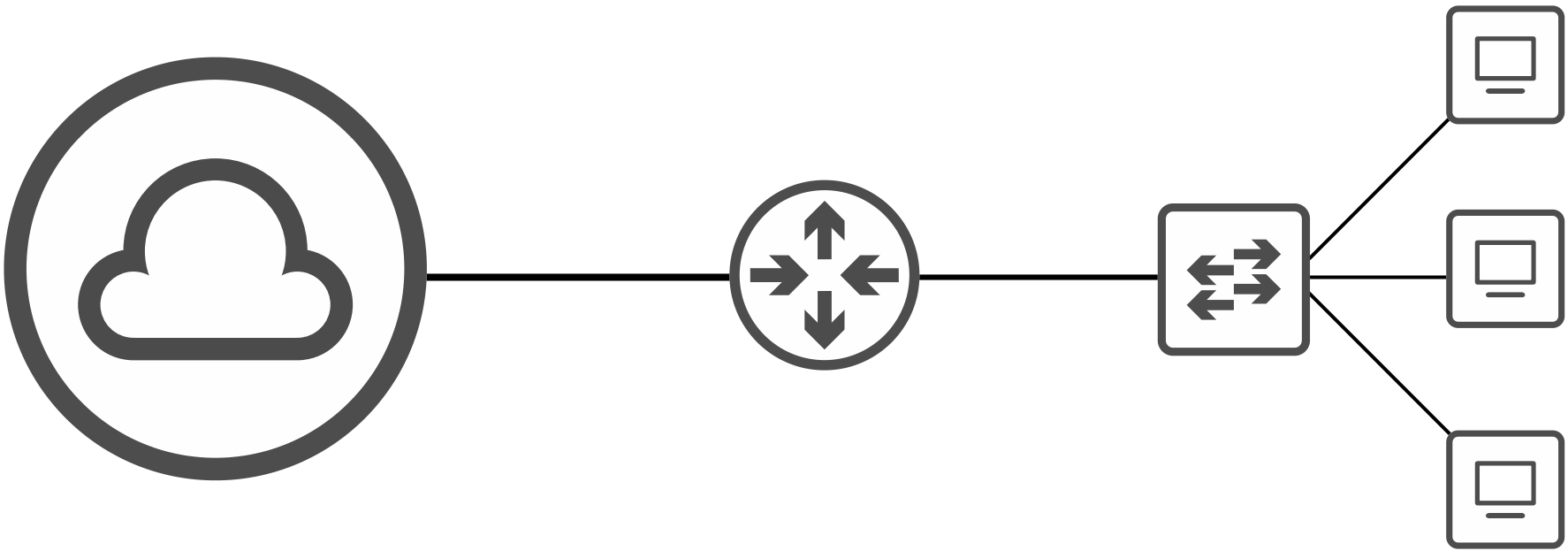
Jeremy's IT Lab

CCNA 200-301 Day 20

STP (Spanning Tree Protocol)



Things we'll cover

- Redundancy in networks
- STP (Spanning Tree Protocol)

Network Redundancy

- Redundancy is an essential part of network design.
- Modern networks are expected to run 24/7/365. Even a short downtime can be disastrous for a business.
- If one network component fails, you must ensure that other components will take over with little or no downtime.
- As much as possible, you must implement redundancy at every possible point in the network.

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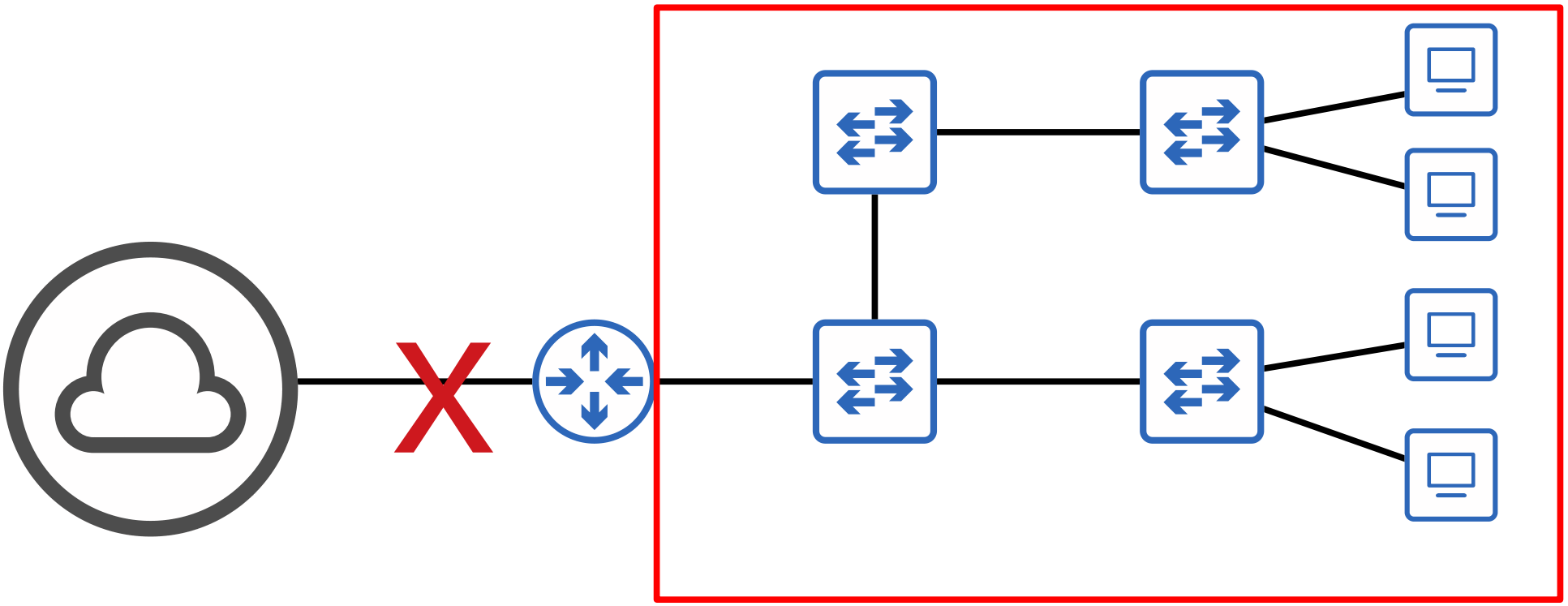
Network Redundancy



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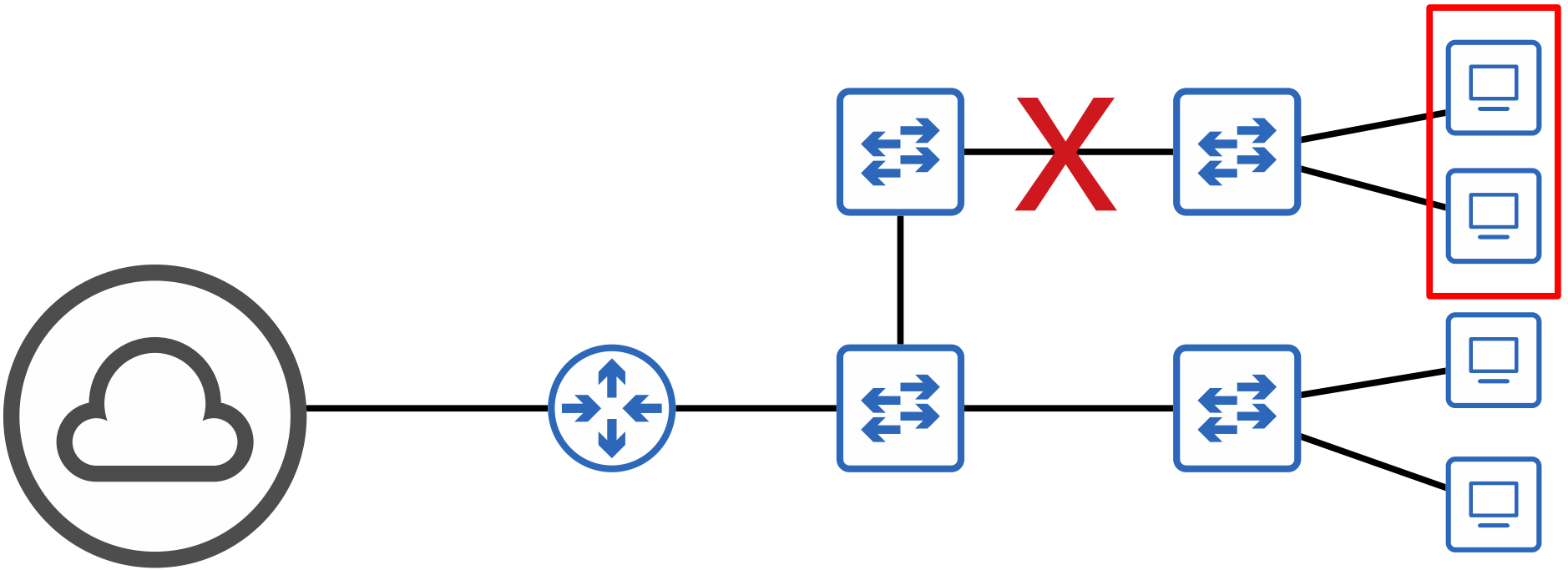
Network Redundancy



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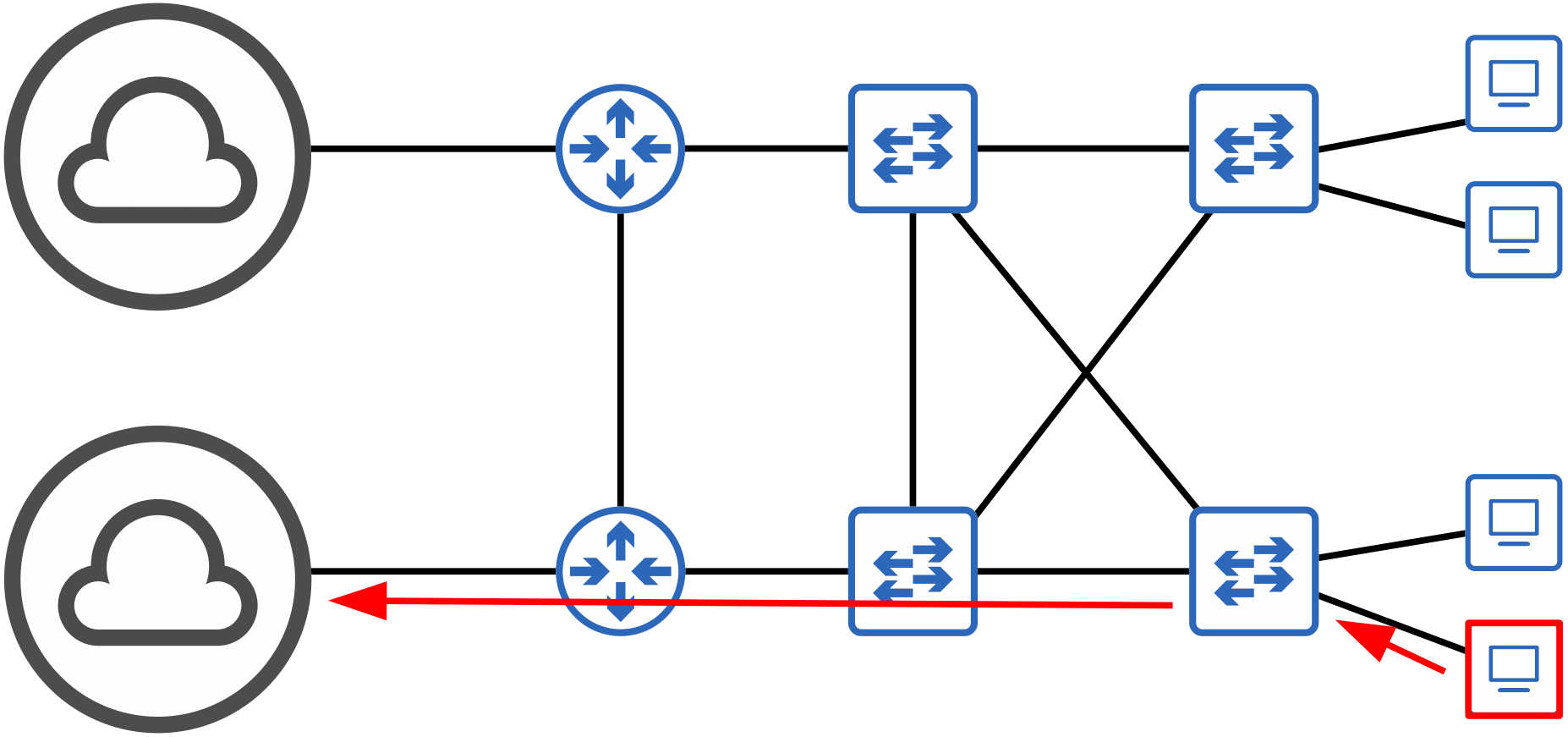
Network Redundancy



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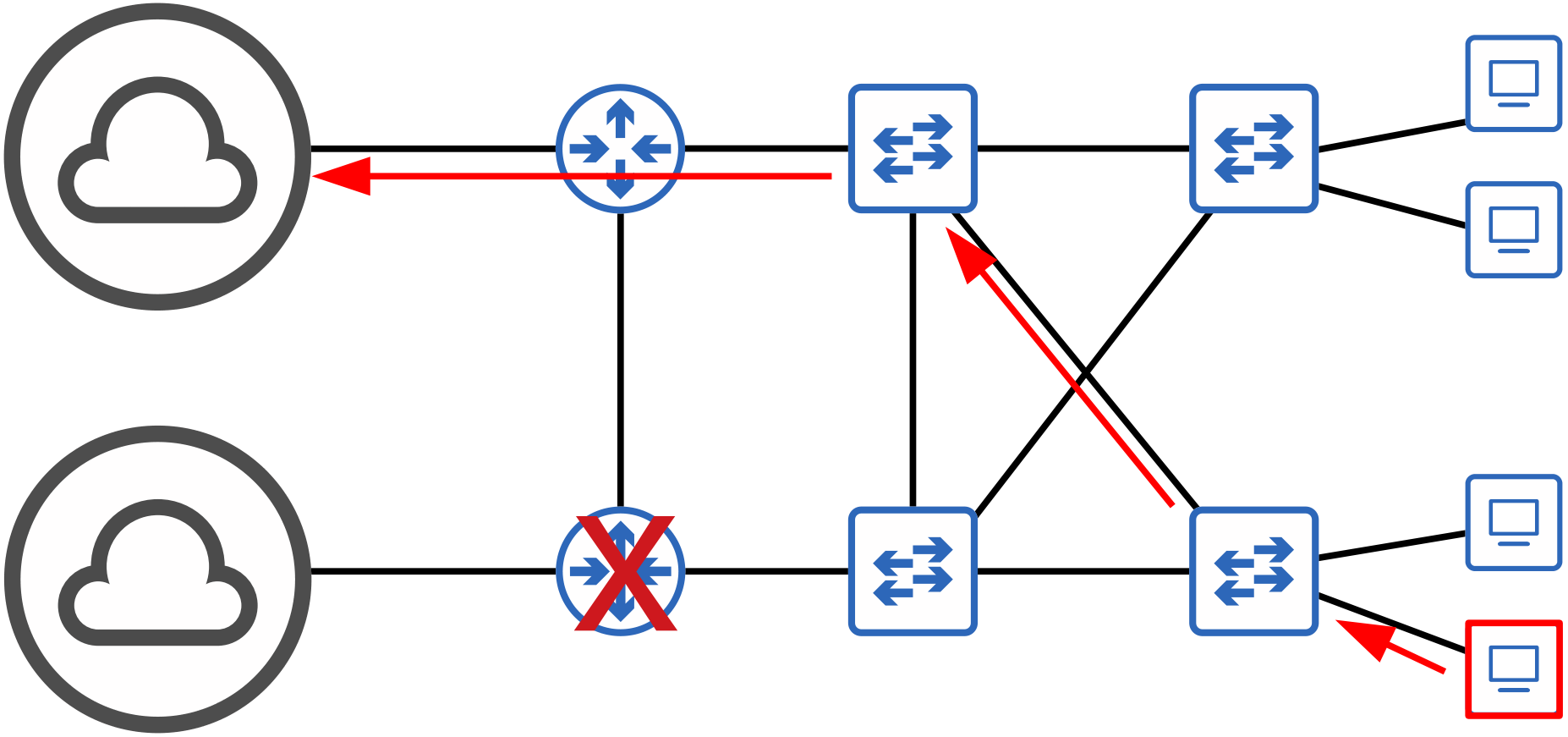
Network Redundancy



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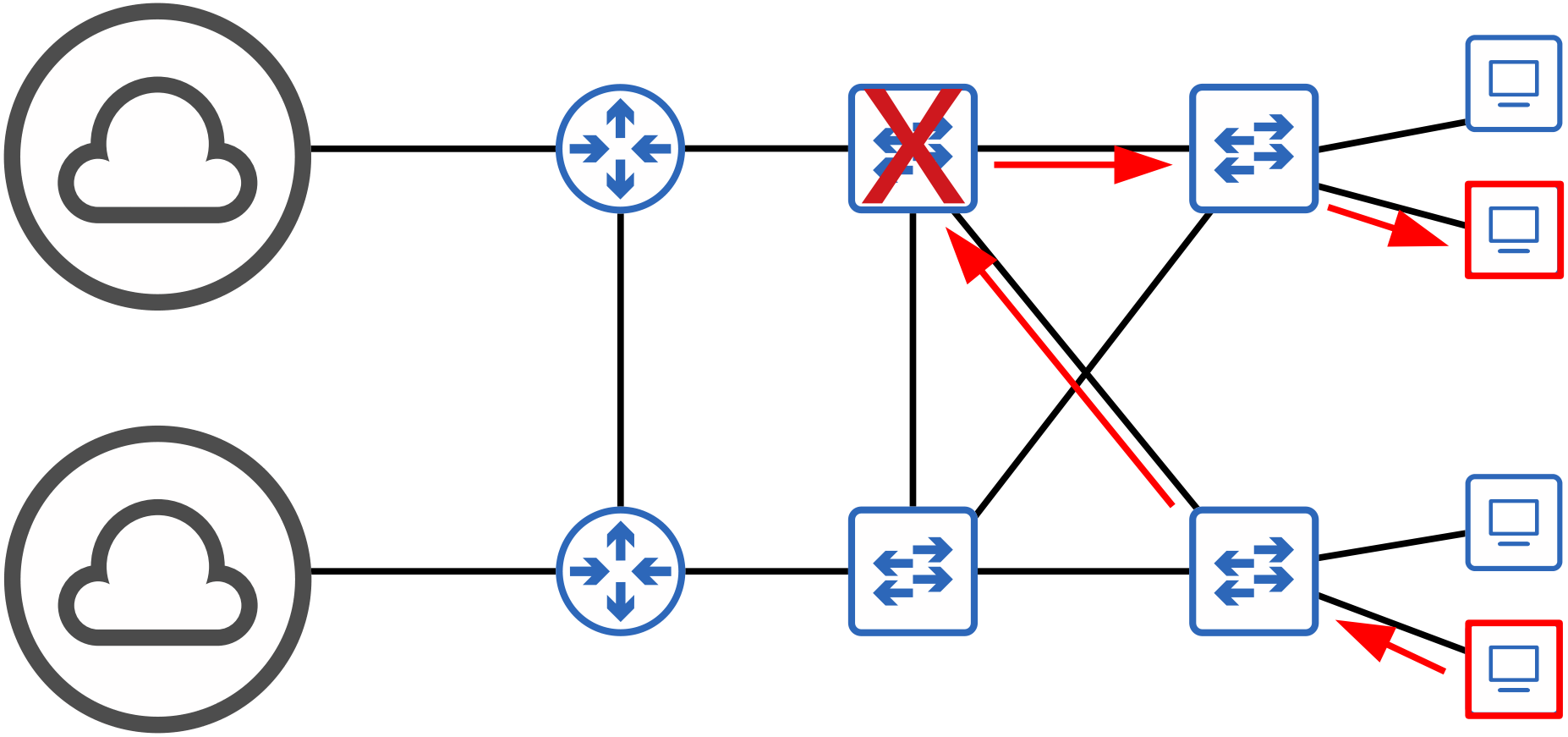
Network Redundancy



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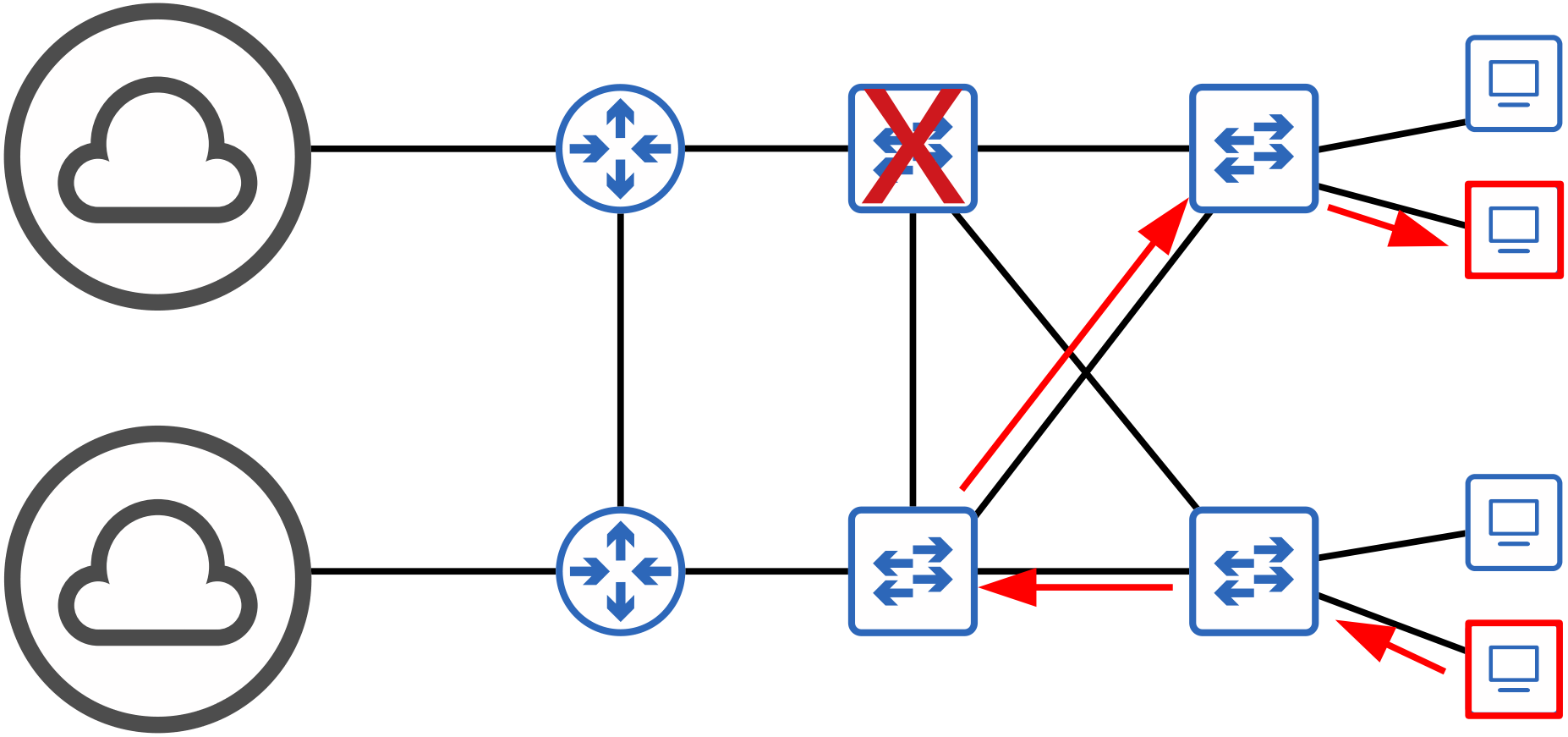
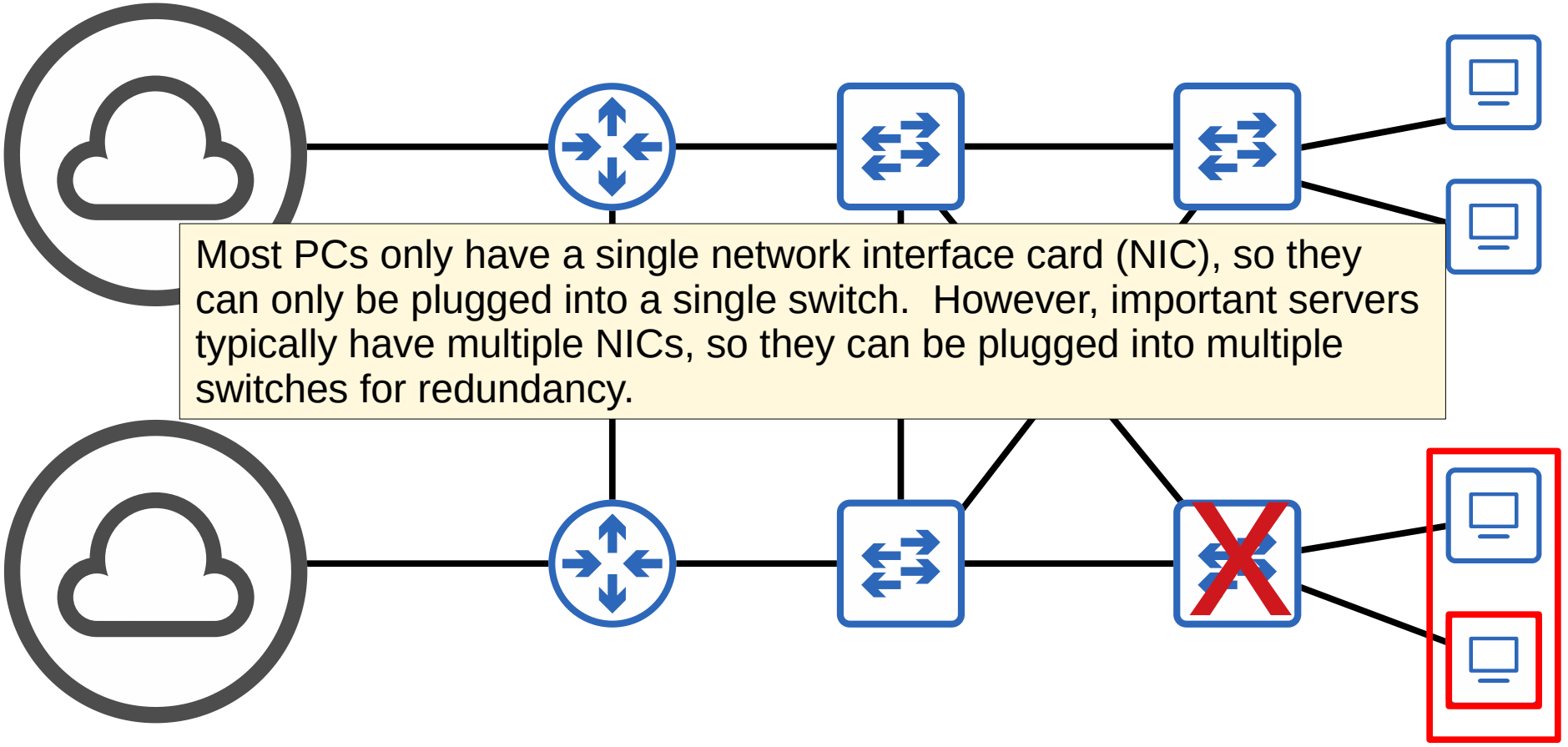
Network Redundancy



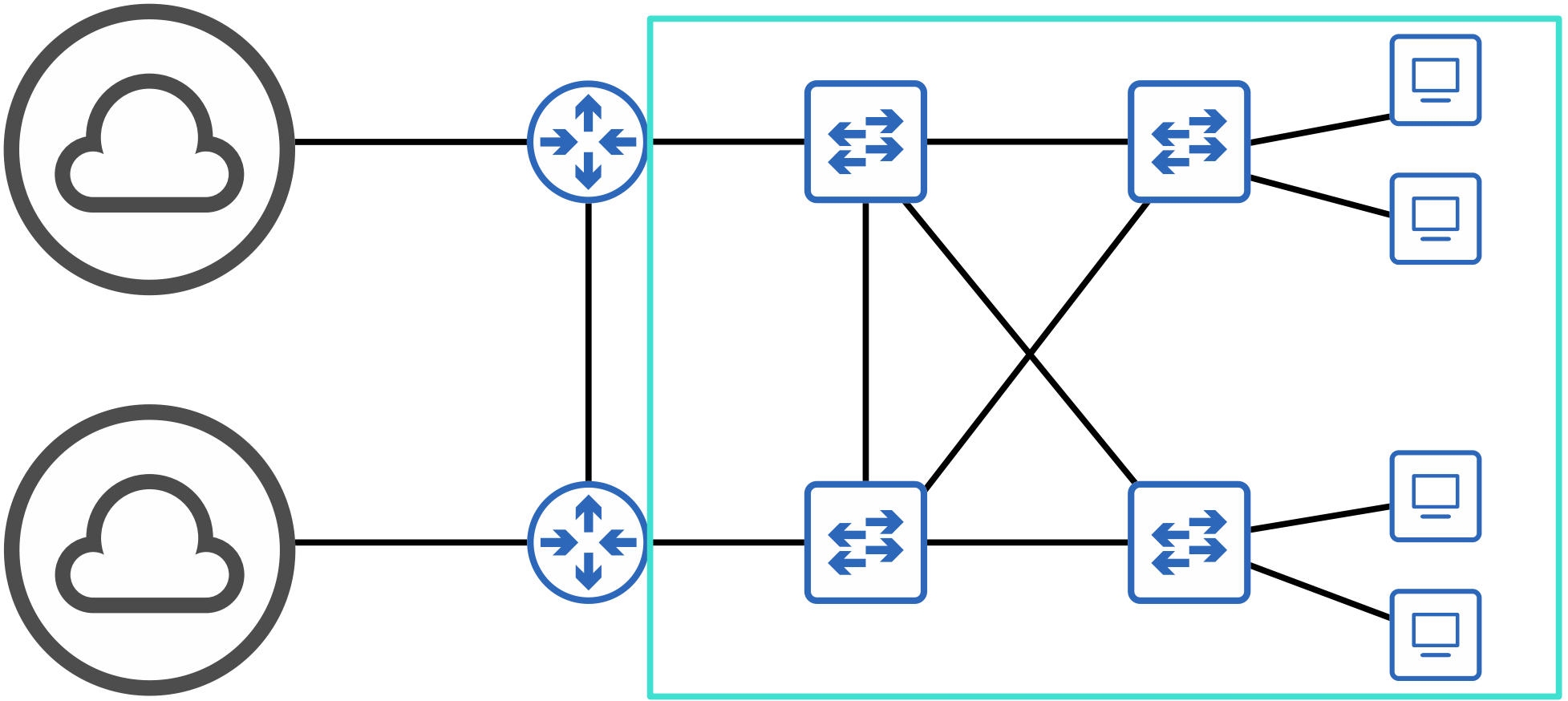
Network Redundancy



Most PCs only have a single network interface card (NIC), so they can only be plugged into a single switch. However, important servers typically have multiple NICs, so they can be plugged into multiple switches for redundancy.

Network Redundancy

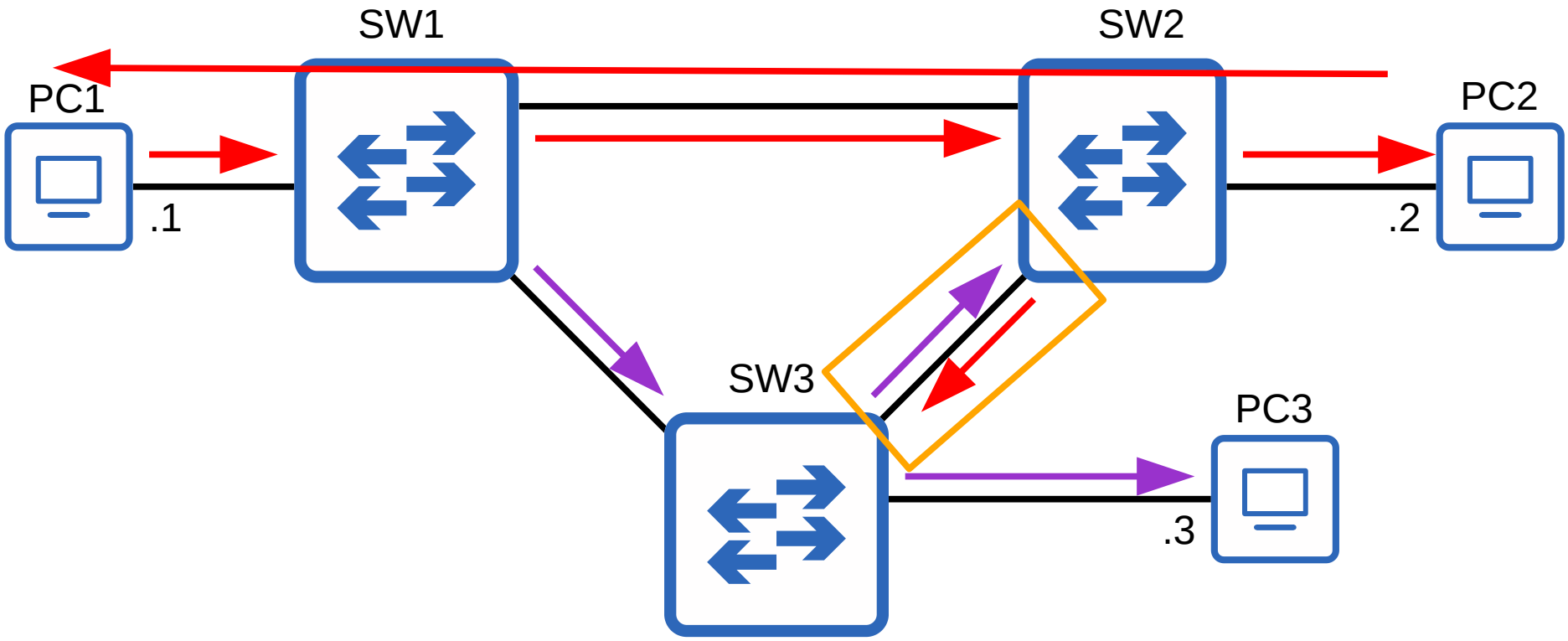
Where is the problem???



Broadcast Storms

ARP Request
Dst: FFFF.FFFF.FFFF

10.0.0.0/24



Broadcast Storms

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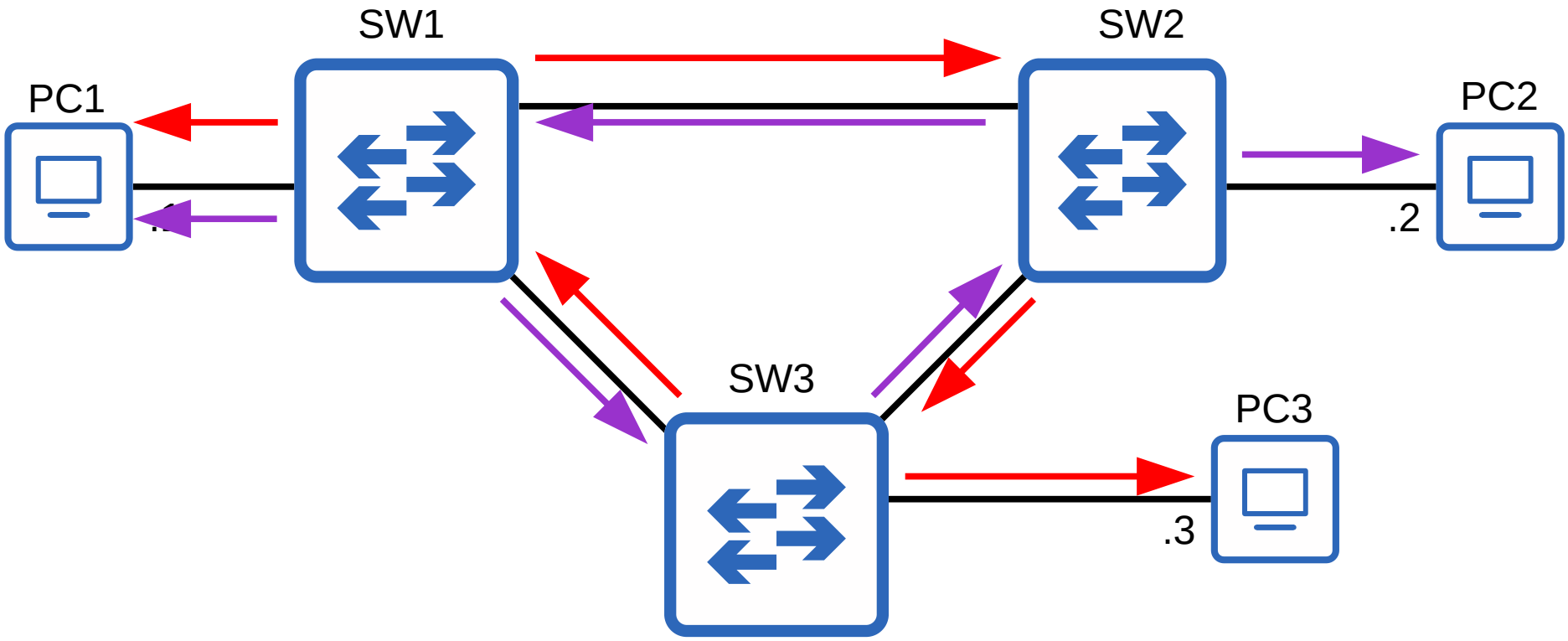
10.0.0.0/24



Broadcast Storms

ARP Request
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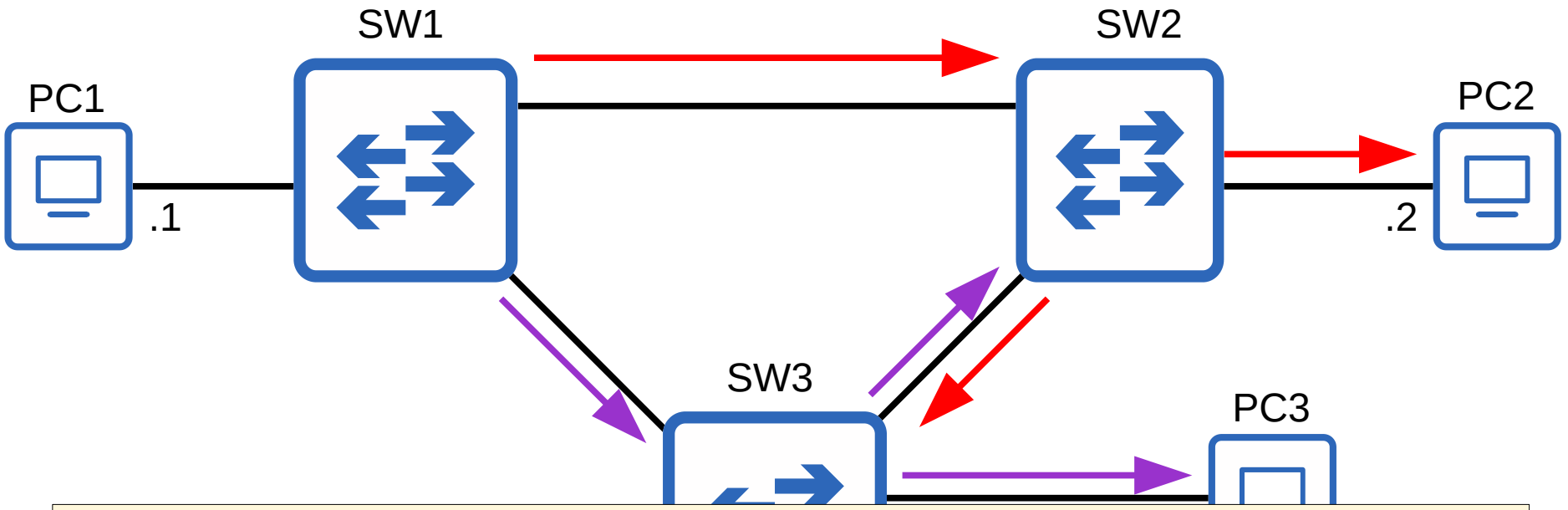
10.0.0.0/24

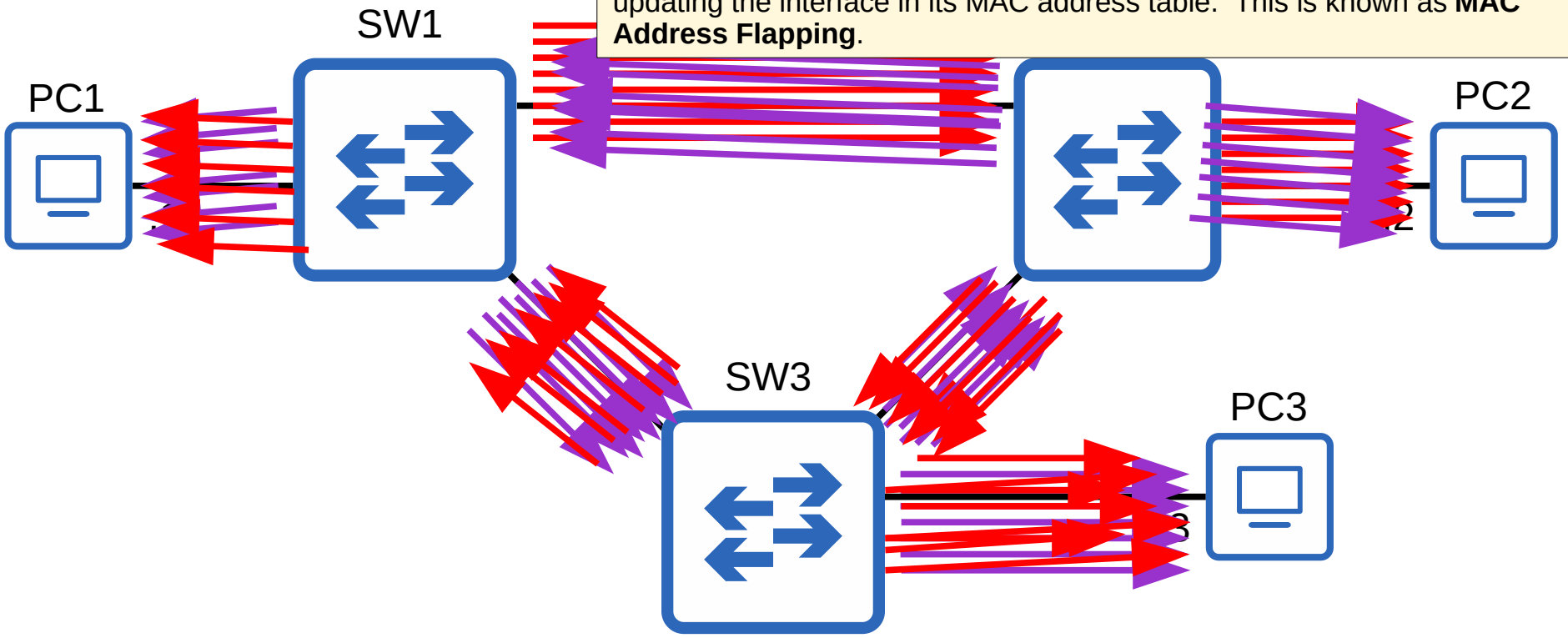


The Ethernet header doesn't have a TTL field. These broadcast frames will loop around the network indefinitely. If enough of these looped broadcasts accumulate in the network, the network will be too congested for legitimate traffic to use the network. This is called a **broadcast storm**.

Broadcast Storms

ARP Request
Dst: FFFF.FFFF.FFFF

Network congestion isn't the only problem. Each time a frame arrives on a switchport, the switch uses the source MAC address field to 'learn' the MAC address and update its MAC address table. When frames with the same source MAC address repeatedly arrive on different interfaces, the switch is continuously updating the interface in its MAC address table. This is known as **MAC Address Flapping**.



Spanning Tree Protocol

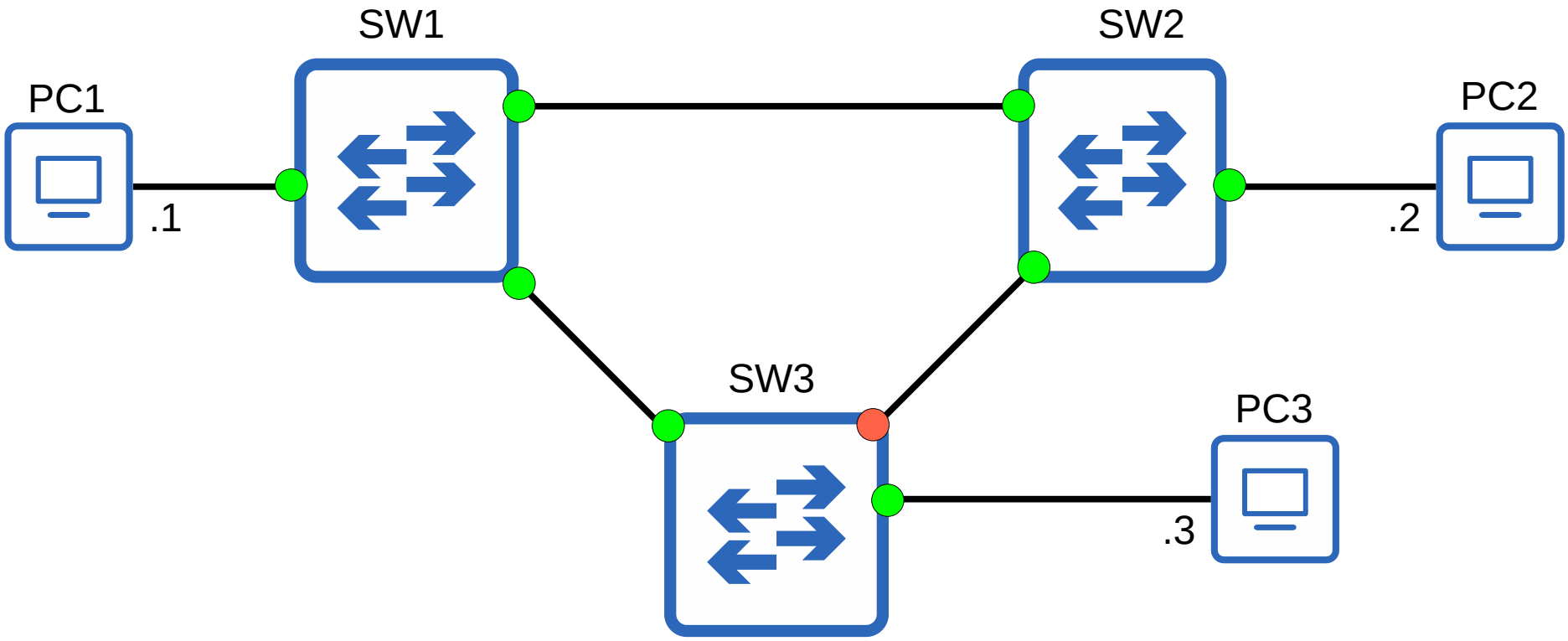
- 'Classic Spanning Tree Protocol' is IEEE 802.1D.
- Switches from ALL vendors run STP by default.
- STP prevents Layer 2 loops by placing redundant ports in a blocking state, essentially disabling the interface.
- These interfaces act as backups that can enter a forwarding state if an active (=currently forwarding) interface fails.
- Interfaces in a forwarding state behave normally. They send and receive all normal traffic.
- Interfaces in a blocking state only send or receive STP messages (called BPDUs = Bridge Protocol Data Units).

Spanning Tree Protocol

Spanning Tree Protocol still uses the term ‘bridge’. However, when we use the term ‘bridge’, we really mean ‘switch’. Bridges are not used in modern networks.

Spanning Tree Protocol

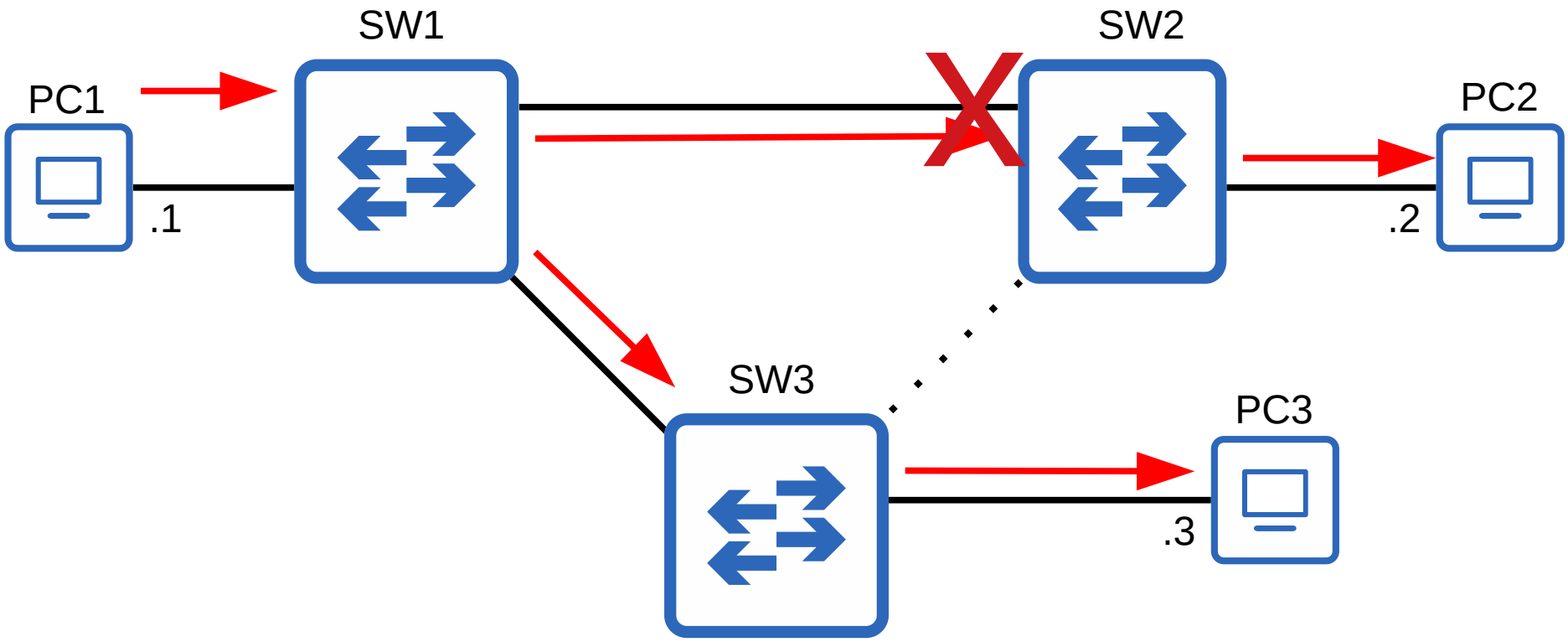
10.0.0.0/24



Spanning Tree Protocol

ARP Request
Dst: FFFF.FFFF.FFFF

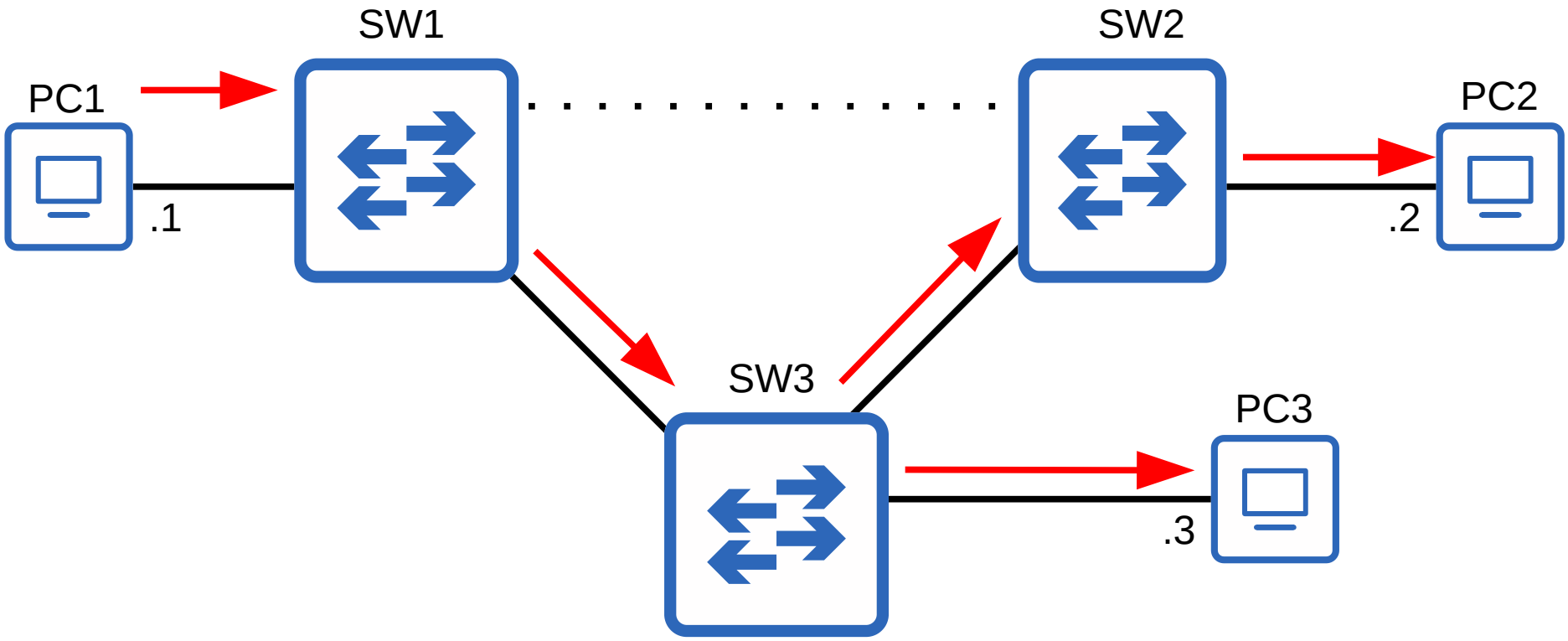
10.0.0.0/24



Spanning Tree Protocol

ARP Request
Dst: FFFF.FFFF.FFFF

10.0.0.0/24



Spanning Tree Protocol

- By selecting which ports are **forwarding** and which ports are **blocking**, STP creates a single path to/from each point in the network. This prevents Layer 2 loops.

- There is a set process that STP uses to determine which ports should be forwarding and which should be blocking.

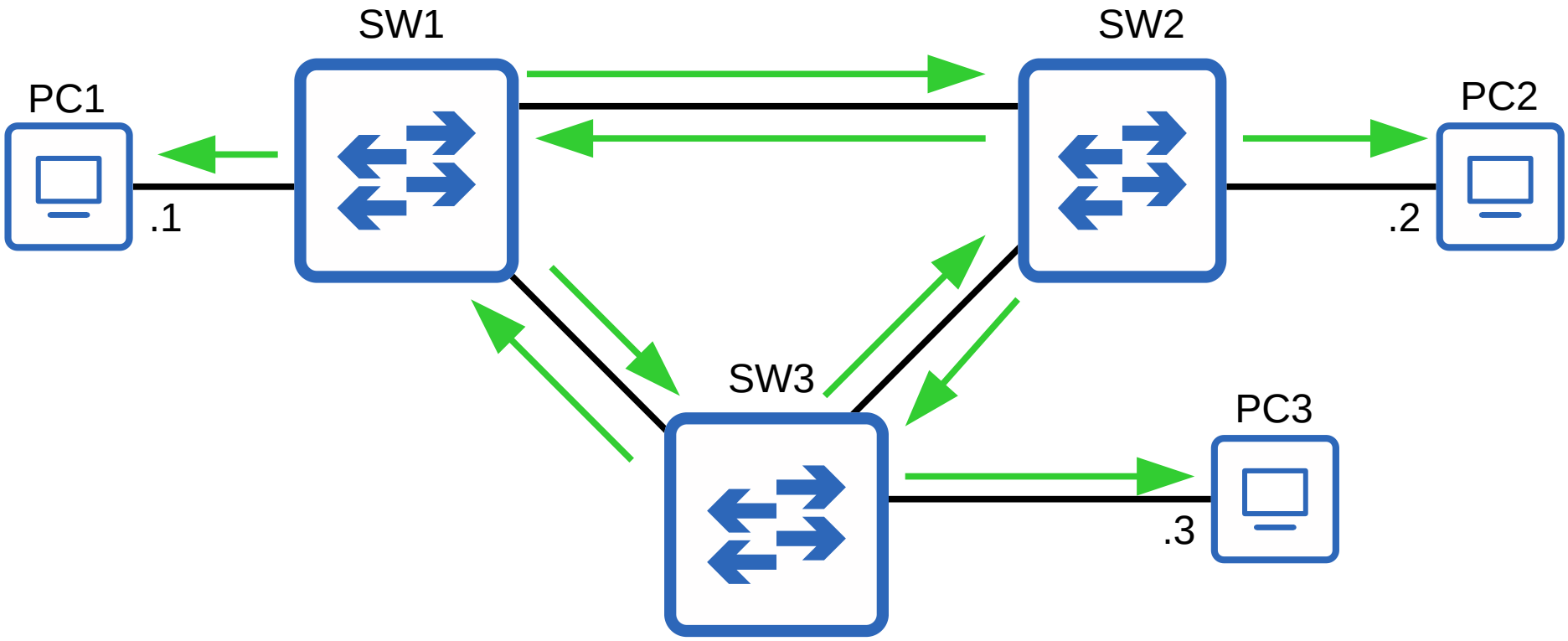
- STP-enabled switches send/receive Hello BPDUs out of all interfaces, the default timer is 2 seconds (the switch will send a Hello BPDU out of every interface, once every 2 seconds).

- If a switch receives a Hello BPDU on an interface, it knows that interface is connected to another switch (routers, PCs, etc. do not use STP, so they do not send Hello BPDUs).

Spanning Tree Protocol

= Hello BPDU

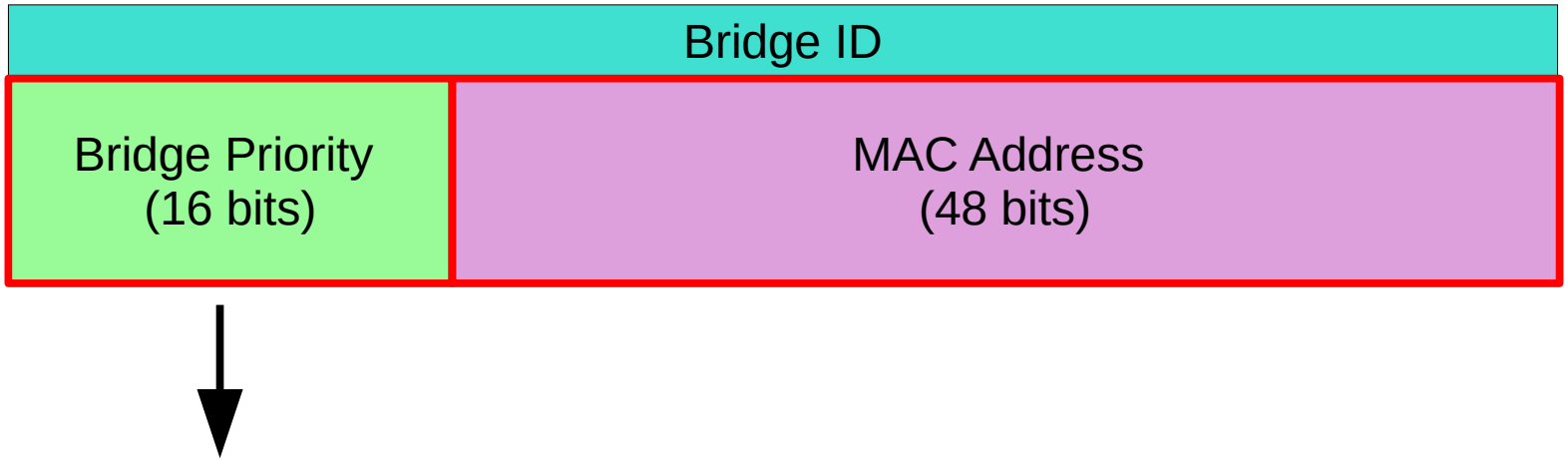
10.0.0.0/24



Spanning Tree Protocol

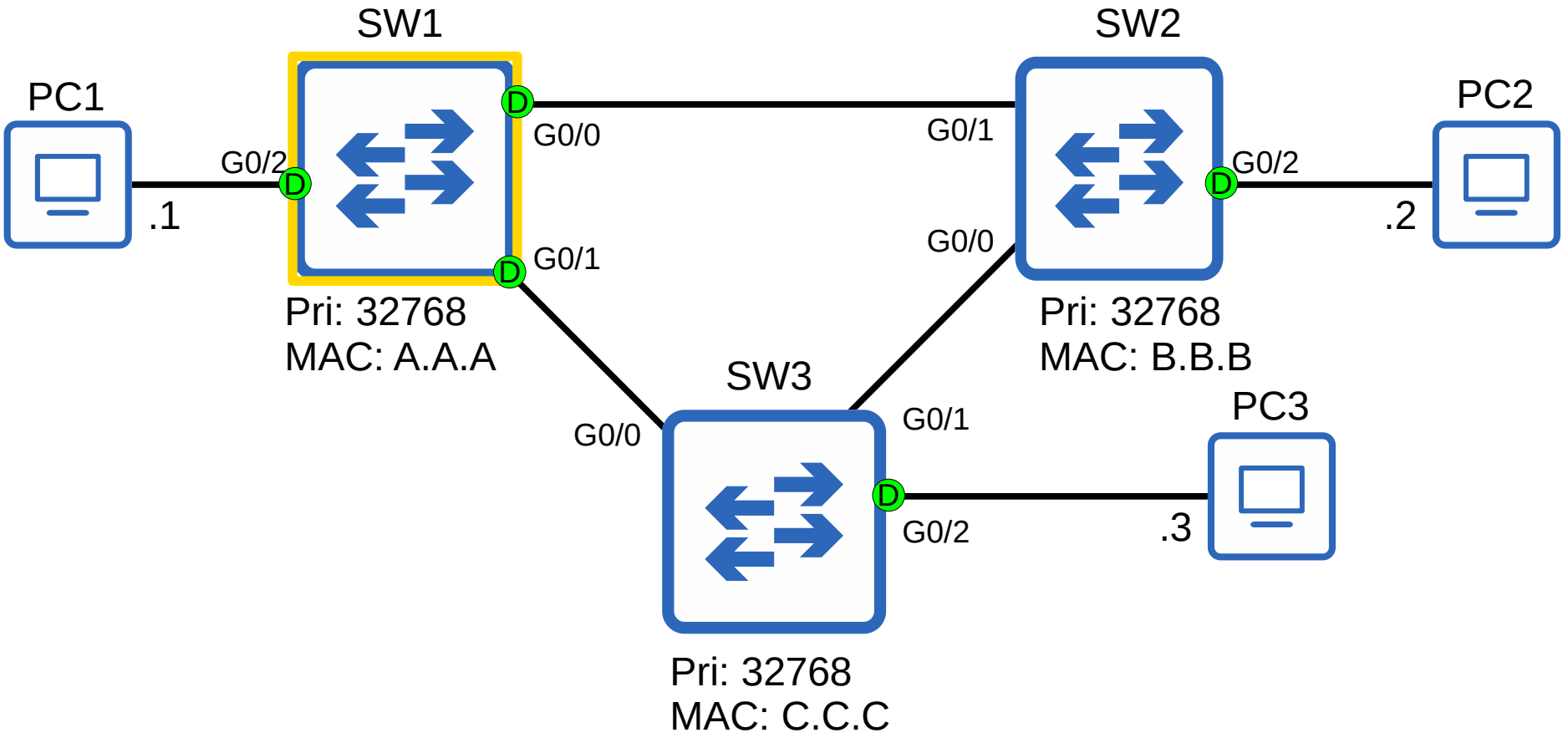
- Switches use one field in the STP BPDU, the **Bridge ID** field, to elect a **root bridge** for the network.
- The switch with the lowest **Bridge ID** becomes the **root bridge**.
- ALL ports on the **root bridge** are put in a forwarding state, and other switches in the topology must have a path to reach the root bridge.

Spanning Tree Protocol

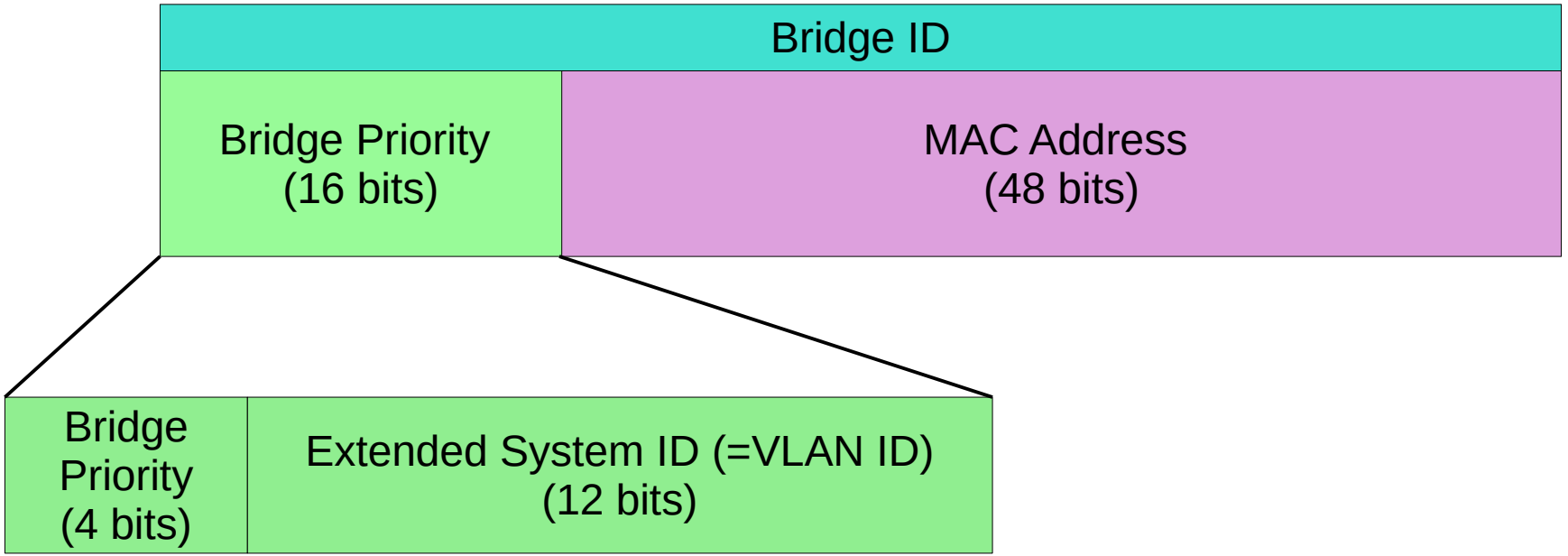


The default bridge priority is 32768 on all switches, so by default the MAC address is used as the tie-breaker (lowest MAC address becomes the root bridge).

Spanning Tree Protocol



Spanning Tree Protocol



Cisco switches use a version of STP called **PVST** (Per-VLAN Spanning Tree). PVST runs a separate STP 'instance' in each VLAN, so in each VLAN different interfaces can be forwarding/blocking.

Spanning Tree Protocol

Bridge Priority				Extended System ID (VLAN ID)											
32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

In the default VLAN of 1, the default bridge priority is actually **32769** (32768 + 1).

If you want to change the switch's bridge priority (without changing VLAN numbers), what is the minimum unit of increase/decrease?

Spanning Tree Protocol

Bridge Priority				Extended System ID (VLAN ID)											
32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

The **bridge priority** + **extended system ID** is a single field of the bridge ID, however the extended system ID is set and cannot be changed (because it is determined by the VLAN ID.

Therefore, the you can only change the total bridge priority (bridge priority + extended system ID) in units of 4096, the value of the least significant bit of the bridge priority.

Spanning Tree Protocol

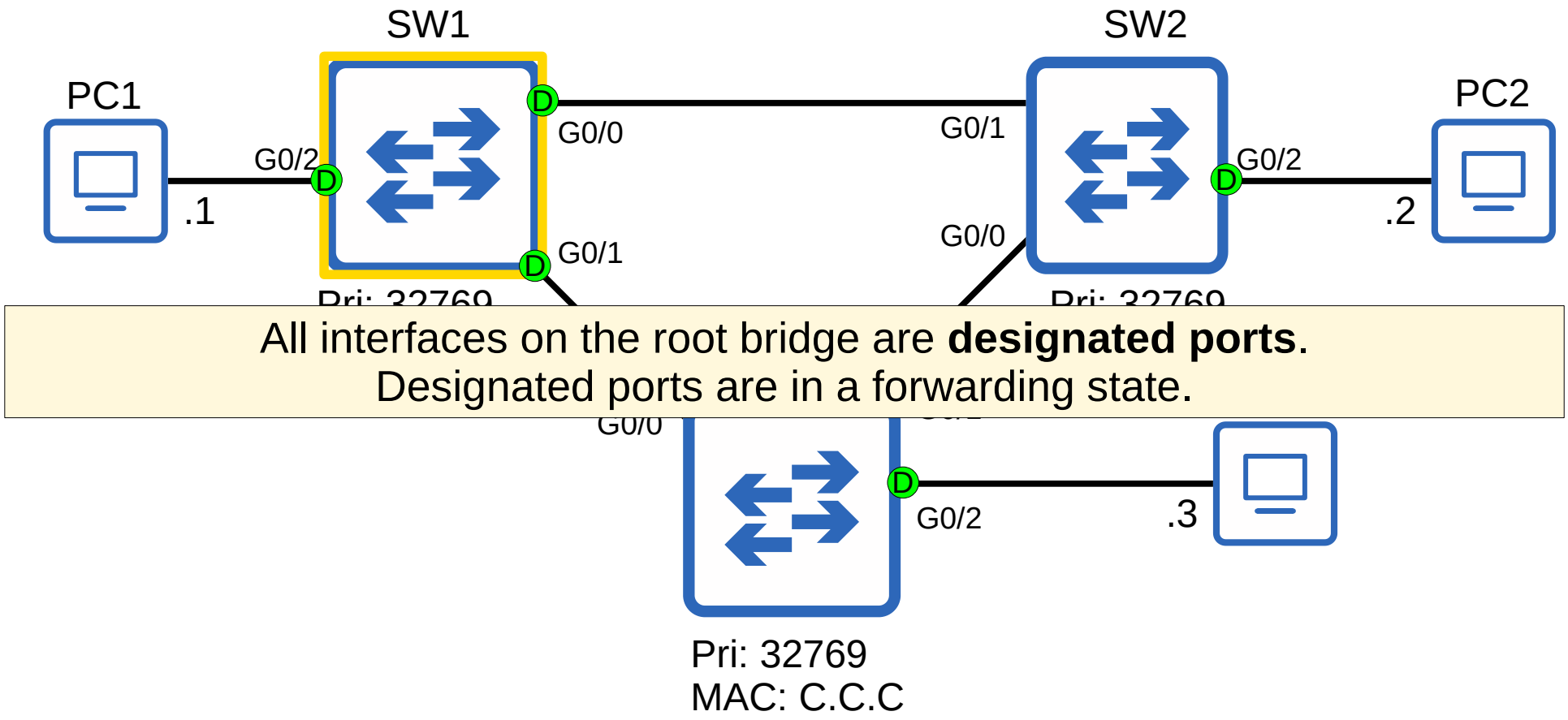
Bridge Priority				Extended System ID (VLAN ID)											
32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1

= 28673 (16384 + 8192 + 4096 + 1)

The STP bridge priority can only be changed in units of 4096.

The valid values you can configure are:
0, 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, or 61440.
The Extended System ID will then be added to this number to make the total bridge priority.

Spanning Tree Protocol



Spanning Tree Protocol

- When a switch is powered on, it assumes it is the root bridge.
- It will only give up its position if it receives a ‘superior’ BPDU (lower bridge ID).
- Once the topology has converged and all switches agree on the root bridge, only the root bridge sends BPDUs.
- Other switches in the network will forward these BPDUs, but will not generate their own original BPDUs.

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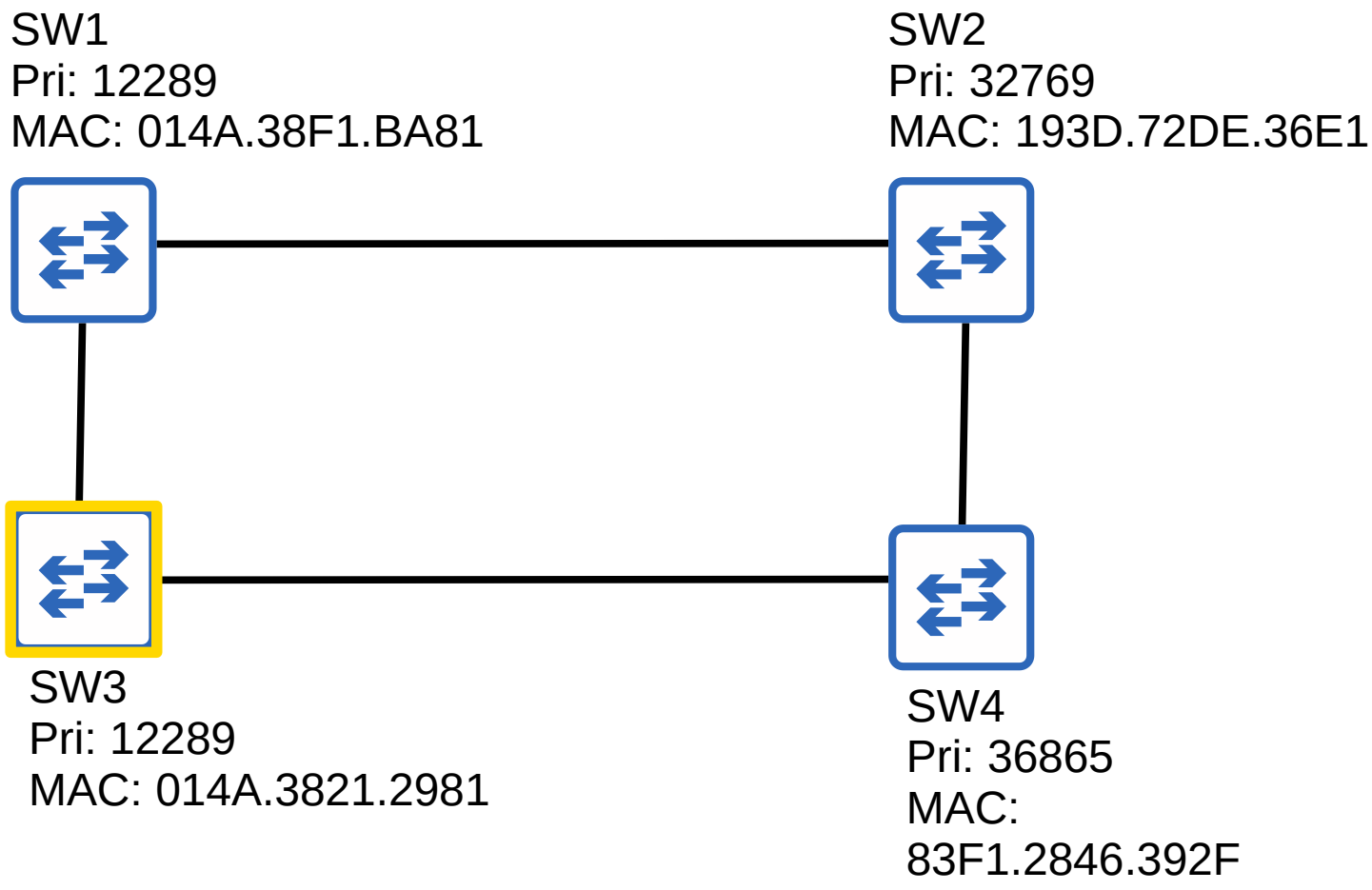
Spanning Tree Quiz 1



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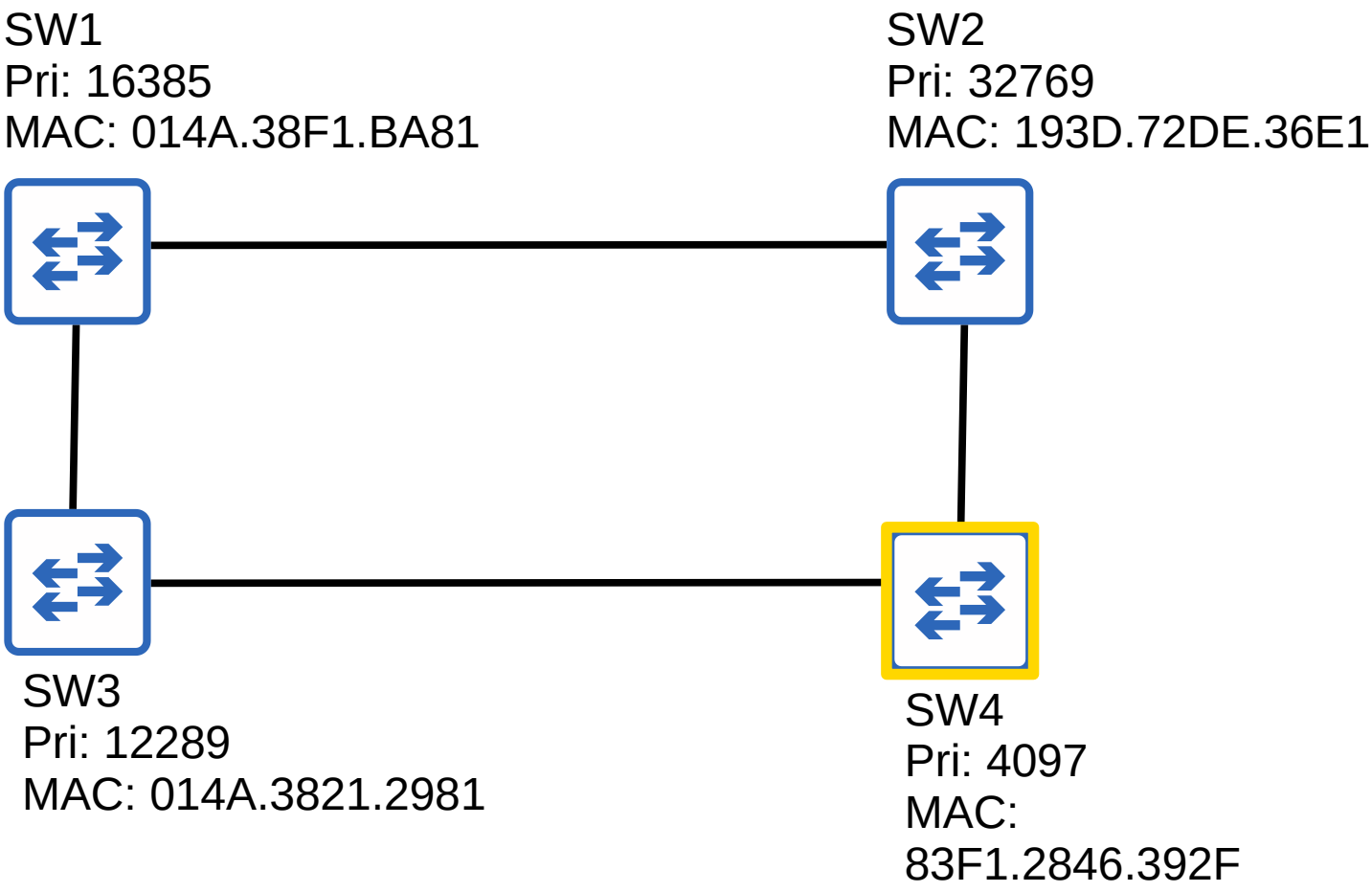
Spanning Tree Quiz 2



Spanning Tree Protocol

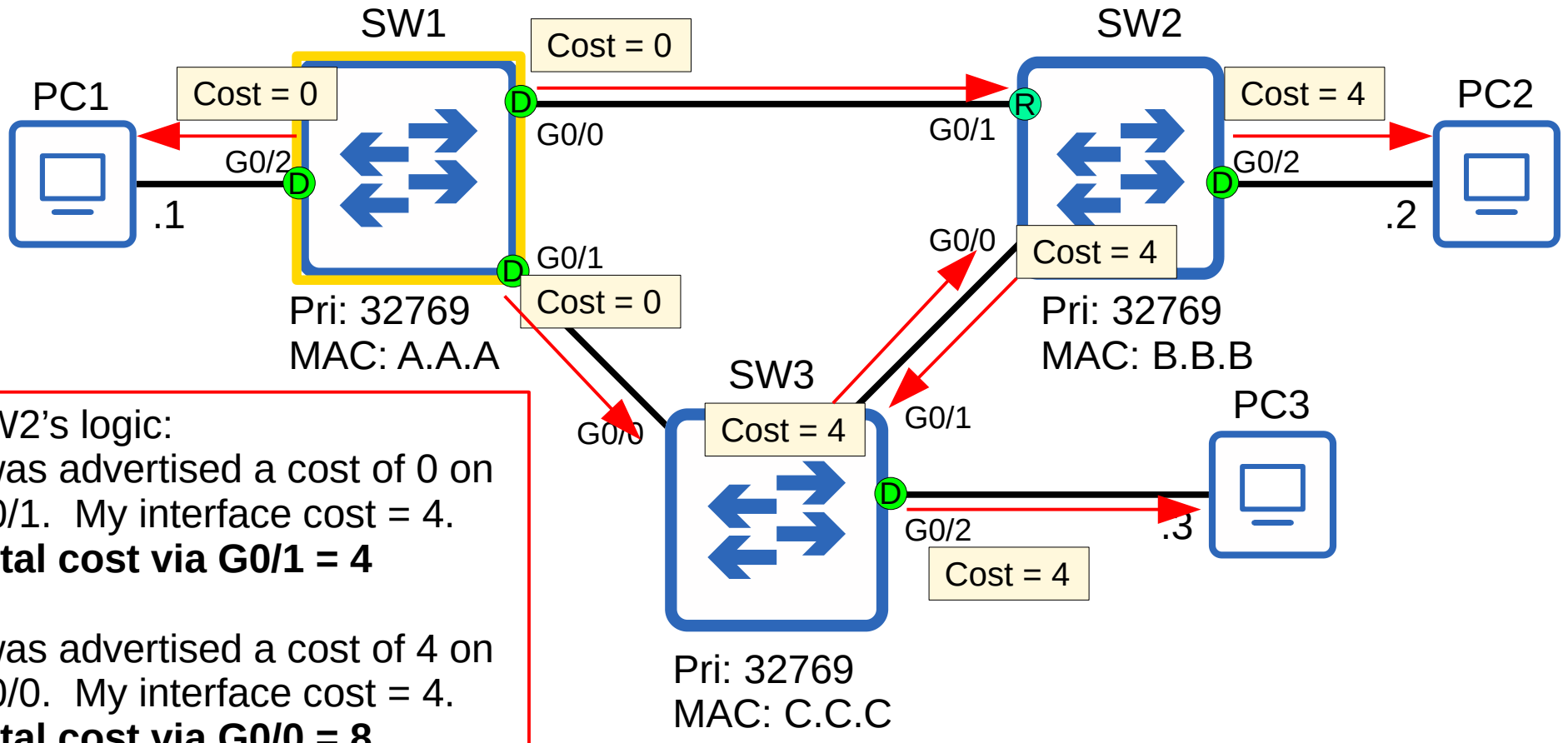
1) The switch with the lowest bridge ID is elected as the root bridge. All ports on the root bridge are **designated ports** (forwarding state).

2) Each remaining switch will select ONE of its interfaces to be its **root port.** The interface with the lowest *root cost* will be the root port. Root ports are also in a forwarding state.

Spanning Tree Protocol

Speed	STP Cost
10 Mbps	100
100 Mbps	19
1 Gbps	4
10 Gbps	2

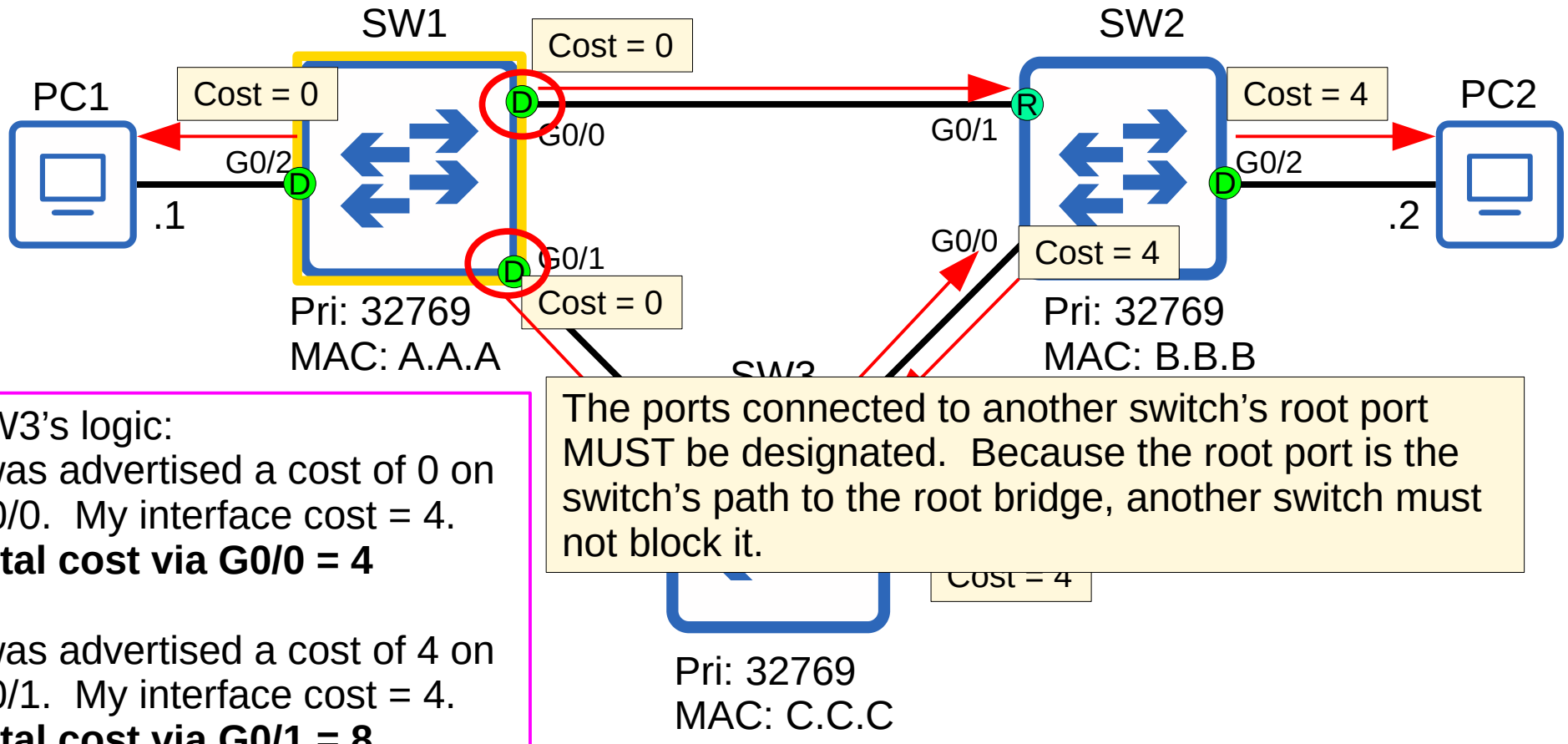
Spanning Tree Protocol



SW2's logic:
I was advertised a cost of 0 on G0/1. My interface cost = 4.
Total cost via G0/1 = 4

I was advertised a cost of 4 on G0/0. My interface cost = 4.
Total cost via G0/0 = 8

Spanning Tree Protocol



SW3's logic:
I was advertised a cost of 0 on G0/0. My interface cost = 4.
Total cost via G0/0 = 4

I was advertised a cost of 4 on G0/1. My interface cost = 4.
Total cost via G0/1 = 8

The ports connected to another switch's root port MUST be designated. Because the root port is the switch's path to the root bridge, another switch must not block it.

Spanning Tree Protocol

1) One switch is elected as the root bridge. All ports on the root bridge are **designated ports** (forwarding state). Root bridge selection:
   1: Lowest bridge ID

2) Each remaining switch will select ONE of its interfaces to be its **root port** (forwarding state)**.** Ports across from the root port are always **designated** ports.
   Root port selection:
   1: Lowest root cost
   2: Lowest neighbor bridge ID

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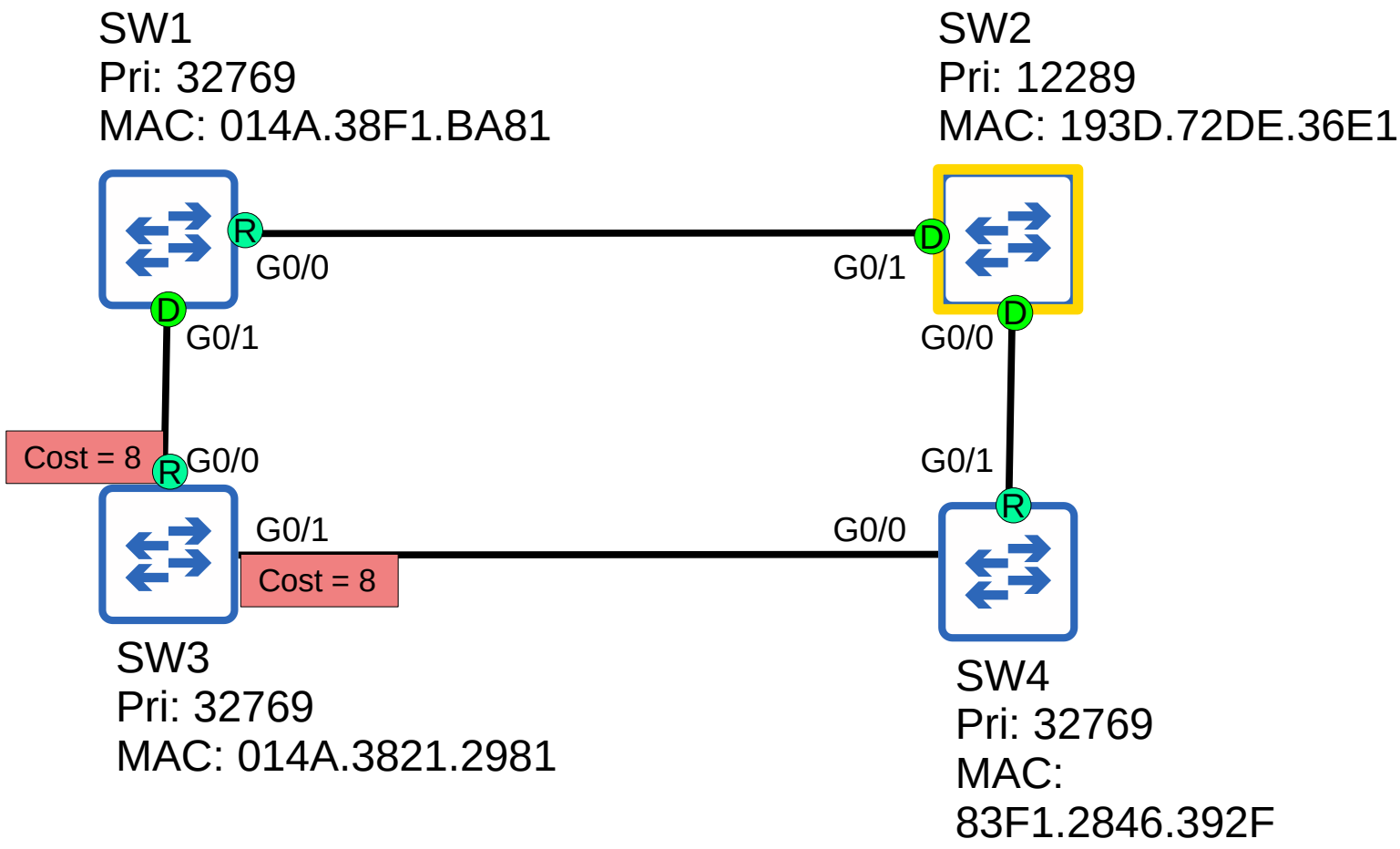
Spanning Tree Quiz 3



Spanning Tree Protocol

1) One switch is elected as the root bridge. All ports on the root bridge are **designated ports** (forwarding state). Root bridge selection:
   1: Lowest bridge ID

2) Each remaining switch will select ONE of its interfaces to be its **root port** (forwarding state)**.** Ports across from the root port are always **designated** ports.
   Root port selection:
   1: Lowest root cost
   2: Lowest neighbor bridge ID
   3: Lowest neighbor port ID

Spanning Tree Protocol

```
SW1#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID     Priority    32769
              Address     aaaa.aaaa.aaaa
              This bridge is the root
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32769  (priority 32768 sys-id-ext 1)
              Address     aaaa.aaaa.aaaa
              Aging Time  15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi0/0               Desg FWD 4         128.1    Shr
Gi0/1               Desg FWD 4         128.2    Shr
Gi0/2               Desg FWD 4         128.3    Shr
Gi0/3               Desg FWD 4         128.4    Shr
Gi1/0               Desg FWD 4         128.5    Shr
Gi1/1               Desg FWD 4         128.6    Shr
Gi1/2               Desg FWD 4         128.7    Shr
Gi1/3               Desg FWD 4         128.8    Shr
```

STP Port ID = port priority (default 128) + port number

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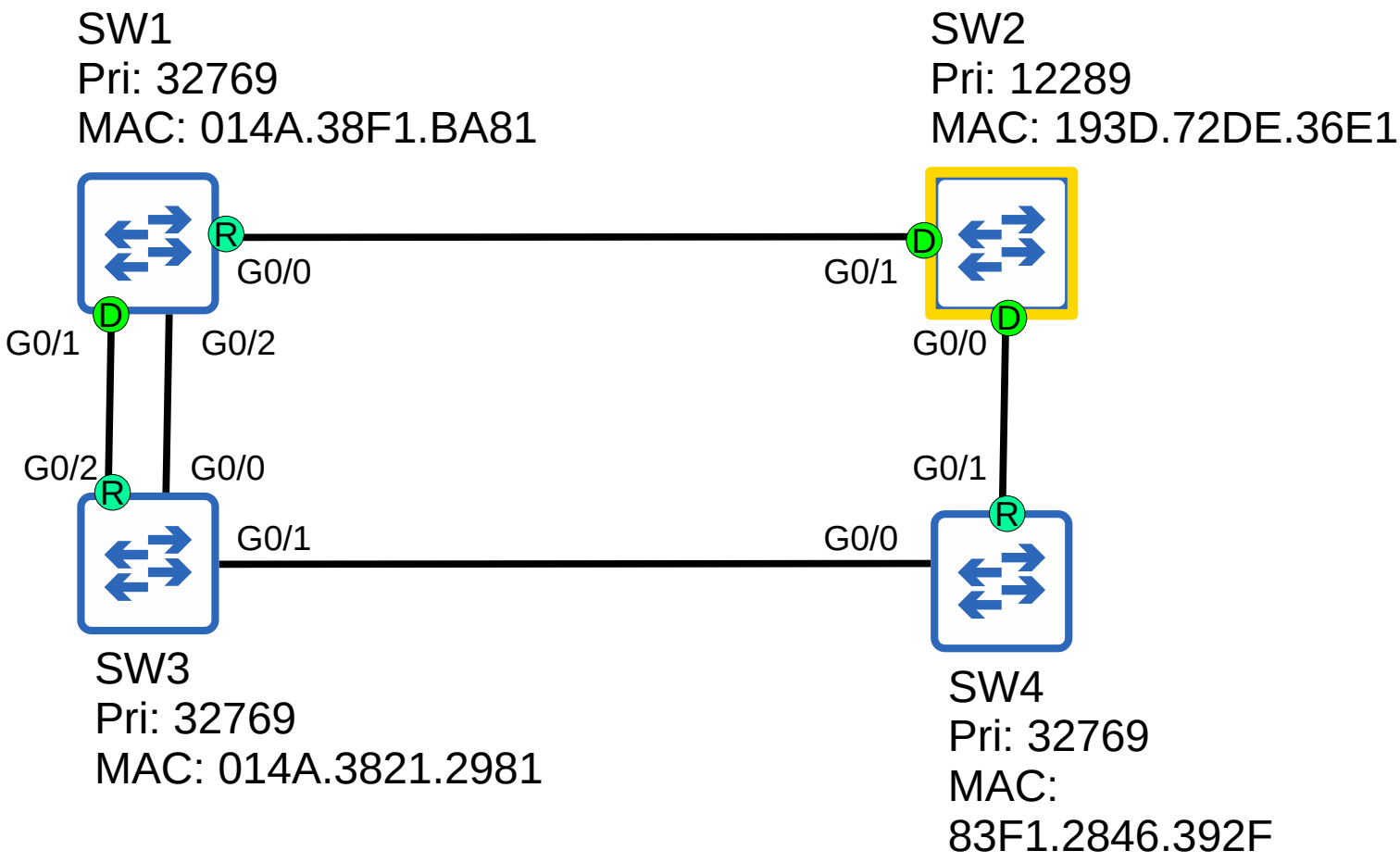
The NEIGHBOR switch's port ID is used to break the tie, not the local switch's port ID.



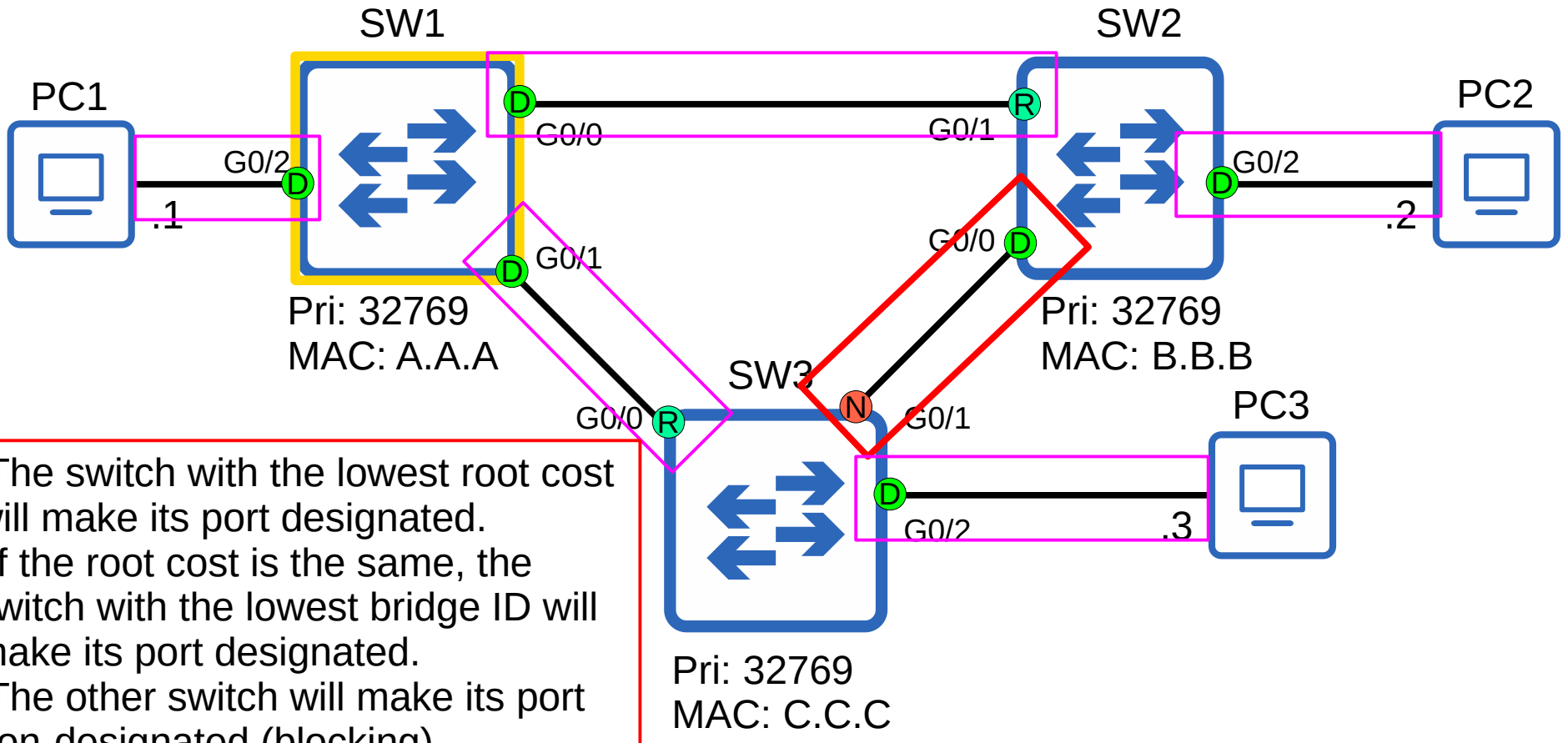
Spanning Tree Protocol

1) One switch is elected as the root bridge. All ports on the root bridge are **designated ports** (forwarding state). Root bridge selection:
   1: Lowest bridge ID

2) Each remaining switch will select ONE of its interfaces to be its **root port** (forwarding state)**.** Ports across from the root port are always **designated** ports.
   Root port selection:
   1: Lowest root cost
   2: Lowest neighbor bridge ID
   3: Lowest neighbor port ID

Spanning Tree Protocol

Every collision domain has a single STP designated port.



1) The switch with the lowest root cost will make its port designated.
2) If the root cost is the same, the switch with the lowest bridge ID will make its port designated.
3) The other switch will make its port non-designated (blocking)

Spanning Tree Protocol

1) One switch is elected as the root bridge. All ports on the root bridge are **designated ports** (forwarding state). Root bridge selection:
   1: Lowest bridge ID

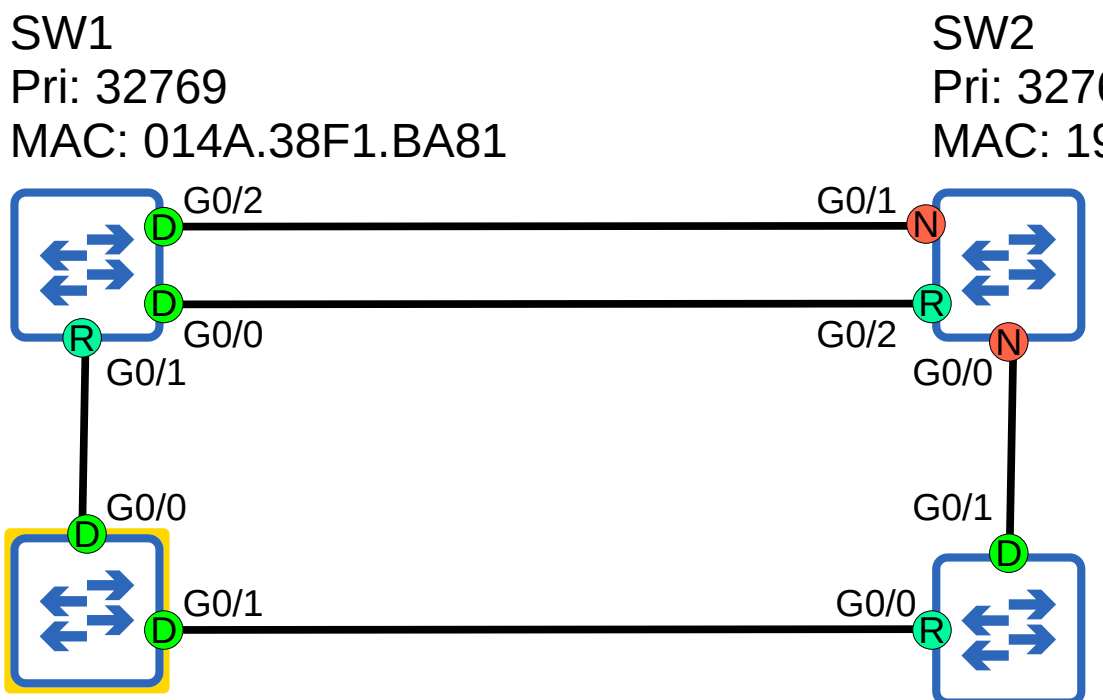
2) Each remaining switch will select ONE of its interfaces to be its **root port** (forwarding state)**.** Ports across from the root port are always **designated** ports.
   Root port selection:
   1: Lowest root cost
   2: Lowest neighbor bridge ID
   3: Lowest neighbor port ID

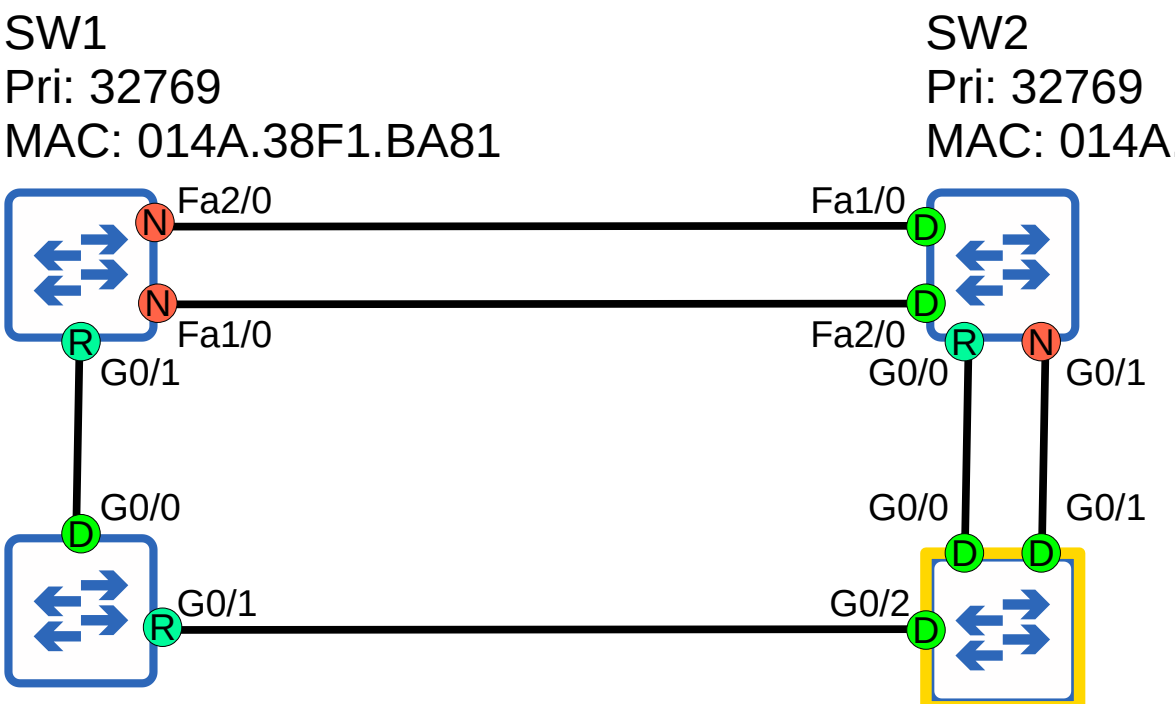
3) Each remaining collision domain will select ONE interface to be a **designated port** (forwarding state). The other port in the collision domain will be **non-designated** (blocking)
   Designated port selection:
   1: Interface on switch with lowest root cost
   2: Interface on switch with lowest bridge ID

QUIZ

Spanning Tree Quiz 5

Identify the root bridge, and the role of each interface on each switch in the network (root/designated/non-designated)



Spanning Tree Quiz 6

Identify the root bridge, and the role of each interface on each switch in the network (root/designated/non-designated)