

Spanning Tree protocol

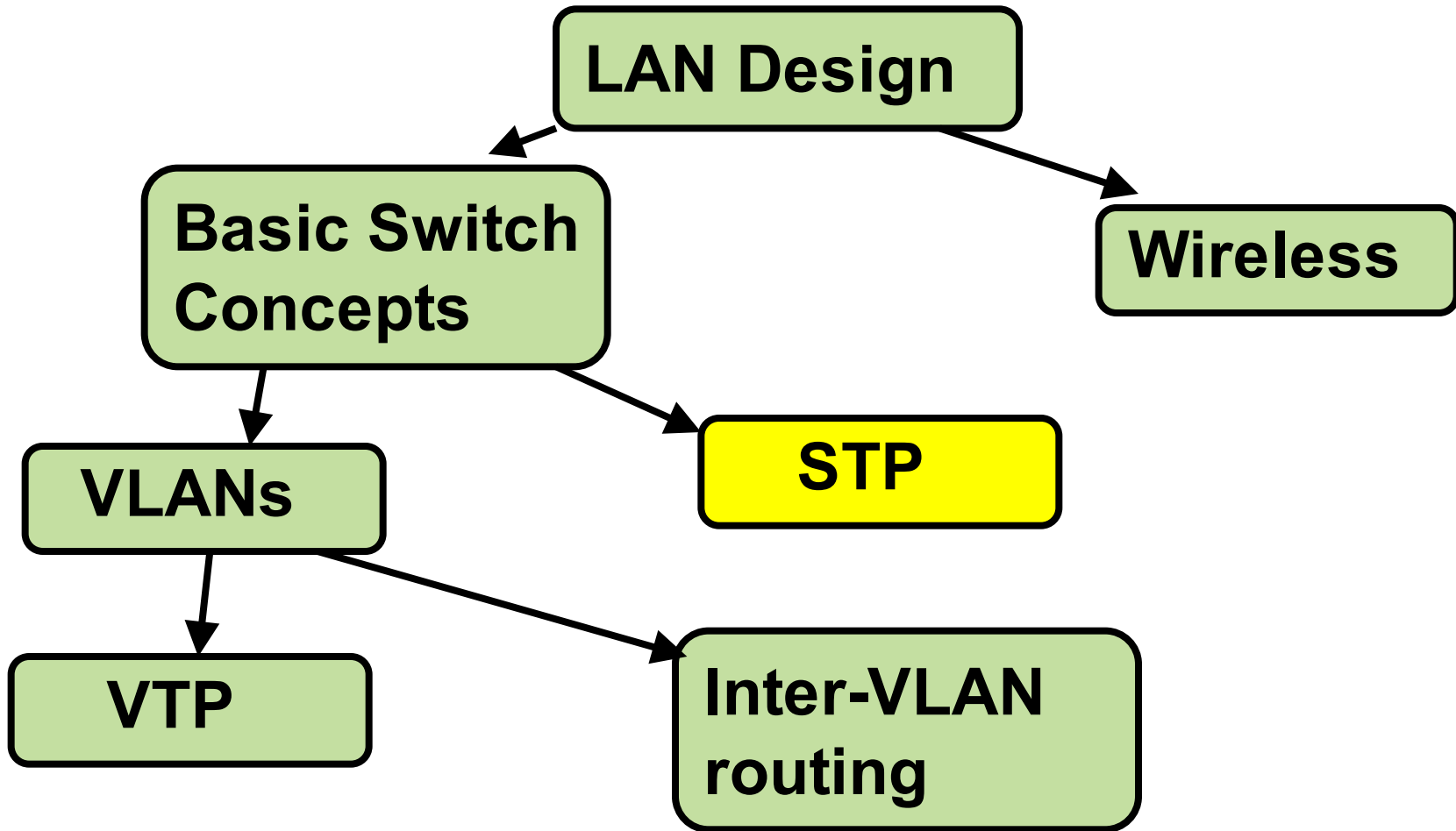
CCNA Exploration Semester 3

Chapter 5

Topics

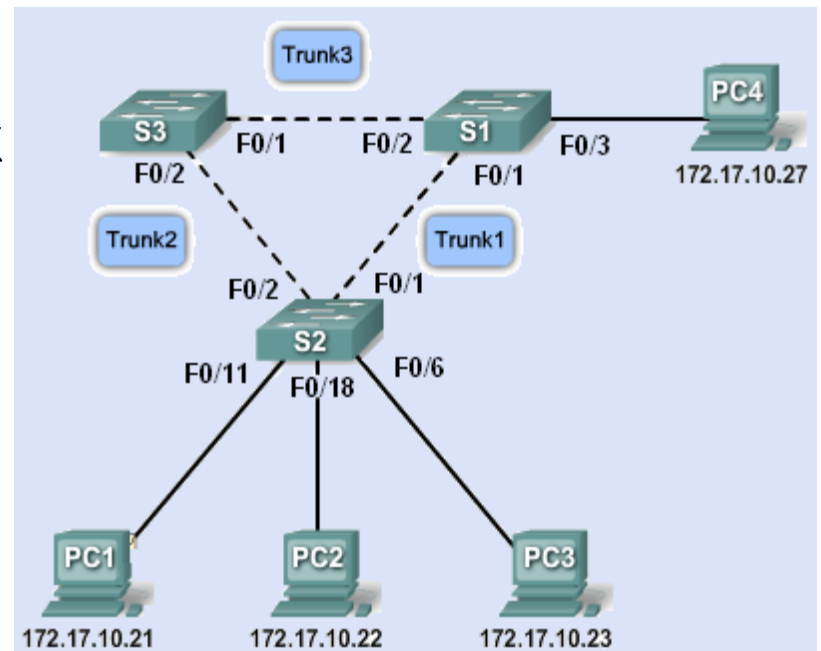
- Redundancy in a converged network
- How Spanning Tree Protocol (STP) eliminates layer 2 loops
- The STP algorithm and its 3 steps
- Rapid spanning tree protocol

Semester 3



We want:

- Redundancy at the distribution and core layers
- Multiple switches and trunk links
- One link or device fails – another takes over.



But redundancy gives loops

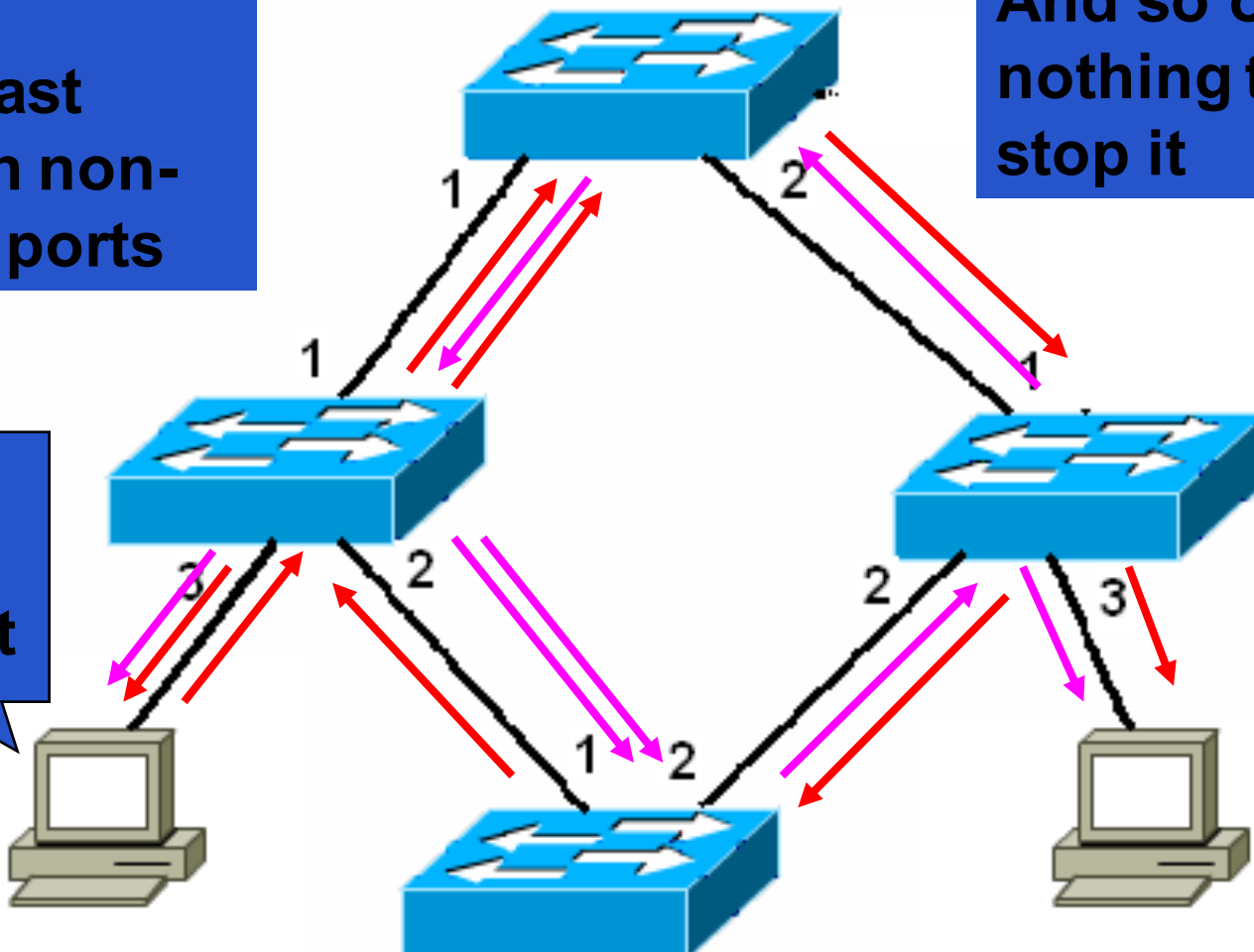
- Switching loops give problems if all the links are active:
- Broadcast storms
- Multiple frame transmission
- Inconsistent switch tables

Broadcast storm

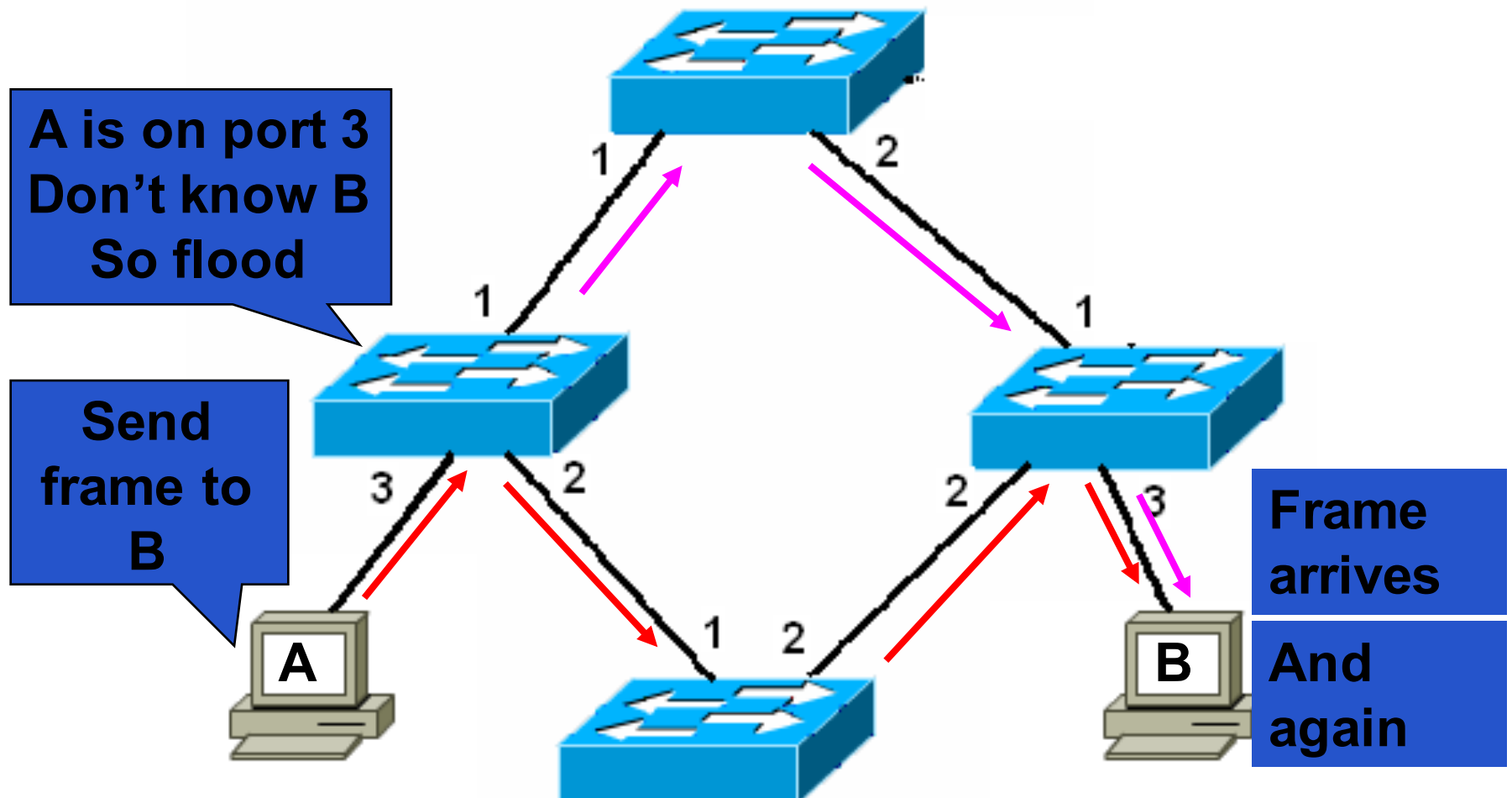
**Flood
broadcast
through non-
source ports**

**And so on with
nothing to
stop it**

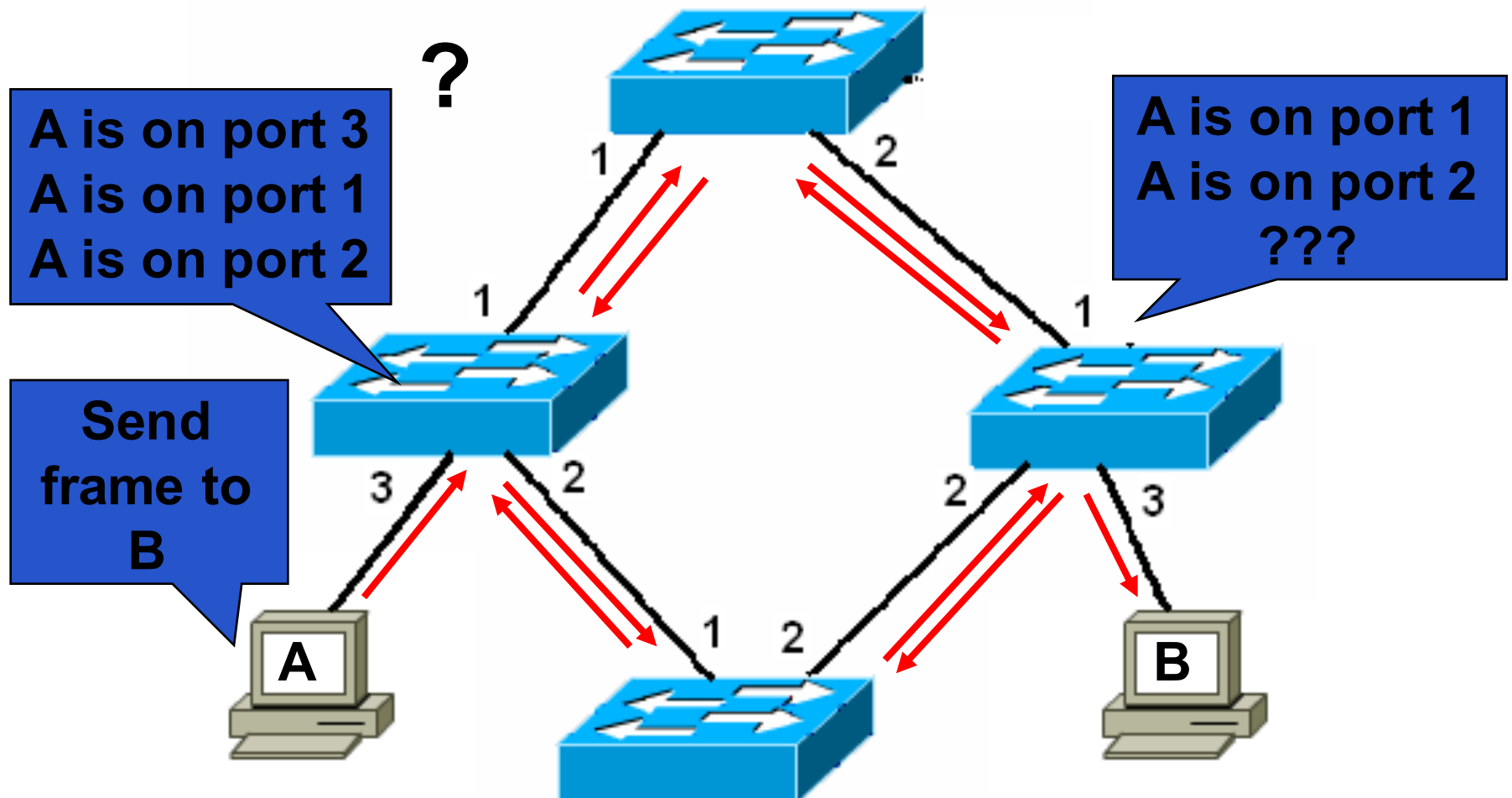
**Send
ARP
request**



Multiple Frame Transmissions



Inconsistent switch tables



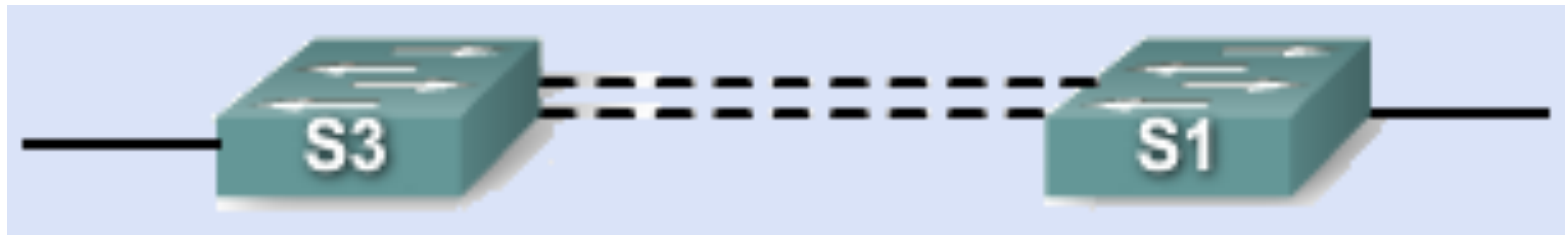
Loops by mistake

- Even if there are no deliberate loops for redundancy, there can be loops set up by mistake.



Etherchannel – the exception

- Multiple connections do not make a loop where Etherchannel is used.
- The links are aggregated to act as one link with the combined bandwidth.



Redundancy without loops

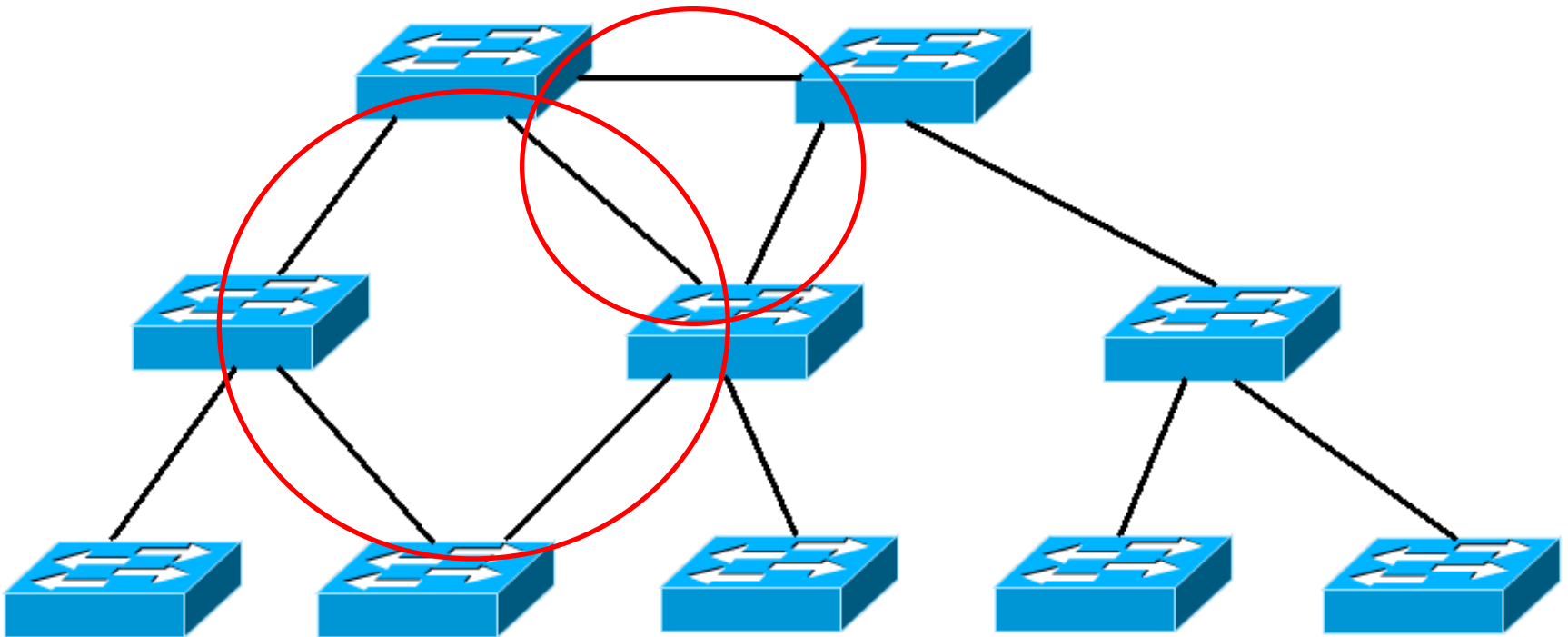
- There needs to be just one path at a time.
- Redundant paths must be shut down, but ready to be opened when they are needed.
- This must be done quickly and automatically.
- **Spanning Tree Protocol** does this.

What is a spanning tree?

- A tree (extended star) topology
 - A tree has no loops
- Spanning all devices
 - All devices are connected (i.e. no device left out)

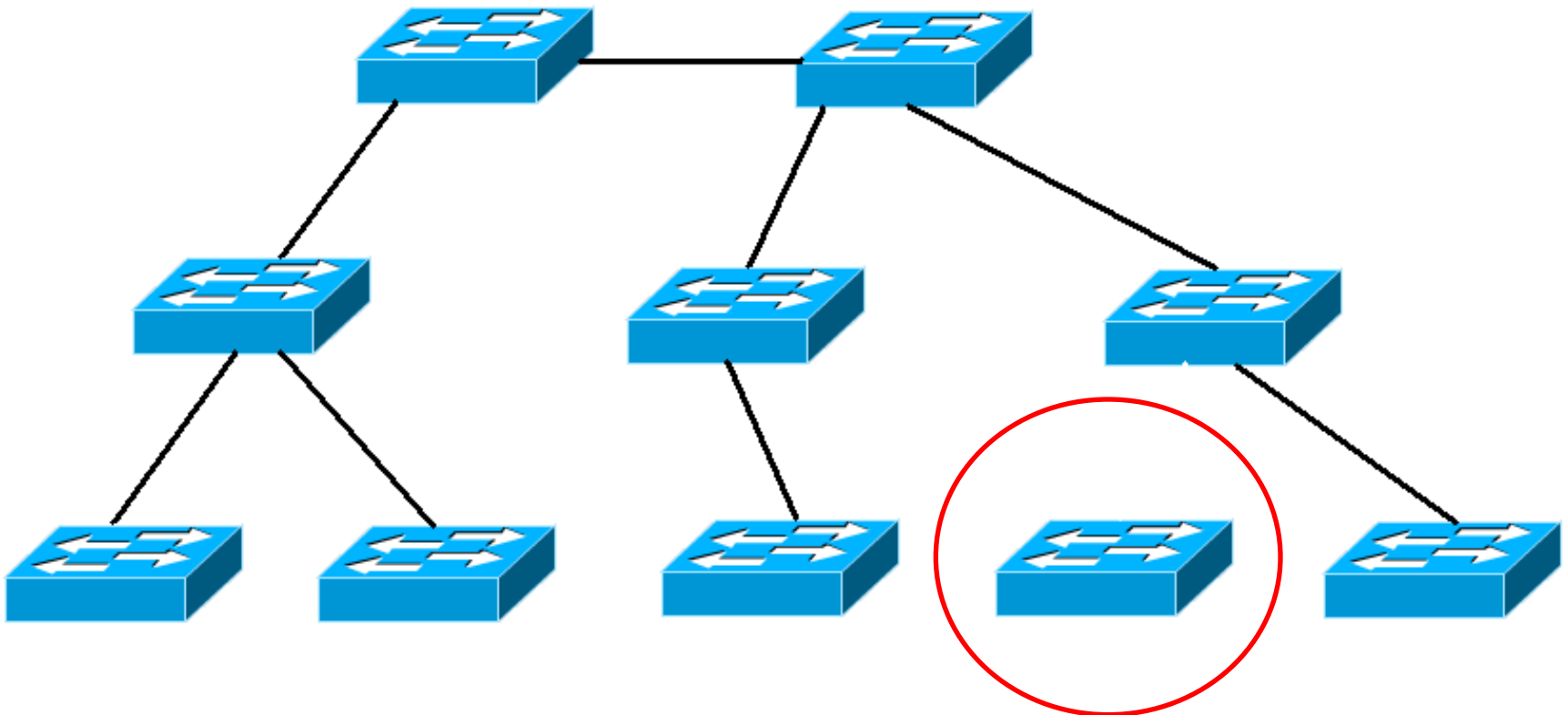
Not a spanning tree

- Not a tree - it has loops.



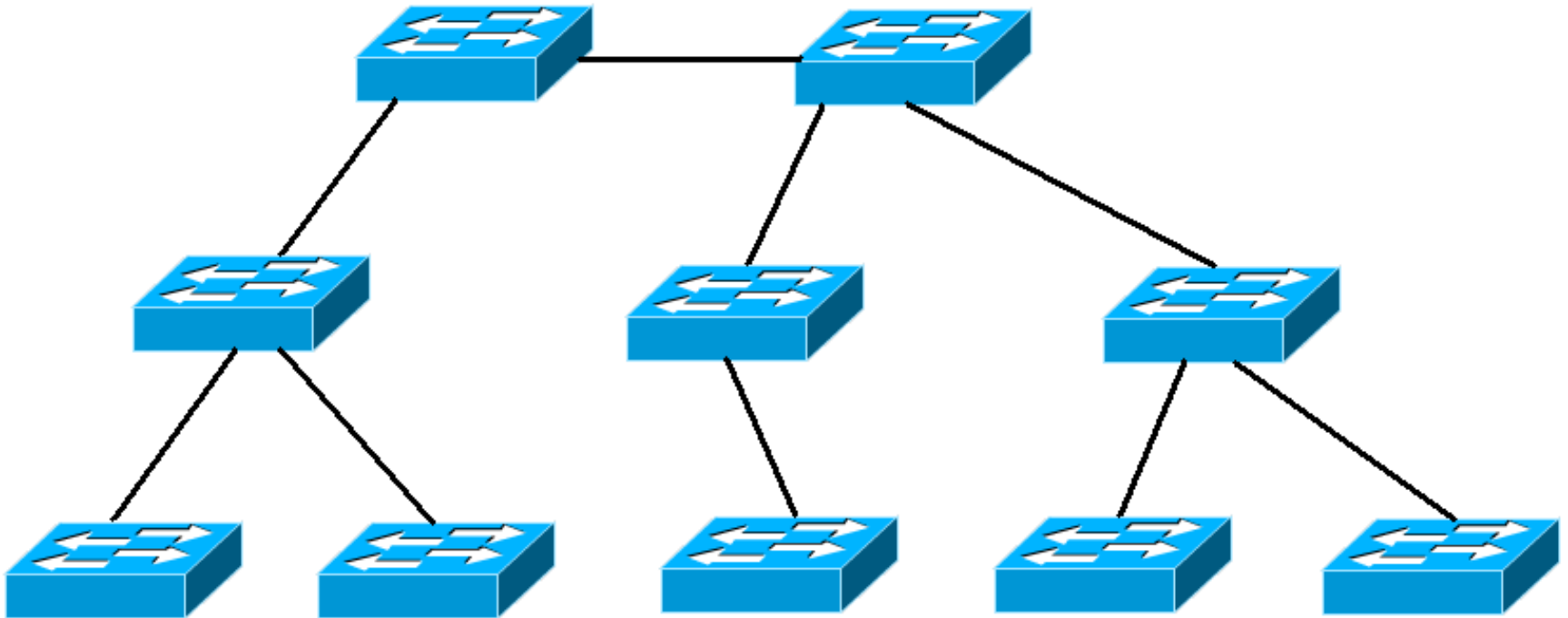
Not a spanning tree

- Not spanning. Device left out.



Spanning tree

- No loops. Includes all devices.



Spanning tree protocol

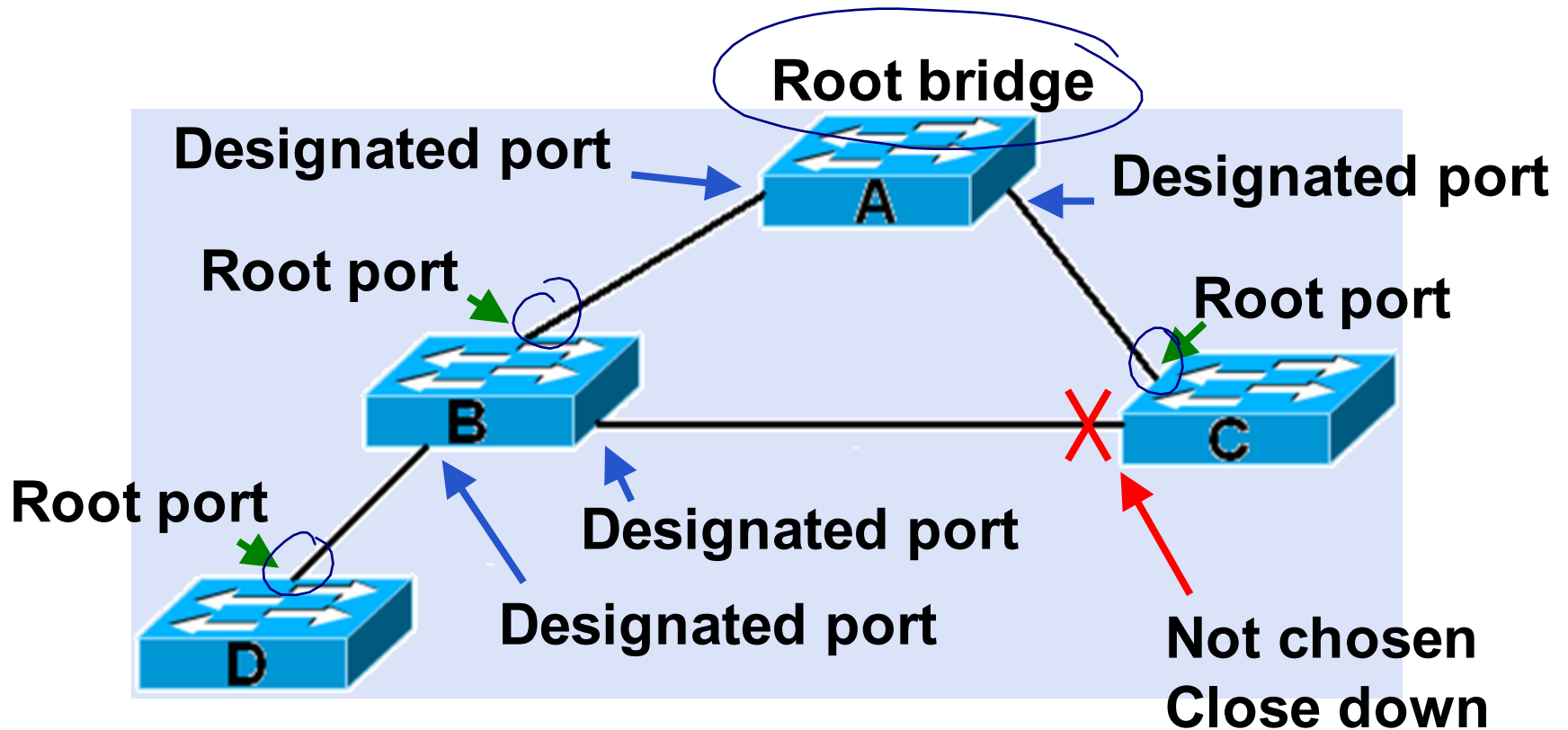
- Used by switches to turn a redundant topology into a spanning tree
- Disables unwanted links by blocking ports
- STP defined by IEEE 802.1d
- Rapid STP defined by IEEE 802.1w
- Switches run STP by default – no configuration needed.

Spanning tree algorithm

The switches use this algorithm to decide which ports should be shut down.

1. Choose one switch to be “root bridge”
2. Choose a “root port” on each other switch
3. Choose a “designated port” on each segment.
4. Close down all other ports.

Outline of process



1 Choose the root bridge

- Each switch has a bridge ID (BID) of priority value followed by MAC address
- Switches exchange Bridge Protocol Data Units (BPDUs) to compare bridge IDs
- The switch with the **lowest** bridge ID becomes the root bridge
- Administrator can set the priority to fix the selection

Bridge ID

- The bridge ID consists of bridge priority, extended system ID, and MAC address
- By default the priority is 32768
- Lowest priority wins
- Value 1 - 65536, multiples of 4096
- Extended system ID identifies VLAN.
- MAC address used if priority is the same. Better not to rely on MAC address.

Configure priority

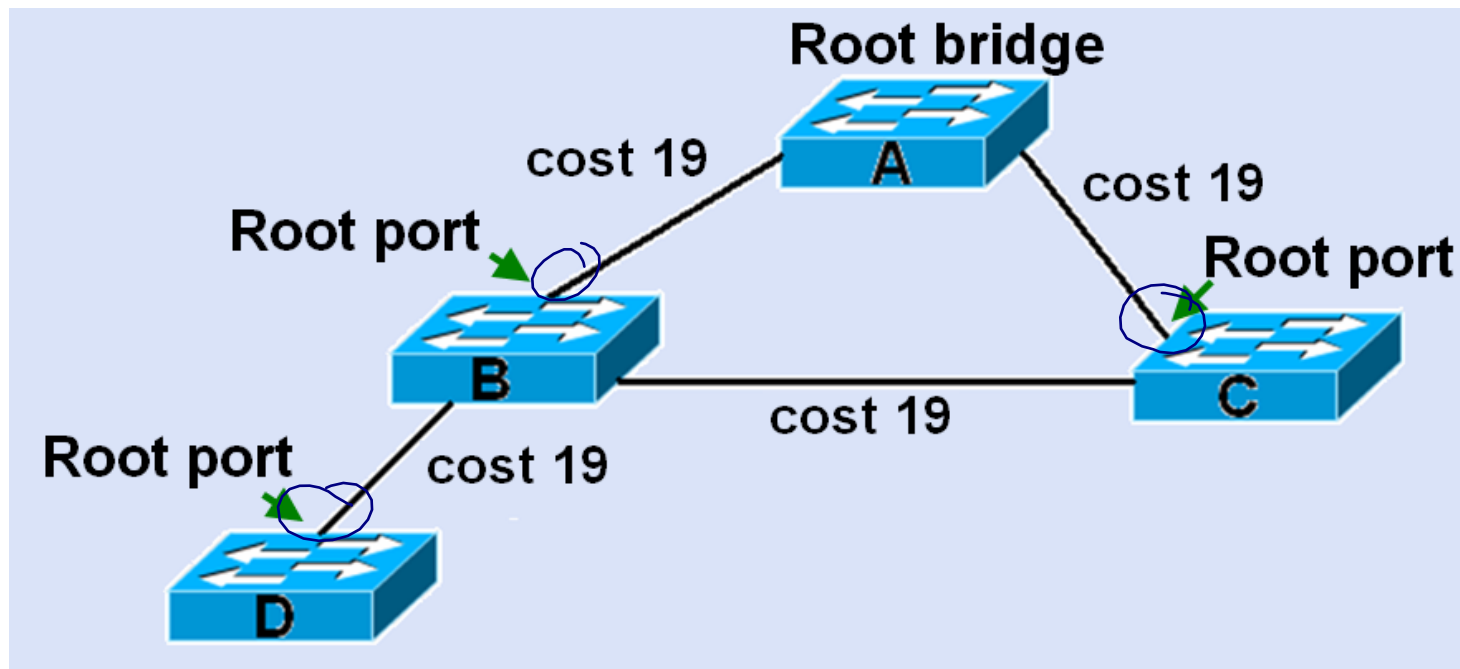
- Set priority directly
- **SW1#spanning-tree vlan 1 priority 24576**
- Or indirectly
- **SW1#spanning-tree vlan 1 root primary**
- Sets value to 24576 or 4096 less than lowest priority detected.
- **SW1#spanning-tree vlan 1 root secondary**
- Sets value to 28672. This switch should become the root bridge if the primary root bridge fails.

1 Choose the root bridge

- A switch starts up. It sends out BPDU frames containing the switch BID and the root ID every 2 seconds.
- At first each switch identifies itself as the root bridge.
- If a switch receives a BPDU with a lower BID then it identifies the switch with that BID as root bridge. It passes on this information in its own BPDUs.
- Eventually all switches agree that the switch with the lowest BID is the root bridge.

Select root ports

- Every non-root bridge (Switch) selects a root port
- This is the port with the lowest cost path to the root bridge



Finding the cost of a link

- Default port costs depend on the speed of the link. Set by IEEE.
- Costs may change as faster Ethernet is developed.

Link speed	Revised cost	Previous cost
10 Gbps	2	1
1 Gbps	4	1
100 Mbps	19	10
10 Mbps	100	100

Changing the cost of a link

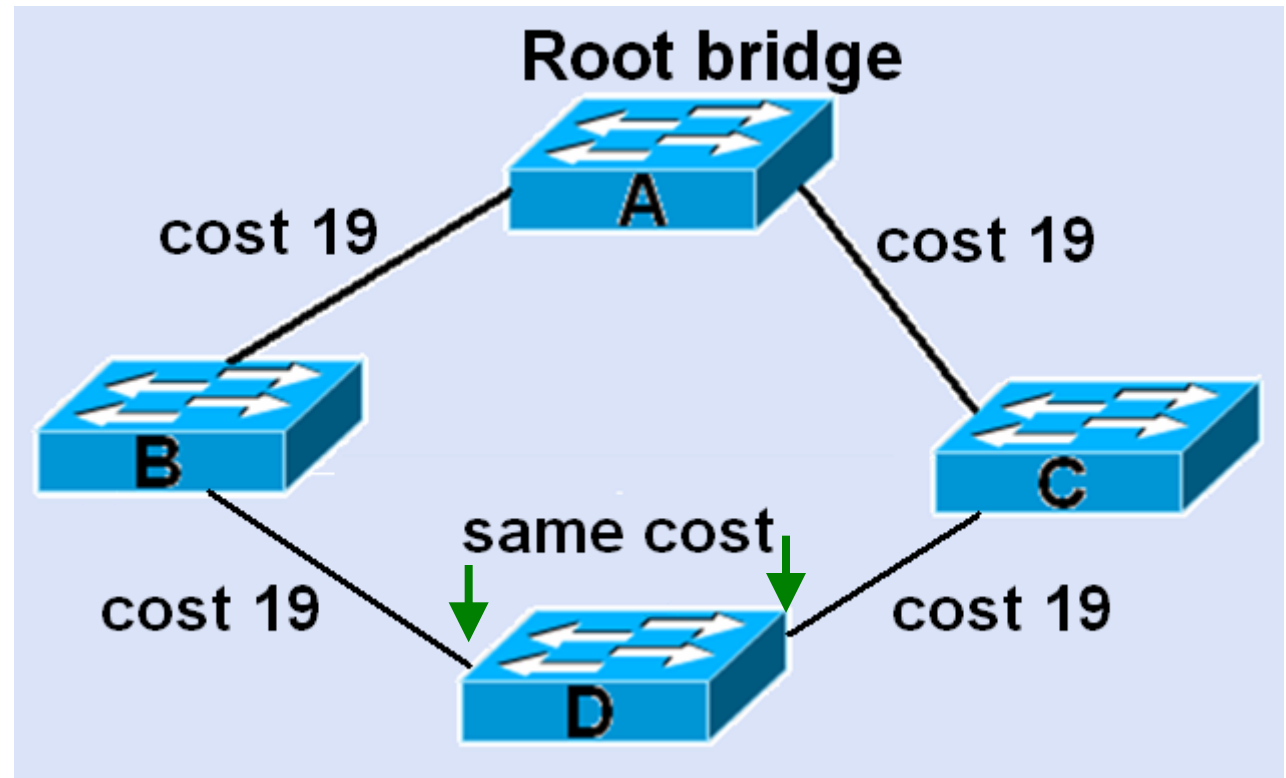
- **SW1(config)#int fa0/1**
 - **SW1(config-if)#spanning-tree cost 25**
 - **SW1(config-if)#end**
-
- **SW1(config)#int fa0/1**
 - **SW1(config-if)#no spanning-tree cost**
 - **SW1(config-if)#end**

What if ports have the same cost?

- Use the port priority and port number.

- By default
F0/1 has
128.1
F0/2 has

128.2
↑ priority ↑ number



Configure port priority

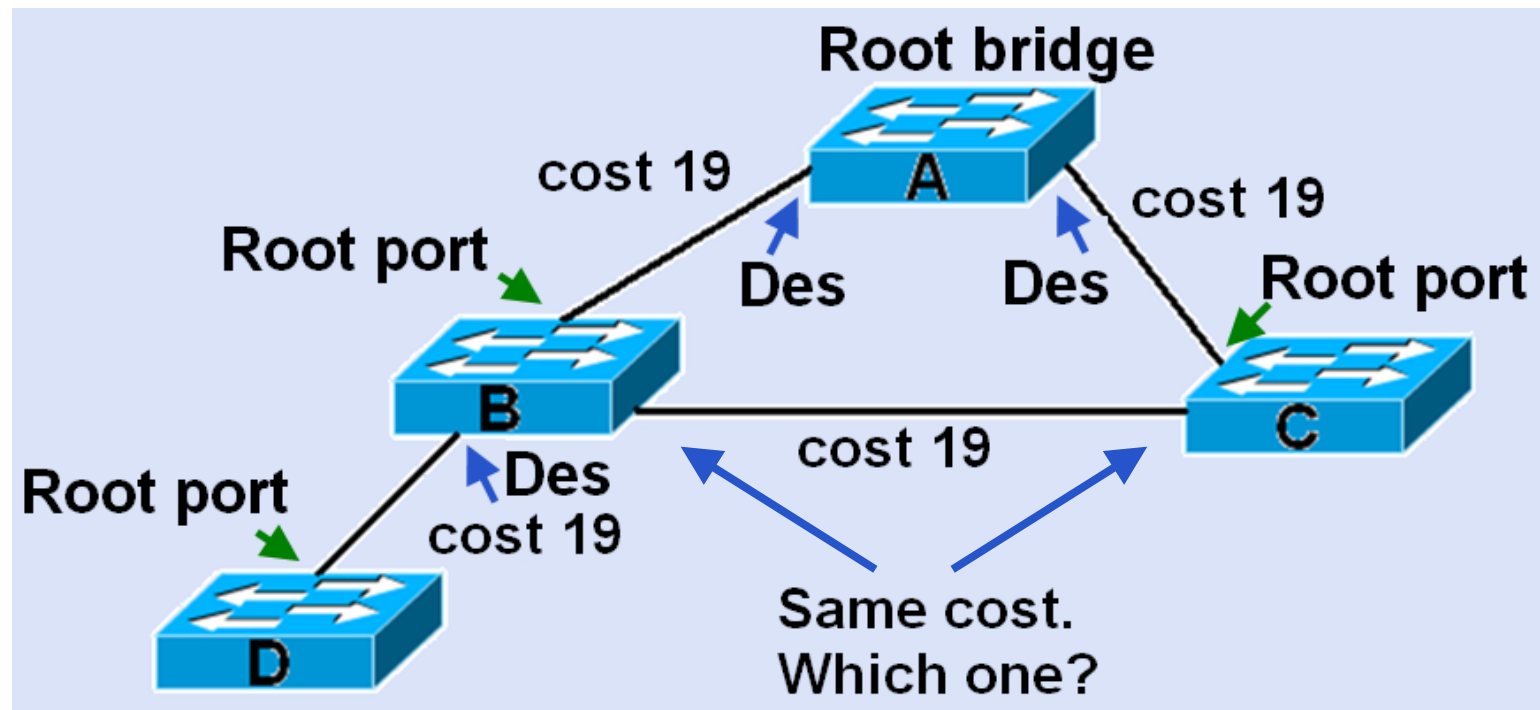
- SW2(config-if)#spanning-tree port-priority 112
- Priority values range from 0 - 240, in increments of 16.
- The default port priority value is 128.
- Lower port priority value wins.
- Default port priority is 128.
- Losing port is shut down.

Passing cost information

- Each BPDU includes the cost of the path back to the root bridge.
- The cost is the total cost of all the links.
- As a switch receives a BPDU, it updates the cost by adding on the cost of the port through which the BPDU was received.

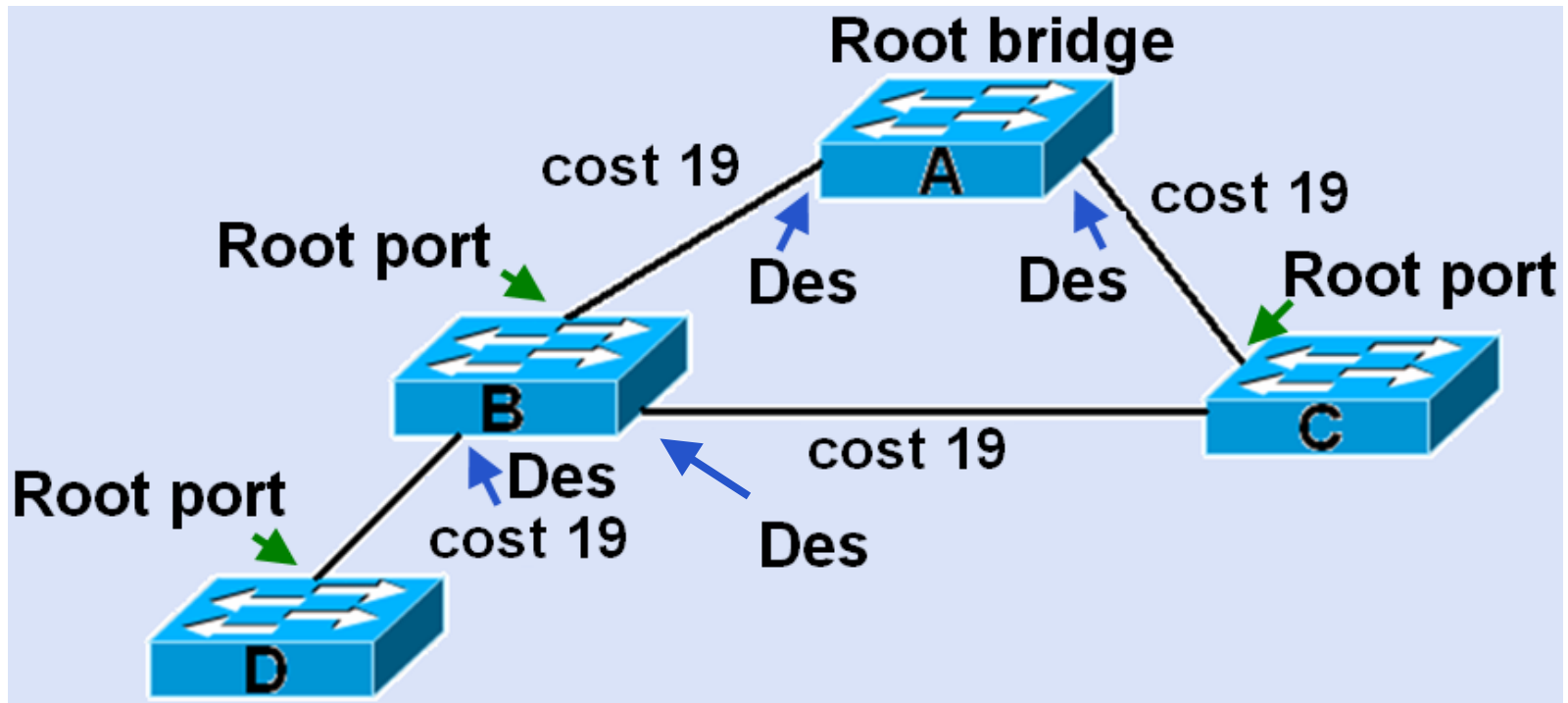
Select designated ports

- On every ^{link} segment, the port with the lowest cost path to the root bridge becomes the designated port



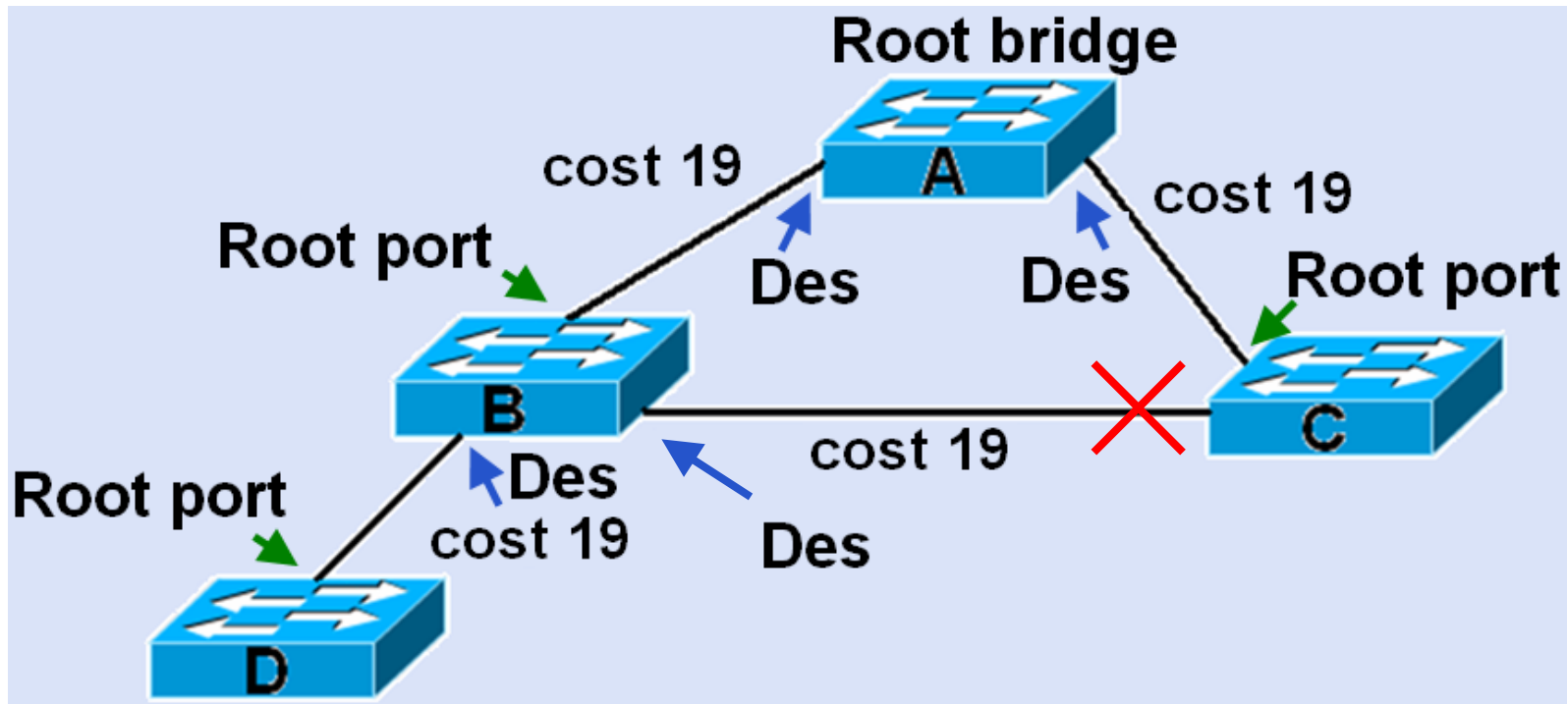
Designated port if same cost

- Choose the port on the switch with the lower bridge ID. Suppose this is switch B.



Close down redundant links

- Any port that is not a root port or a designated port is put in blocking state



BPDU

- The BPDU message is encapsulated in an Ethernet frame.
- The destination MAC address is 01:80:C2:00:00:00, which is a multicast address for the spanning-tree group.

BPDU fields

2 bytes	Protocol ID	Admin
1 byte	Version	
1 byte	Message type	
1 byte	Flags	
8 bytes	Root ID	BID and path information
4 bytes	Cost of path	
8 bytes	Bridge ID	
2 bytes	Port ID	
2 bytes	Message age	Timers
2 bytes	Max age	
2 bytes	Hello time	
2 bytes	Forward delay	

Port roles

- STP makes ports:
- Root ports (forwarding)
- Designated ports (forwarding)
- Non-designated ports (shut down)

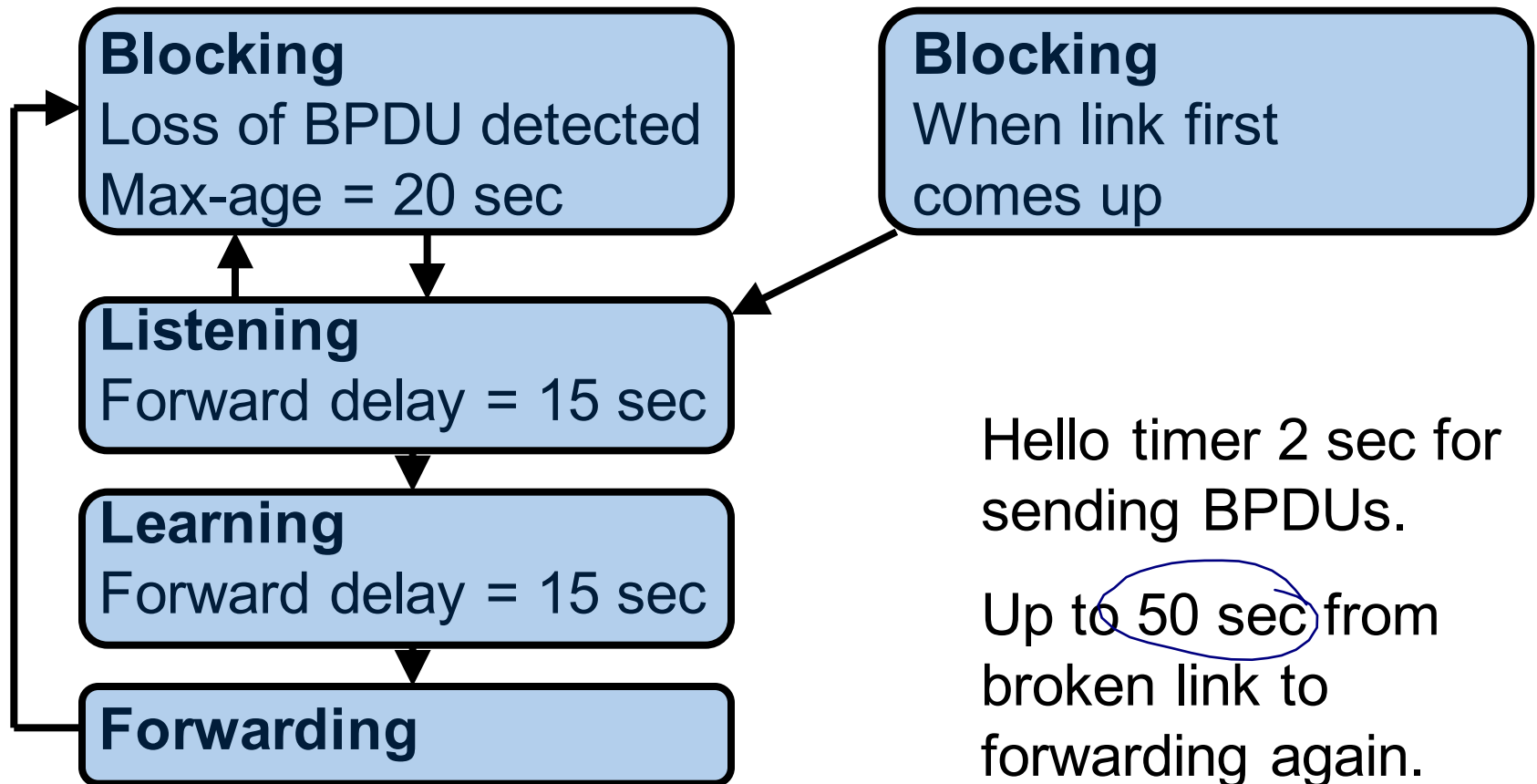
Port states in traditional STP

after STP completes

- **Blocking** – receives and transmits BPDU frames.
- Listening - receives and transmits BPDU frames.
- Learning - receives and transmits BPDU frames.
Learns MAC addresses.
- **Forwarding** – Fully active, forwards user data.
- Disabled – Administratively shut down.

in operation

States and timers



BPDU timers

- Timers are optimised for a 7-switch diameter network.
- The network has time to converge before switches forward user data.
- Timers should not be adjusted individually.
- The diameter can be adjusted and this will change all the timers. (Better not.)
- spanning-tree vlan 1 root primary diameter 5

Cisco PortFast

- An access port leading to a workstation or server does not need to go through the STP modes because it will not be closed down.
- PortFast allows the port to go directly from blocking to forwarding.
- If a switch is connected later and the port receives a BPDU then can go to blocking and then through the modes.

Verify spanning tree

SW2#show spanning tree

VLAN0001

Spanning tree enabled protocol ieee

Root ID Priority 27577

Address 000A.0033.3333

Cost 19

Port 1

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

← Root bridge

Bridge ID Priority 32769 (priority 32768 sys-id-ext 1)

Address 000A.0011.1111

Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Aging time 300

← This switch

Interface	Role	Sts	Cost	Prio.Nbr	Type
F0/1	Root	FWD	19	128.1	Edge P2P
F0/2	Desg	FWD	19	128.2	Edge P2P

Topology change notification (TCN)

- After the network converges, the root bridge sends out BPDUs, but the other switches do not normally send BPDUs back.
- If there is a topology change, a switch sends a special BPDU called the topology change notification (TCN) towards the root bridge.
- Each switch that receives the TCN sends an acknowledgement and sends a TCN towards the root bridge until the root bridge receives it.
- The root bridge then sends out BPDUs with the topology change (TC) bit set.

STP developments

Cisco Proprietary

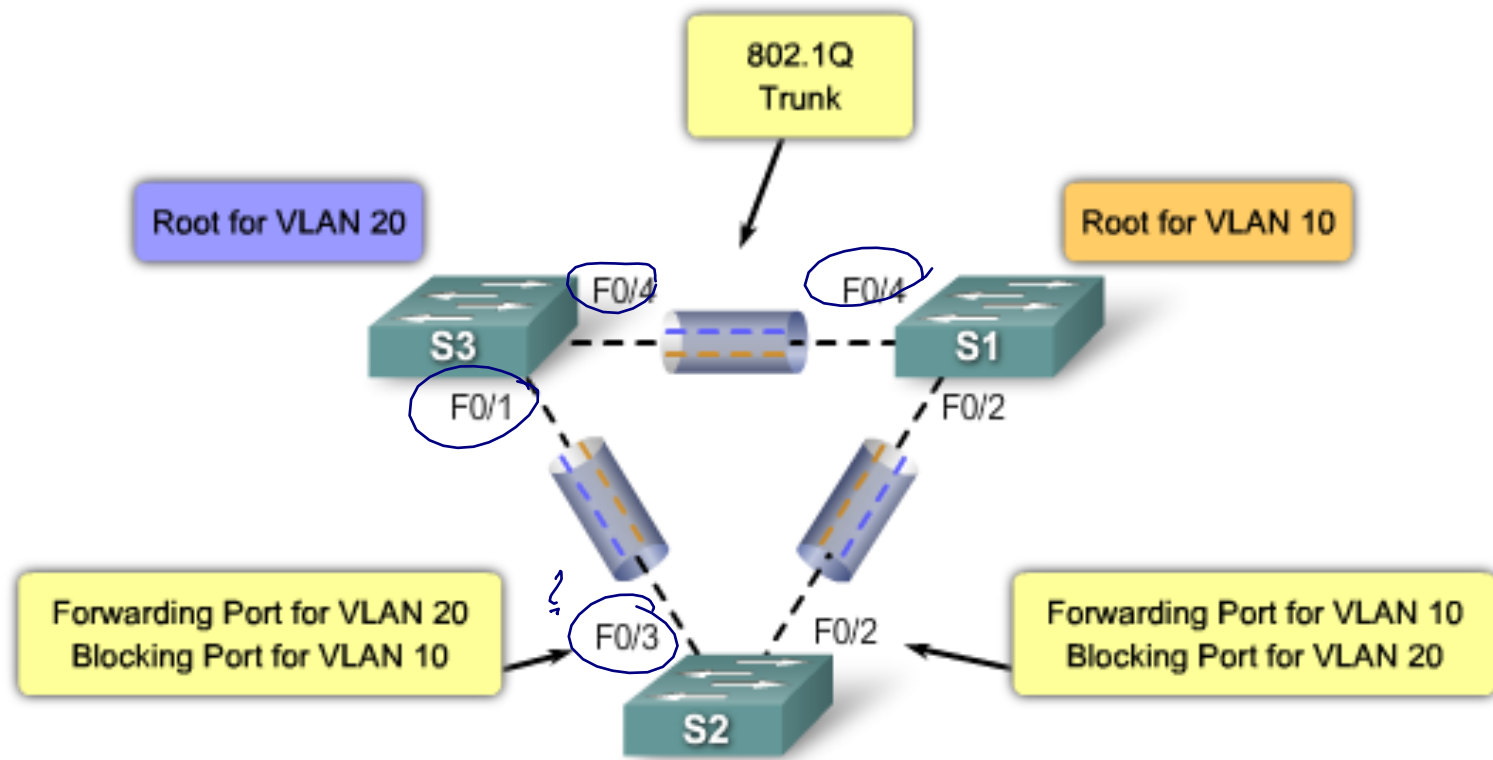
- Per-VLAN spanning tree protocol (PVST).
- Per-VLAN spanning tree protocol plus (PVST+) - supports IEEE 802.1Q
- Rapid per-VLAN spanning tree protocol (rapid PVST+)

IEEE Standards

- Rapid spanning tree protocol (RSTP) -
- Multiple STP (MSTP) -

PVST+

- Separate STP for each VLAN



PVST+

- PVST+ is the default spanning-tree configuration for a Catalyst 2960 switch.
- The VLAN needs to be identified, so each BID has 3 fields: priority, extended system ID field, containing VID, MAC address.
- Original BID just had priority, MAC address

Rapid Spanning Tree Protocol

- Supersedes STP but compatible with it.
- Much faster to converge.
- Same BPDU structure, puts 2 in version field.
- Sends BPDUs every 2 seconds.
- Different port roles and states.
- Does not use timers in the same way.
- 3 missed BPDUs taken to mean loss of the link. (6 seconds)

Edge port in RSTP

- A port that will never connect to a switch.
- Immediately goes to forwarding state.
- Same idea as Cisco's PortFast.
- Configuring an edge port uses the PortFast keyword as before.
- **spanning-tree portfast**
- An edge port becomes a normal spanning-tree port if it receives a BPDU

Link types

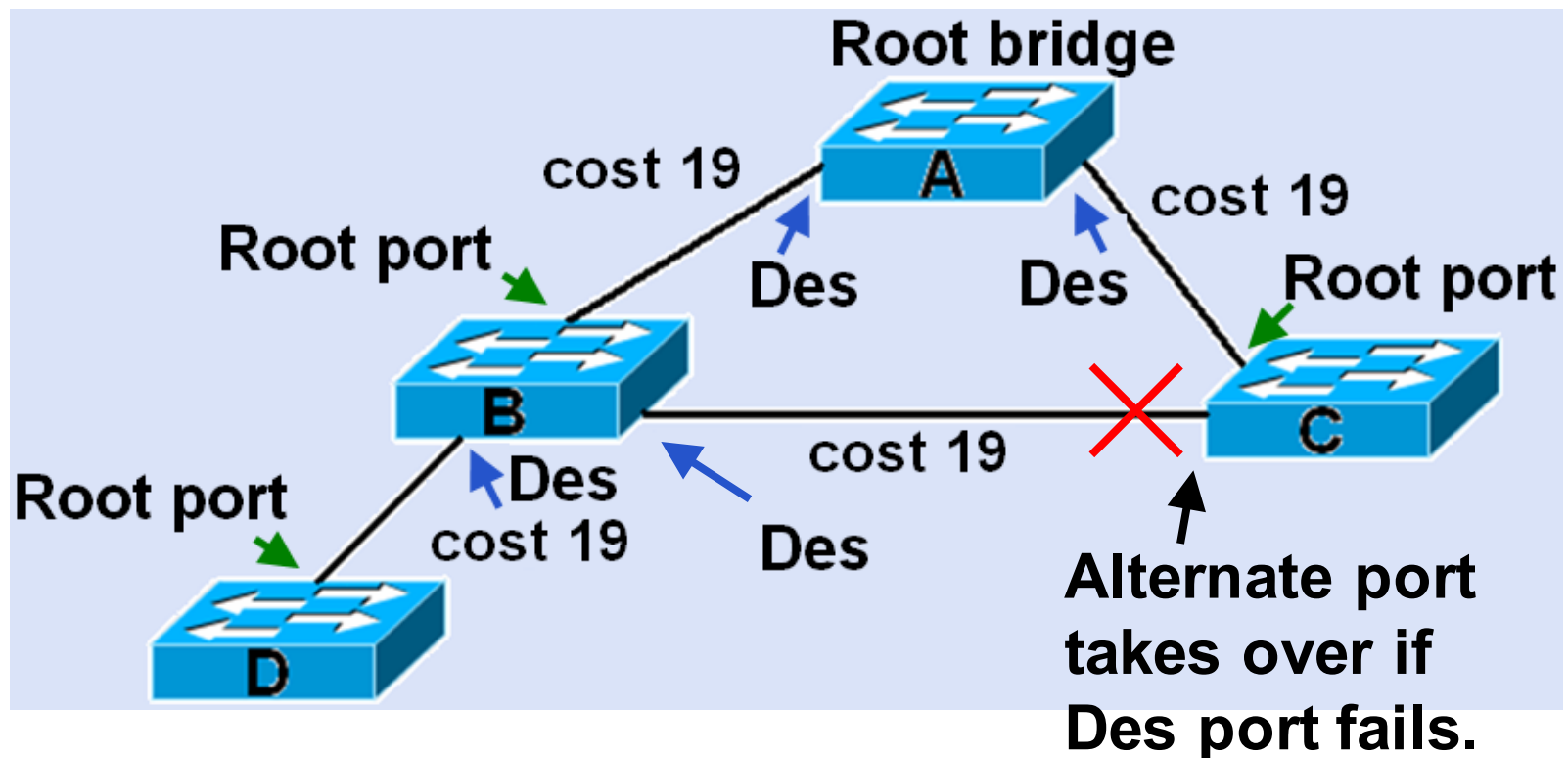
- A link operating in full duplex between two switches is regarded as a **point-to-point** link.
- A link operating in half duplex is regarded as a **shared** link.
- Ports on a point-to-point link are able to move to forwarding state quickly.

Port states

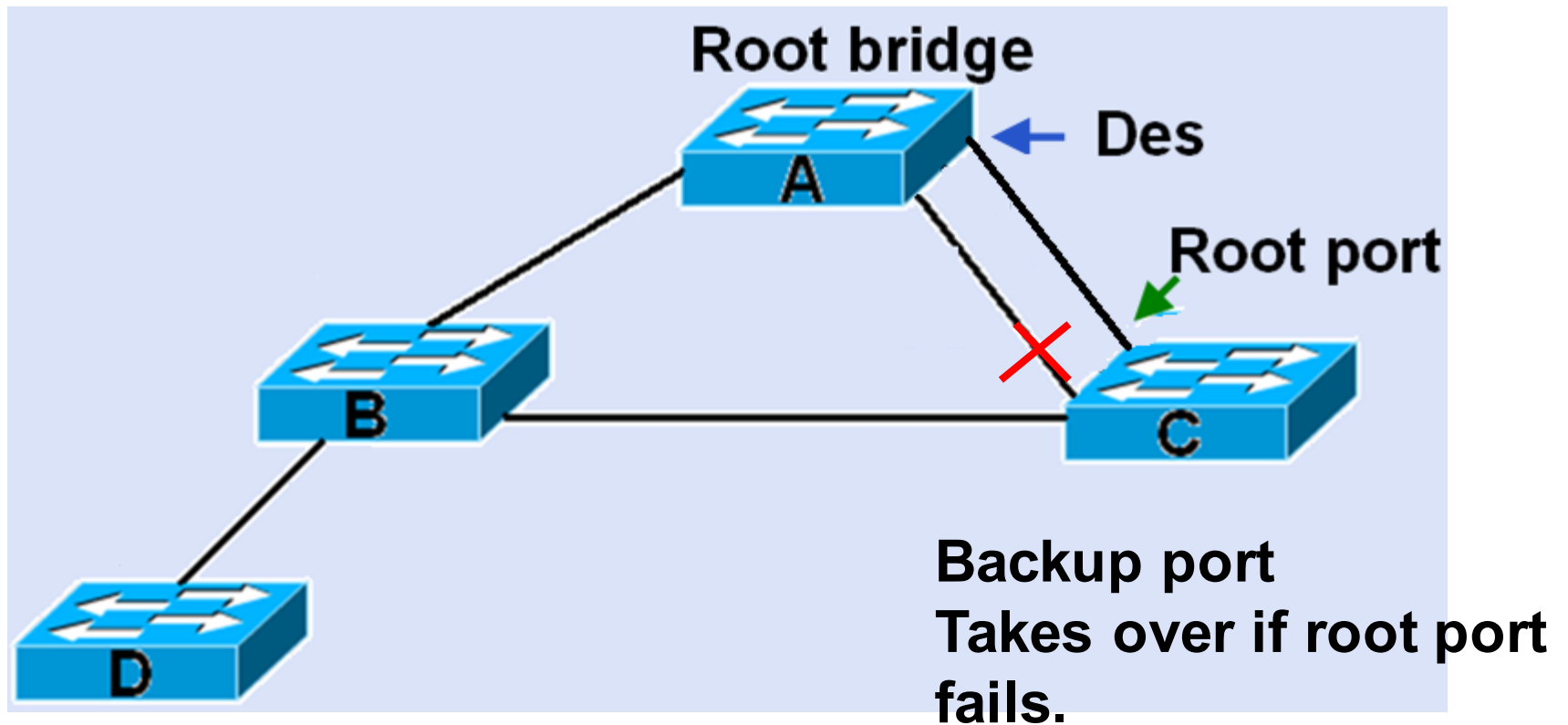
Operational	STP	RSTP
Enabled	Blocking	Discarding
Enabled	Listening	Discarding
Enabled	Learning	Learning
Enabled	Forwarding	Forwarding
Disabled	Disabled	Discarding

RSTP port roles

- Root and designated ports as before.



RSTP port roles



RSTP port roles

Forwarding

- Root port
- Designated port
- Edge port – not to switch

Discarding

- Backup port
- Alternate port
- Both are closed down but are ready to take over at once



Design considerations

- Root bridge should be a powerful switch in the centre of the network.
- Minimise the number of ports that need to be shut down by STP.
- Use VTP pruning.
- Use layer 3 switches in the core.
- Keep STP running even if no ports need to be shut down.

The End