How Spanning Tree Works

- Spanning Tree is an industry standard protocol and is enabled by default on all vendor's switches
- Switches send Bridge Protocol Data Units out all ports when they come online. These are used to detect other switches and potential loops
- The switch will not forward traffic out any port until it is certain it is loop free

Spanning Tree Port States

- When the port first comes online it will be blocking (not forwarding) traffic.
- Spanning Tree will detect if the port forms a potential loop
- If there is no loop the port will transition to Forwarding
- The process can take up to 50 seconds

The Bridge ID

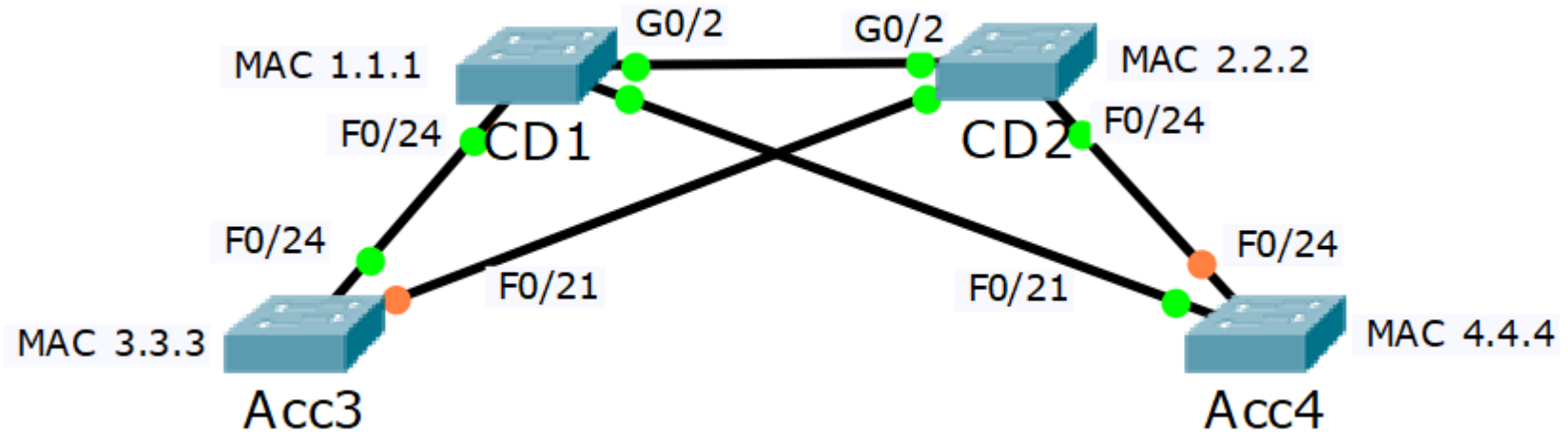
- The BPDU contains the switch's Bridge ID which uniquely identifies the switch on the LAN
- The Bridge ID is comprised of the switch's unique MAC address and an administrator defined Bridge Priority value
- The Bridge Priority can be from 0 – 65535, with 32768 being the default

The Root Bridge

- A Root Bridge is elected based on the switches' Bridge ID values
- The switch with the lowest Bridge Priority value is preferred (16384 is better than 49152)
- In the case of a tie the switch with the lowest MAC address will be selected
- The switches build a loop free forwarding path Tree leading back to the Root Bridge

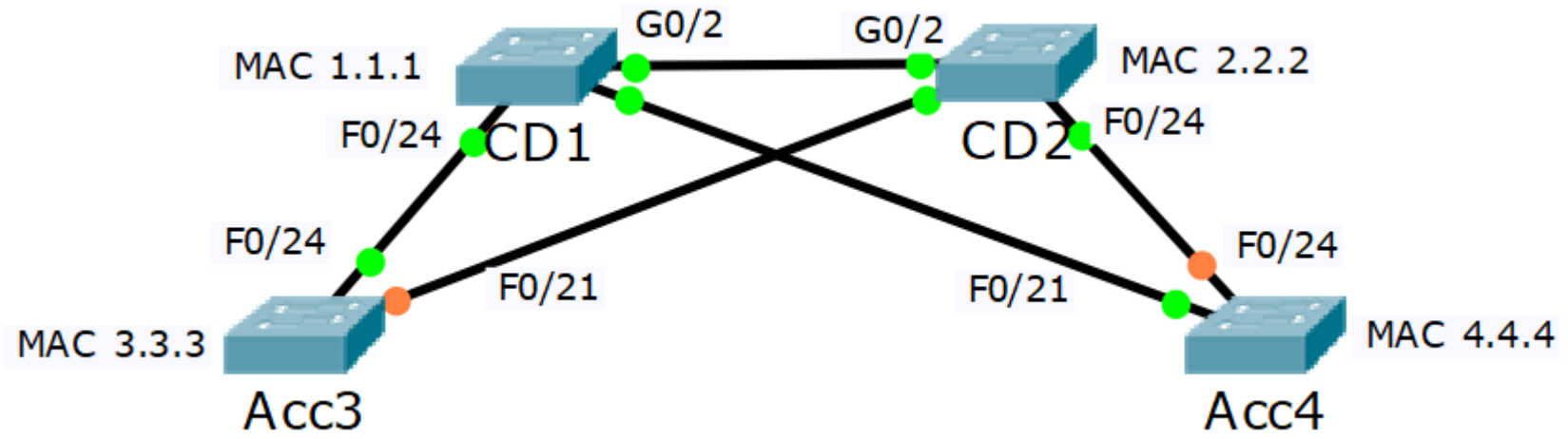
Spanning Tree Example

- In our example we have not manually set Bridge Priority on any switches
- CD1 is elected as the Root Bridge as it has the lowest MAC address



Spanning Tree Example

- The other switches will detect their lowest cost path to the Root Bridge
- These paths will transition to a forwarding state



Spanning Tree Cost

- When a switch calculates its best path towards the Root Bridge, higher bandwidth links are preferred

Link	Short-Mode Cost	Long-Mode Cost (Newer, More Granular Method)
10 Mbps	100	2,000,000
100 Mbps	19	200,000
1 Gbps	4	20,000
10 Gbps	2	2000
20 Gbps	1	1000
100 Gbps	1	200
1 Tbps	1	20
10 Tbps	1	2

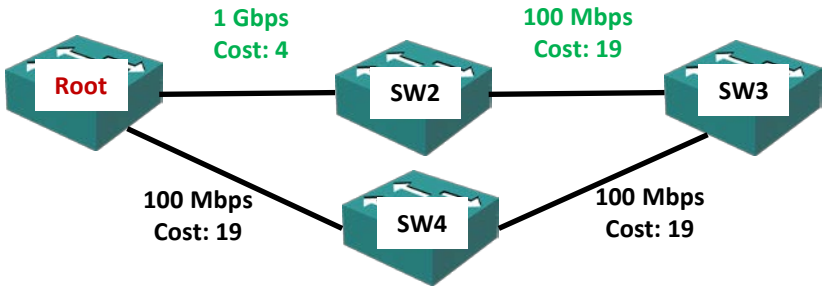
Short-Mode vs Long-Mode

- **Short-Mode (default):** the original standard, a 16-bit value. Reference value is 20 Gbps (cost=1), not granular enough for today's high bandwidth networks.
- **Long-Mode:** 32-bit value. More granular, reference value is 20 Tbps.
  - If you enable Long-Mode make sure you do it on all switches.

```
Acc4#show spanning-tree pathcost method
Spanning tree default pathcost method used is short
SW1(config)# spanning-tree pathcost method long
```

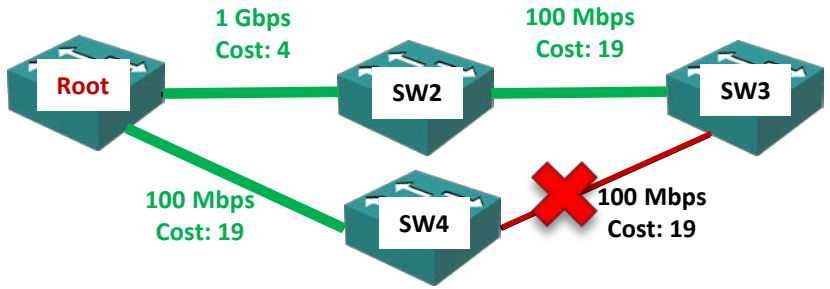
Spanning Tree Path Cost

- The Spanning Tree is built with the Root Bridge at the top.
- All switches forward traffic on their best (lowest cost) path to the Root Bridge.
- Higher cost paths (which could potentially form a loop) are blocked.
- The lowest cumulative STP cost across all links to reach the Root Bridge is chosen as a switch's Root Path
- A Root Path Cost is a switch's cumulative cost for a specific path to reach the Root Bridge



Spanning Tree Path Cost (Cont.)

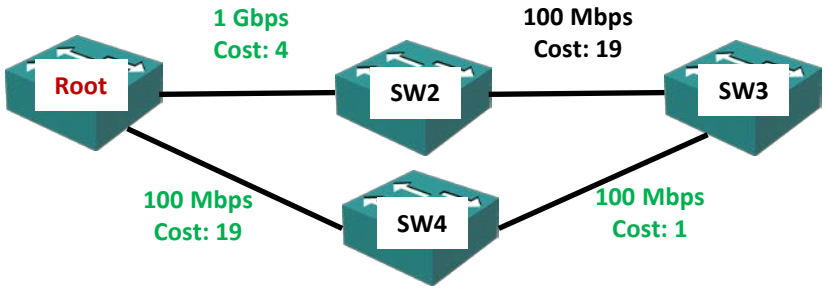
- The Root Bridge advertises a cost of 0 in its BPDUs
- Switches add the cost of the link the BPDU was received on
- Lowest cost paths are preferred
- SW2 can reach the Root Bridge via its direct link with a cost of 4, or via SW3 with a cost of 57 (19 + 19 + 19)
- SW4 can reach the Root Bridge via its direct link with a cost of 19, or via SW3 with a cost of 42 (19 + 19 + 4)
- SW3 can reach the Root Bridge via SW2 with a cost of 23 (4 +19) or via SW4 with a cost of 38 (19 + 19)



Spanning Tree Path Cost

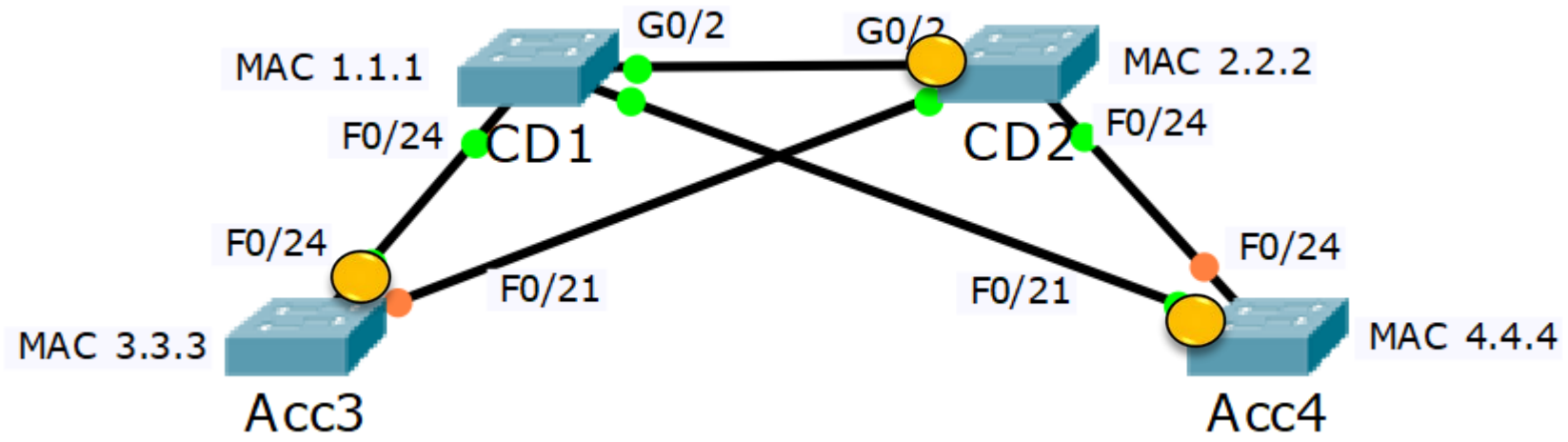
- You can manipulate Spanning Tree paths by changing the cost of an interface
- This is NOT a typical thing to do

```
SW3(config)#interface f0/2
SW3(config-if)#spanning-tree cost 1
```



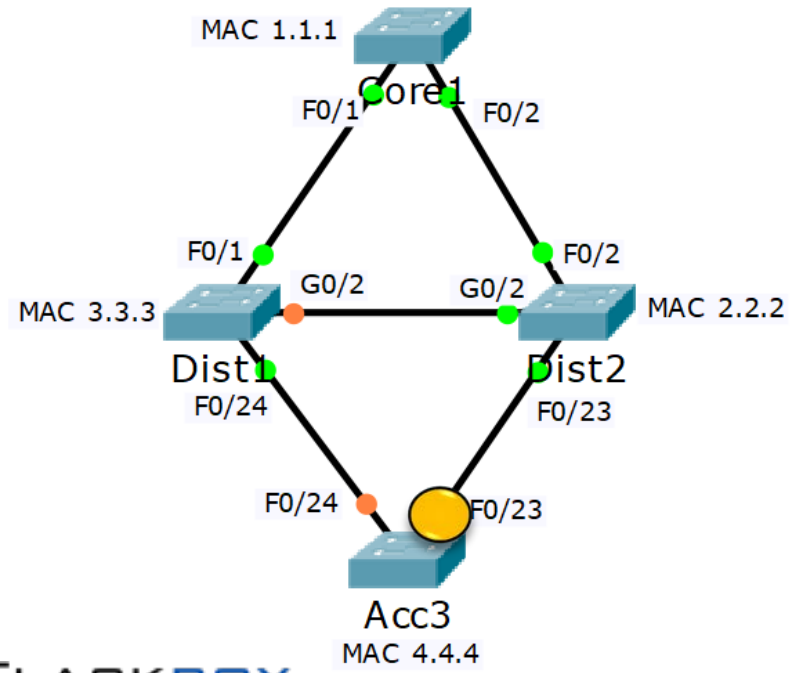
Root Ports

- Each switch's exit interface on the lowest cost path to the Root Bridge is selected as its Root Port
- **Each switch has only one Root Port in the Spanning Tree**



Load Balancing

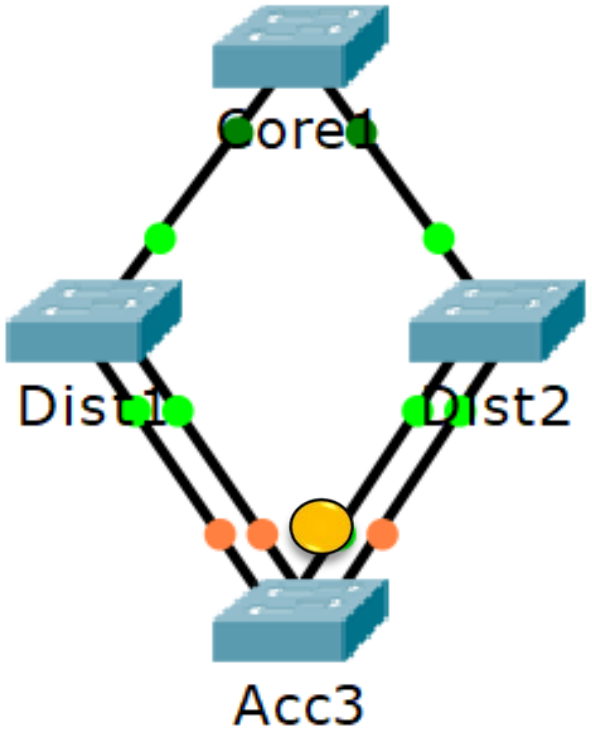
- **A Spanning Tree instance does not do load balancing**
- If a switch has multiple equal cost paths towards the Root Bridge, it will select the neighbour switch with the lowest Bridge ID



- Acc3 selects the path to the Core1 Root Bridge via Dist2 as it has a lower Bridge ID

Load Balancing

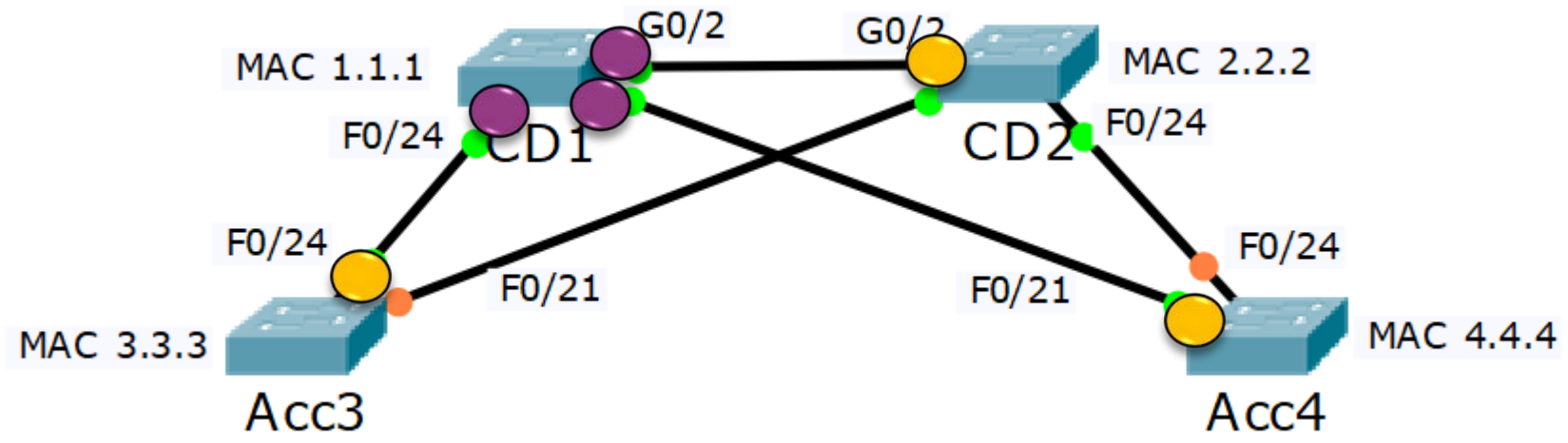
- **A Spanning Tree instance does not do load balancing**
- If a switch has multiple equal cost paths via the same neighbour switch towards the Root Bridge, it will select the port with the lowest Port ID on the neighbour switch



- Acc3 selects the path to the Core1 Root Bridge via Dist2 F0/1 as it is the port with the lowest Port ID going to the lowest Bridge ID

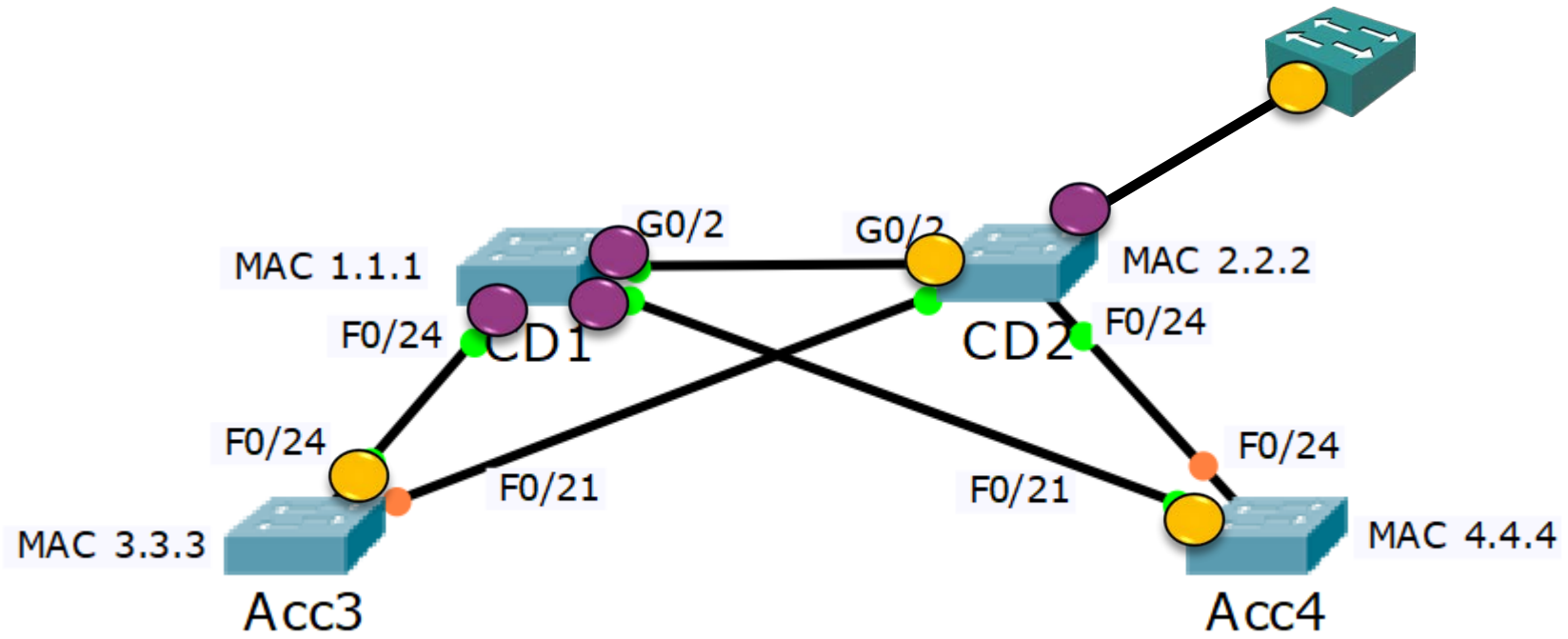
Designated Ports

- Ports on the neighbour switch opposite the Root Port are Designated Ports
- Root Ports point towards the Root Bridge, Designated Ports point away from it
- All ports on the Root Bridge are always Designated Ports



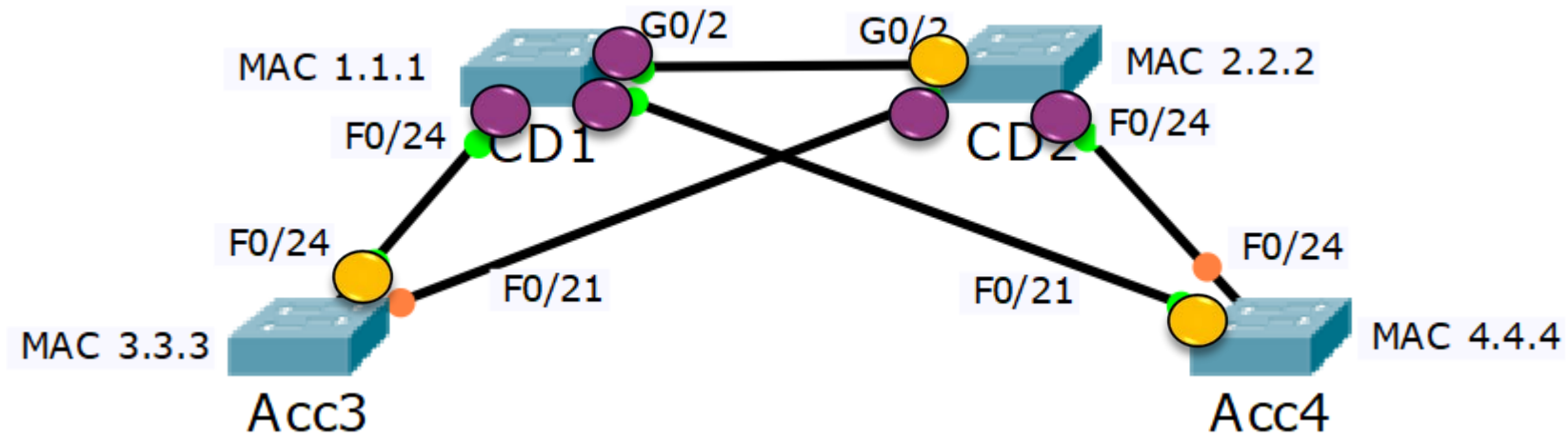
Root Ports and Designated Ports Forward Traffic

- Root Ports and their opposing Designated Ports are the most direct paths to and from the Root Bridge and transition to a forwarding state



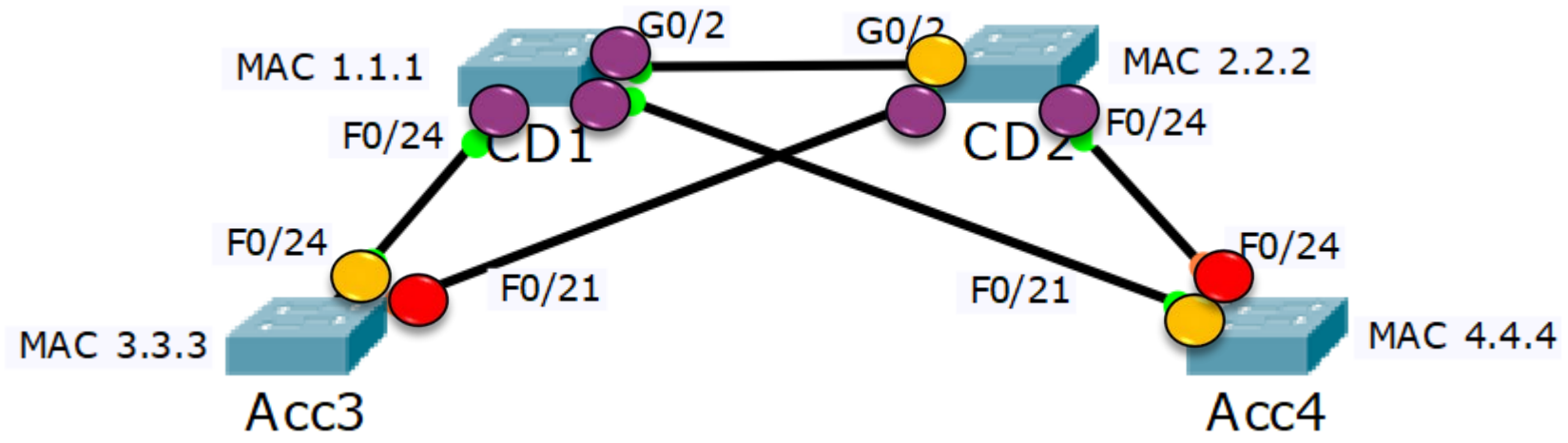
Other Links

- On the remaining links, the switches determine which of them has the least-cost path to the root
- If they have equal cost paths then the Bridge ID is used as a tiebreaker
- The port connecting this switch to the link is selected as a Designated Port.



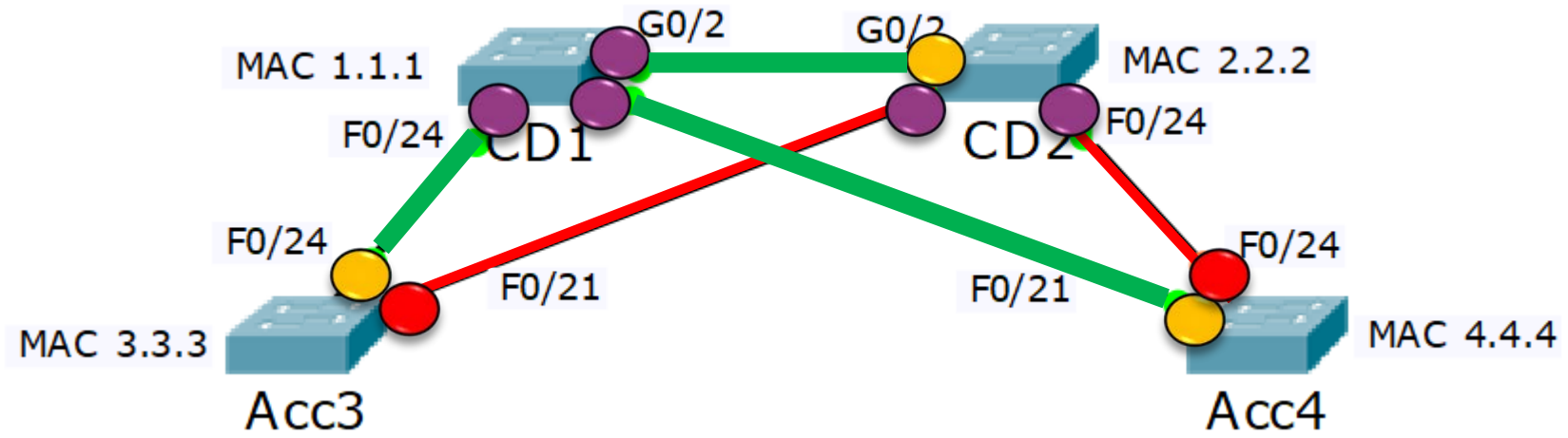
Blocking Ports

- Any ports which have not been selected as a Root Port or Designated Port pair would potentially form a loop
- These are selected as Blocking Ports



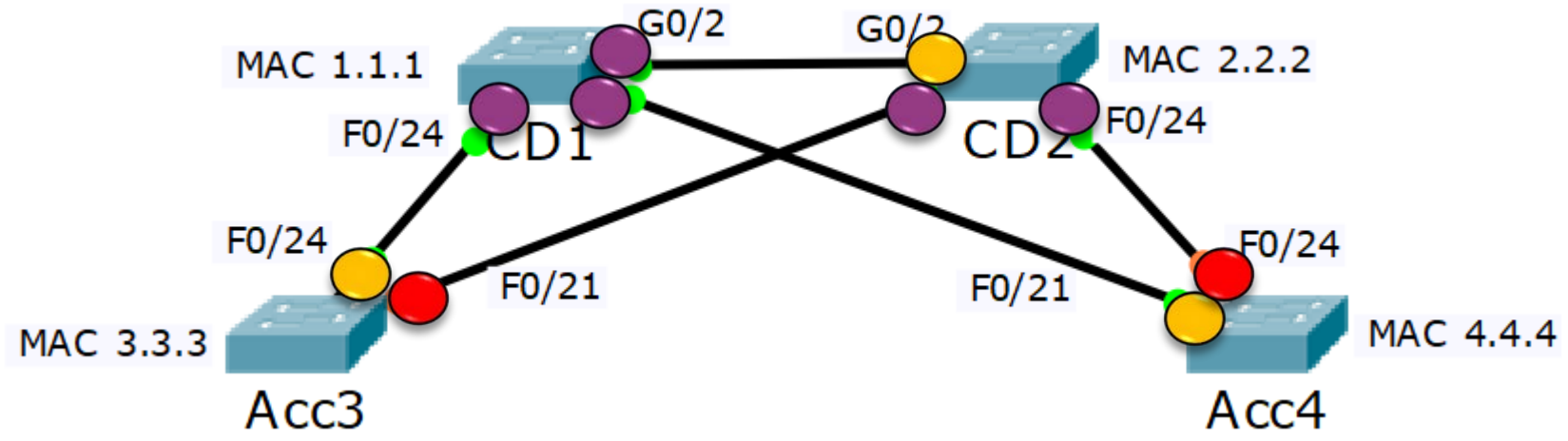
Blocking Ports

- Network traffic is only sent on Root Port links, all other links are blocked
- The way Spanning Tree decides which ports to block is, a switch blocks Non-Root Ports which receive a better BPDU.



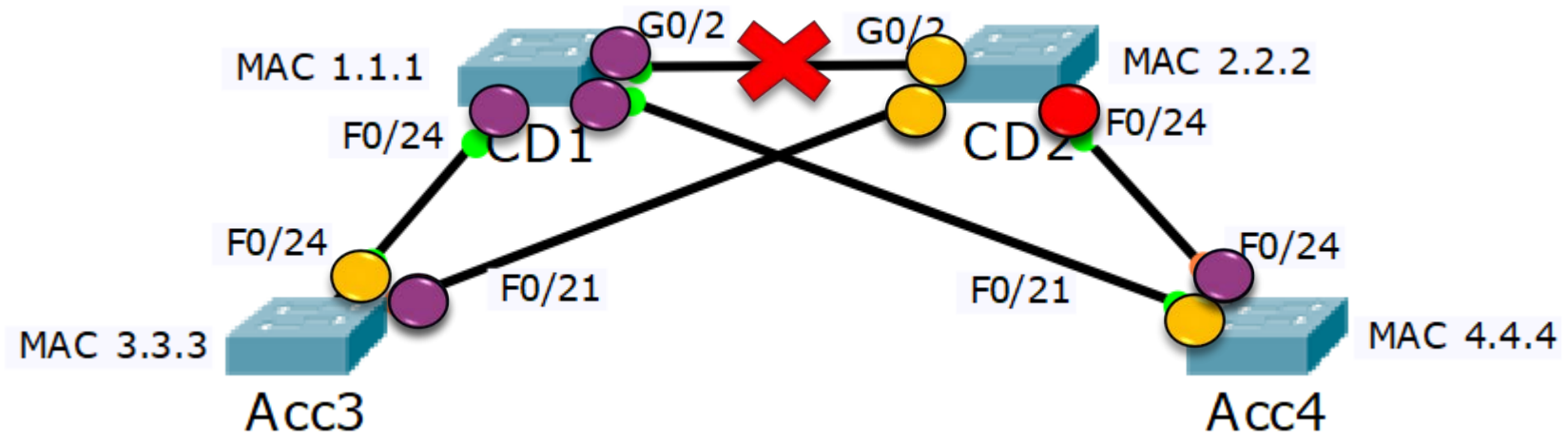
Blocking Ports

- Spanning Tree only blocks ports on one side of the blocked link
- BPDUs continue to be sent over the link from the Designated Port (but not from the Blocked Port)
- Other traffic cannot use the link



Blocking Ports

- If a Blocked Port stops receiving better BPDUs it will unblock and transition to being a Designated (Forwarding) Port.



Root, Designated and Blocking Ports

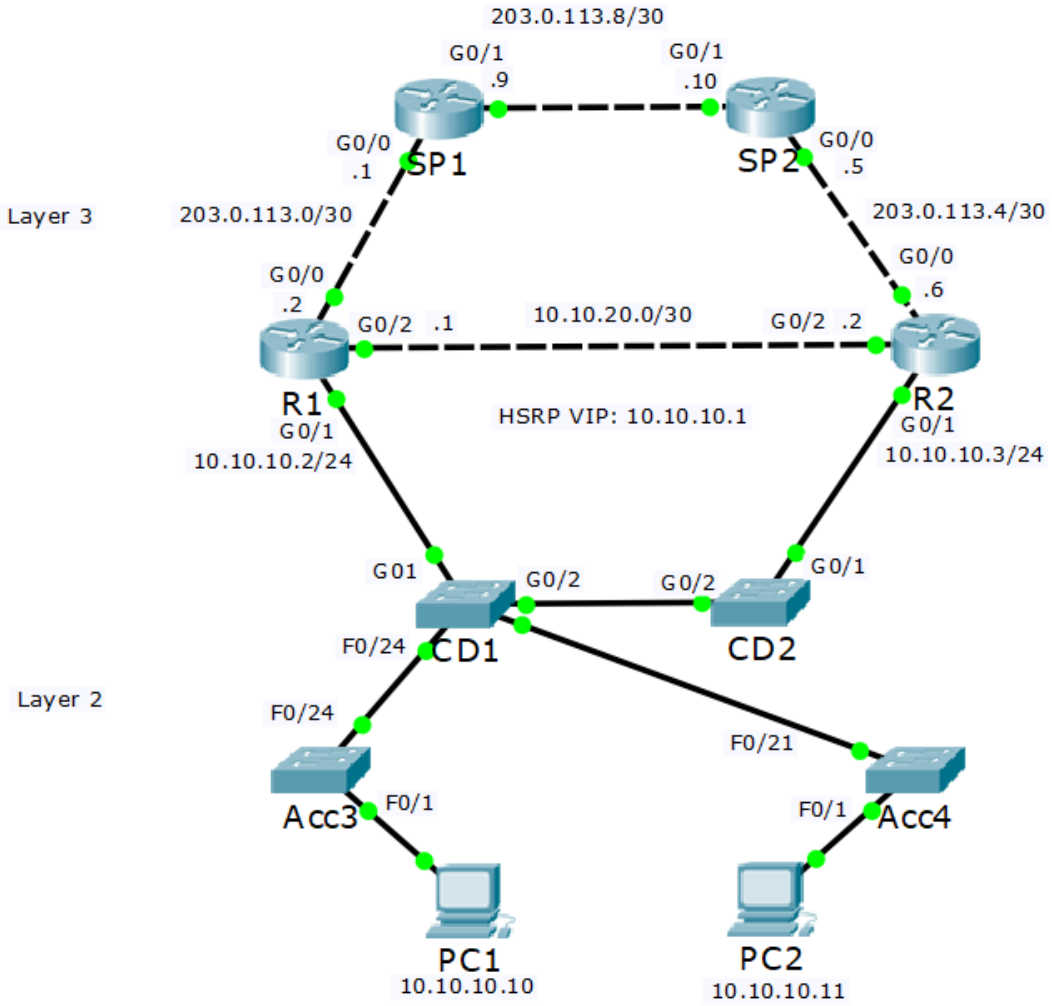
The easy way to figure out which ports are Root, Designated and Blocking:

1. Determine the Root Bridge first (best Bridge ID)
2. All ports on the Root Bridge are Designated Ports
3. Determine the Root Ports on the other switches (lowest cost to Root Bridge)

Root, Designated and Blocking Ports (Cont.)

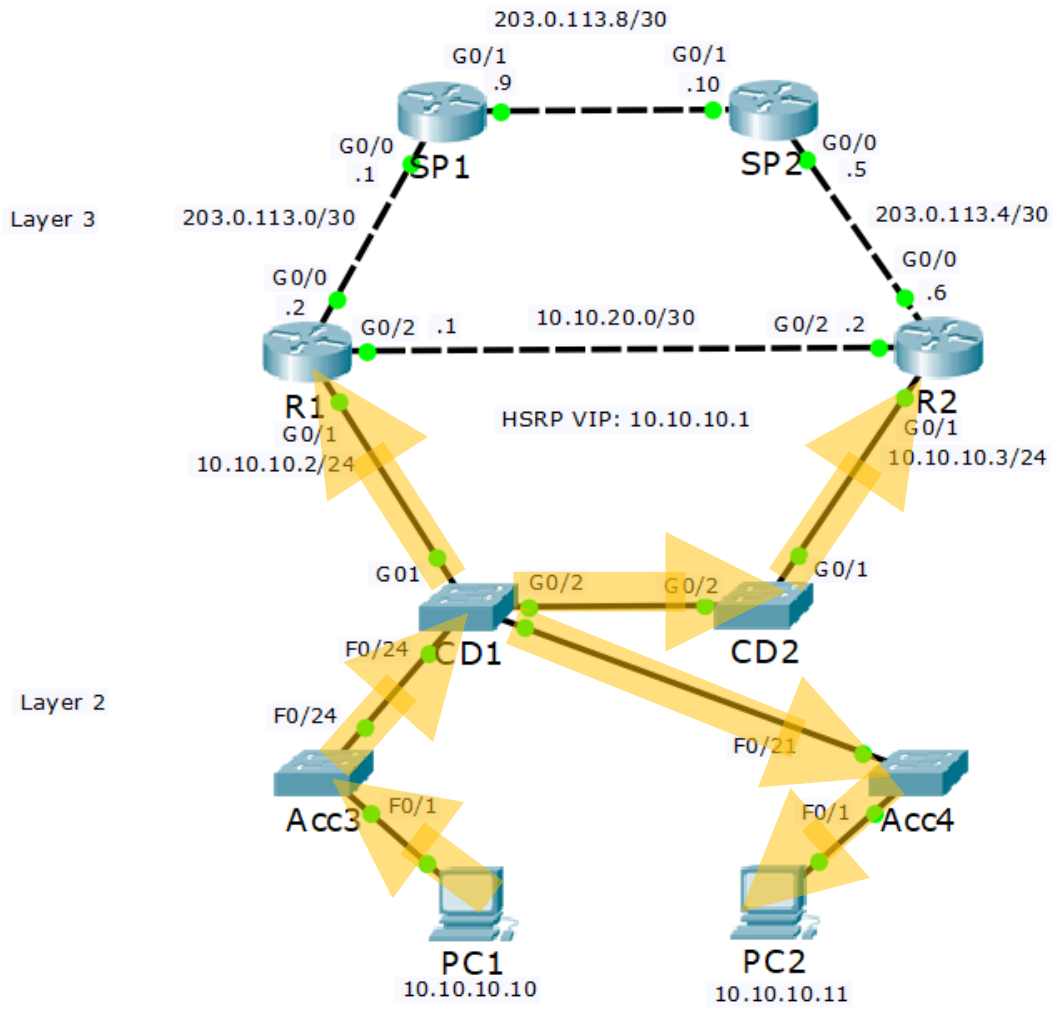
4. The ports on the other side of those links are Designated Ports
5. On the links which are left, one port will be Blocking
6. Determine the Blocking Port (highest cost path to Root Bridge or highest Bridge ID)
7. The ports on the other side of those links are Designated Ports

Layer 2 Forwarding Paths



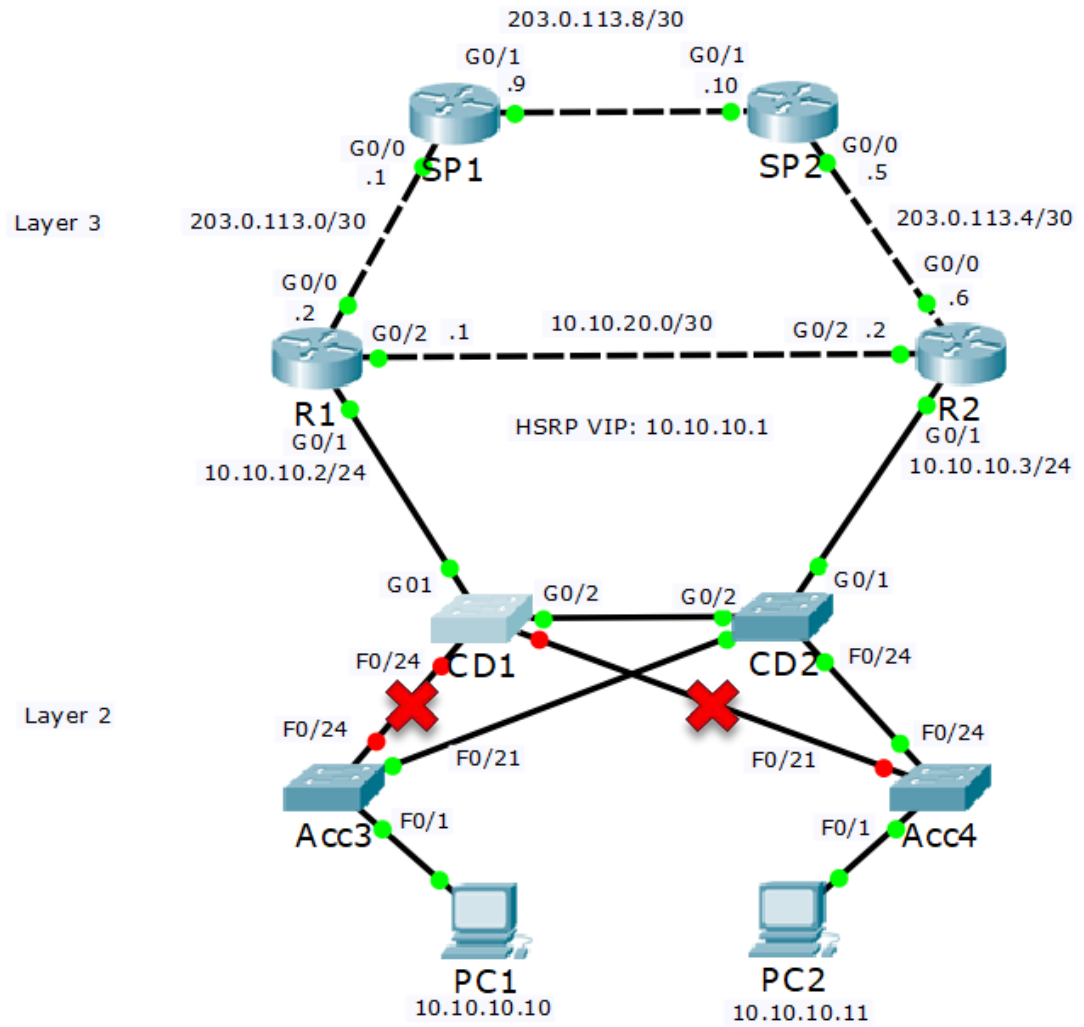
- These are now the available paths through the network
- All unicast, multicast and broadcast traffic can only go over these links
- Routing protocol loop prevention mechanisms and the TTL field prevent traffic looping at Layer 3
- Spanning Tree ensures there are no loops at Layer 2

Ethernet Path Selection Review



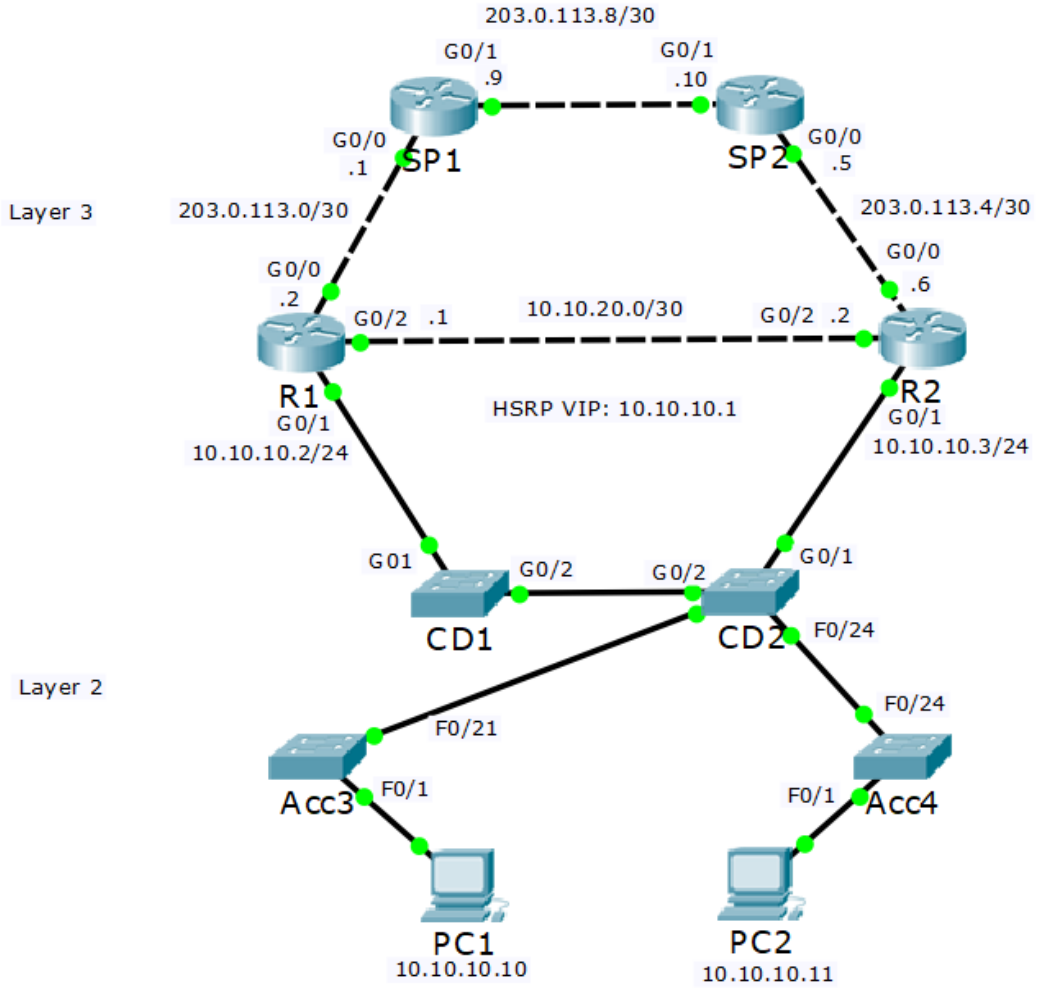
- When PC1 sends an ARP request for 10.10.10.2, it will be flooded over the Spanning Tree

Spanning Tree Failover



- If an uplink to CD1 fails, Spanning Tree will detect it and transition the redundant link to Forwarding

Spanning Tree Failover



- The forwarding paths now go via CD2