LAN Technology

Other Protocols

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Other Protocols

Outlines:

- FDDI: Fiber Distributed Data Interface
- Token Ring: IEEE 802.5 LAN Protocol
- LLC: Logic Link Control (IEEE 802.2)
- SNAP: Sub-Network Access Protocol
- STP: Spanning Tree Protocol (IEEE 802.1D)

Redundancy

Achieving such a goal requires extremely reliable networks.

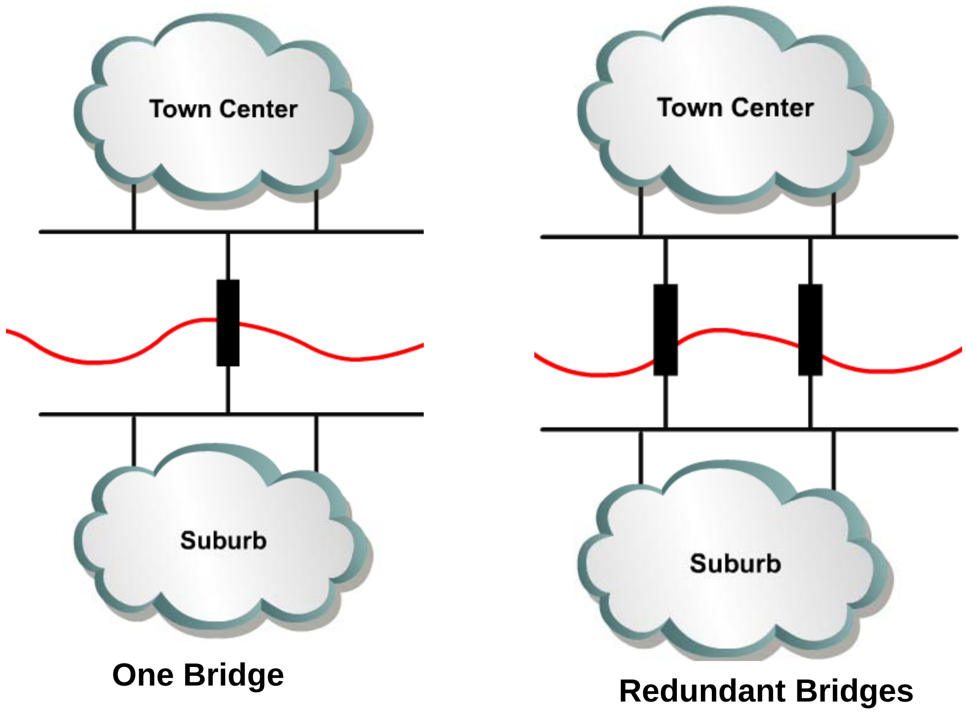
Reliability in networks is achieved by reliable equipment and by designing networks that are tolerant to failures and faults.

The network is designed to reconverge rapidly so that the fault is bypassed.

Fault tolerance is achieved by redundancy.

Redundancy means to be in excess or exceeding what is usual and natural.

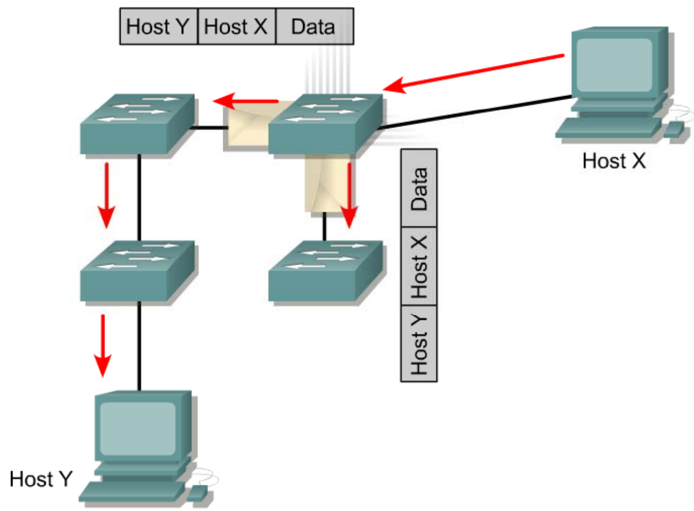
Redundant topologies



A network of roads is a global example of a redundant topology.

If one road is closed for repair there is likely an alternate route to the destination

Types of Traffic

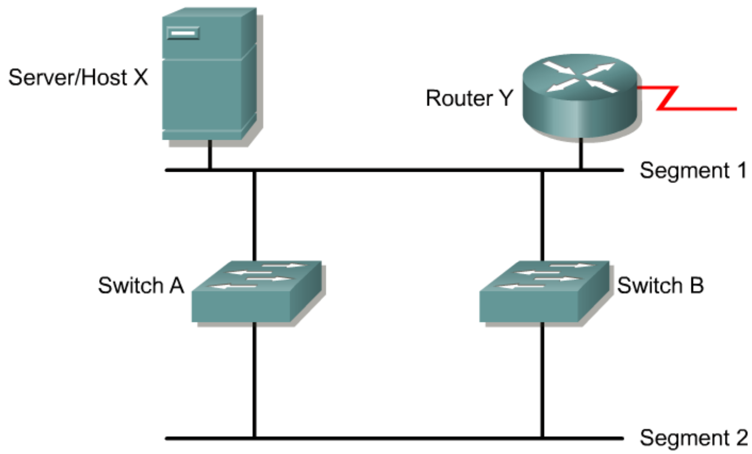


Unknown Unicast

Types of traffic (Layer 2 perspective)

- **Known Unicast**: Destination addresses are in Switch Tables
- **Unknown Unicast**: Destination addresses are <u>not</u> in Switch Tables
- **Multicast**: Traffic sent to a group of addresses
- **Broadcast**: Traffic forwarded out all interfaces except incoming interface.

Redundant switched topologies



Switches learn the MAC addresses of devices on their ports so that data can be properly forwarded to the destination.

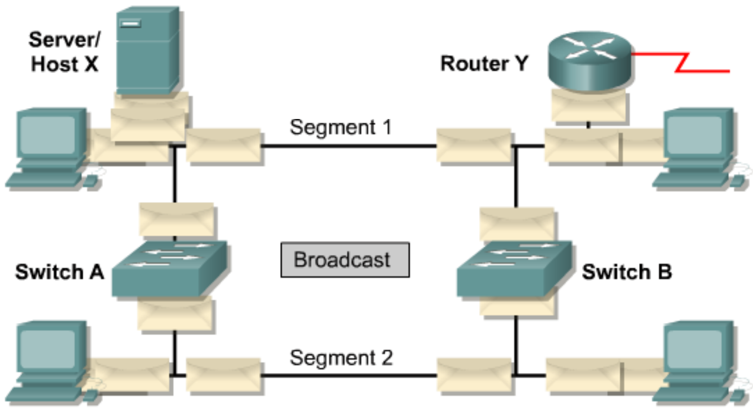
Remember: switches use the Source MAC address to learn where the devices are, and enters this information into their MAC address tables.

Switches will flood frames for unknown destinations until they learn the MAC addresses of the devices.

Broadcasts and multicasts are also flooded. (Unless switch is doing Multicast Snooping or IGMP)

A redundant switched topology ***may*** (STP disabled) cause broadcast storms, multiple frame copies, and MAC address table instability problems.

Broadcast Storm

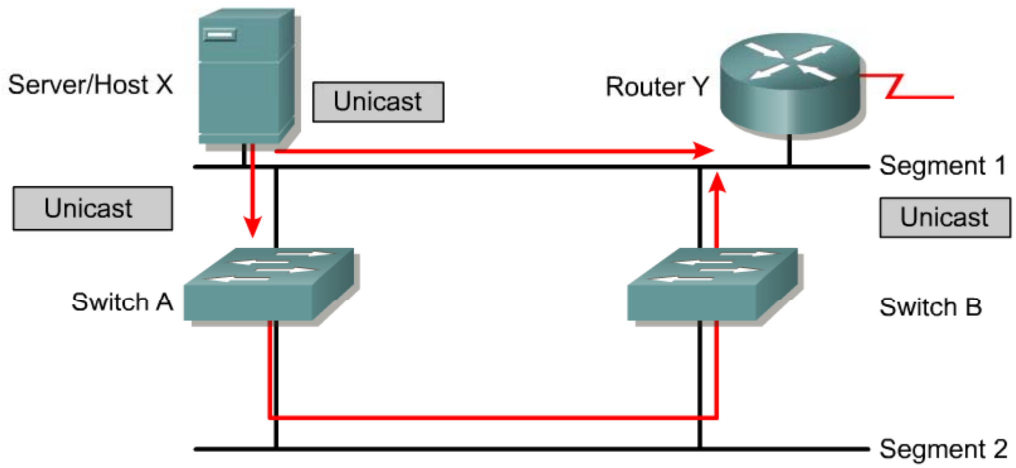


Broadcast storm: *"A state in which a message that has been broadcast across a network results in even more responses, and each response results in still more responses in a snowball effect." www.webopedia.com*

A broadcast storm because Spanning Tree Protocol is not enabled:

- Broadcasts and multicasts can cause problems in a switched network.
- If Host X sends a broadcast, like an ARP request for the Layer 2 address of the router, then Switch A will forward the broadcast out all ports.
- Switch B, being on the same segment, also forwards all broadcasts.
- Switch B sees all the broadcasts that Switch A forwarded and Switch A sees all the broadcasts that Switch B forwarded.
- Switch A sees the broadcasts and forwards them.
- Switch B sees the broadcasts and forwards them.
- The switches continue to propagate broadcast traffic over and over.
- This is called a broadcast storm.

Multiple frame transmissions



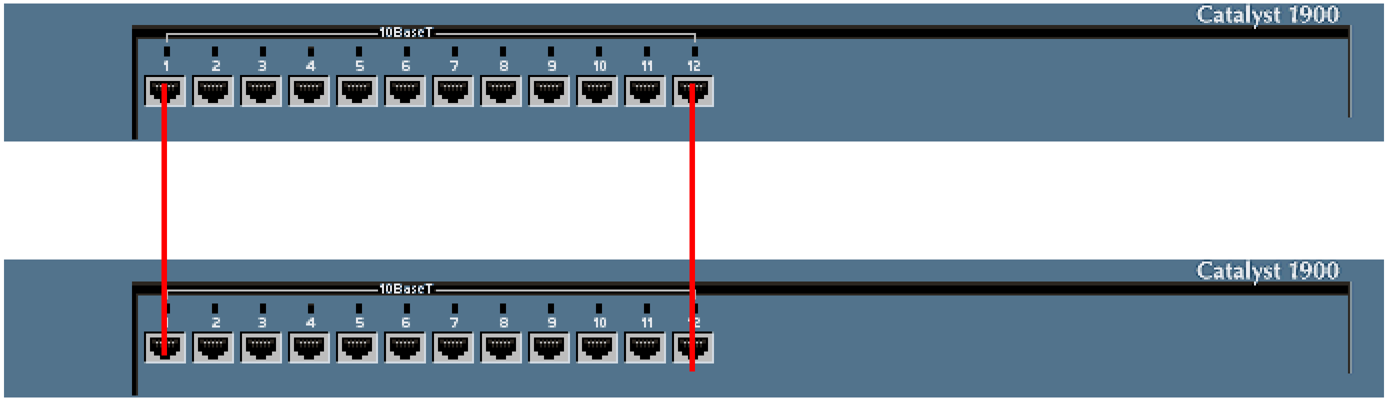
In a redundant switched network it is possible for an end device to receive multiple frames.

Assumptions:

- Spanning Tree Protocol is not enabled
- MAC address of Router Y has been timed out by both switches.
- Host X still has the MAC address of Router Y in its ARP cache

Host X sends a unicast frame to Router Y.

Let’s try it

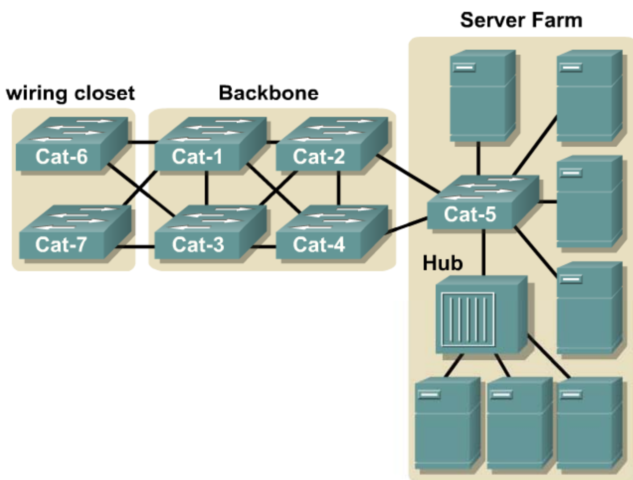


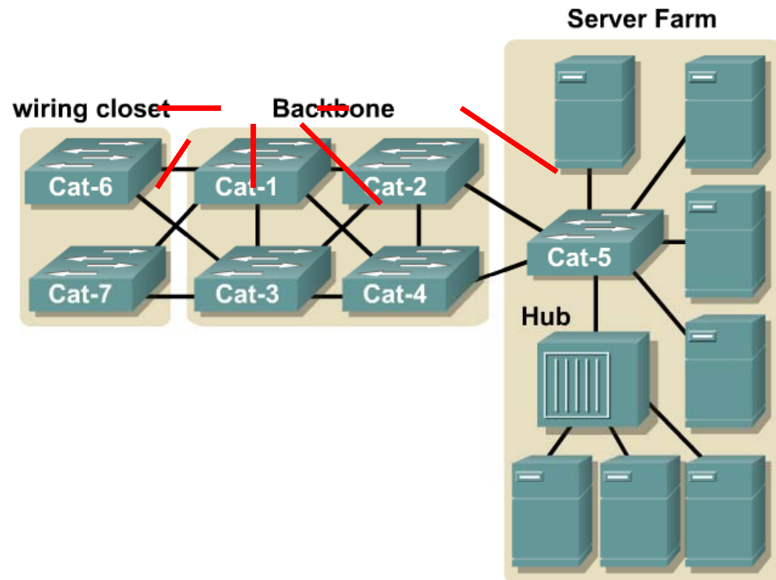
We will connect two switches with two paths

Connect multiple computers

Disable Spanning Tree

Redundant topology and spanning tree



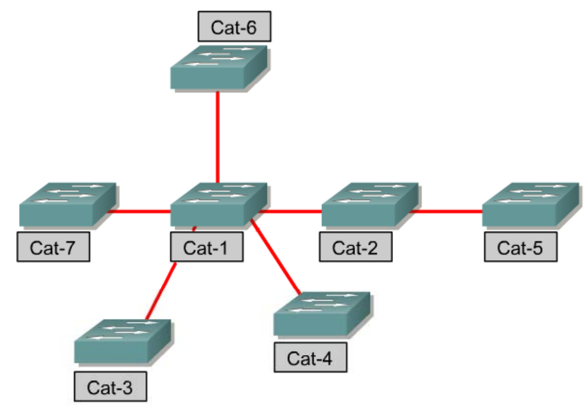


Unlike IP, in the Layer 2 header there is **no Time To Live (TTL).**

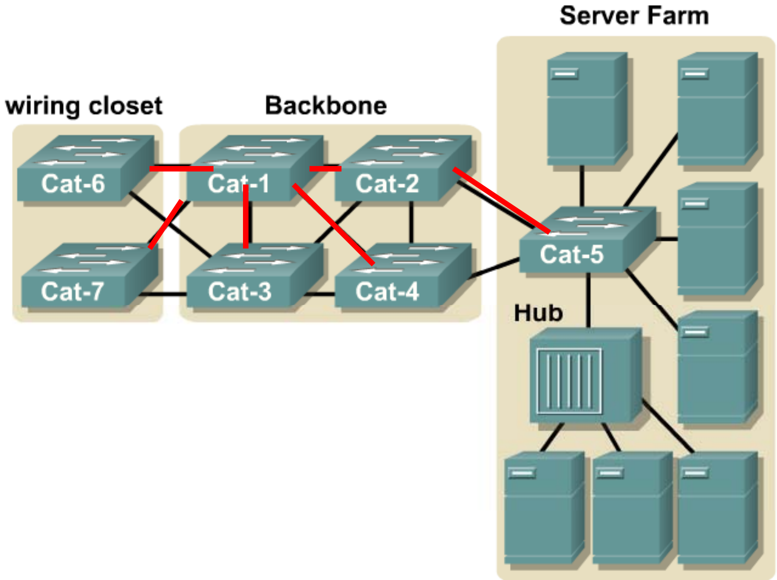
The solution is to **allow physical loops (redundant physical connections) but create a loop free logical topology**.

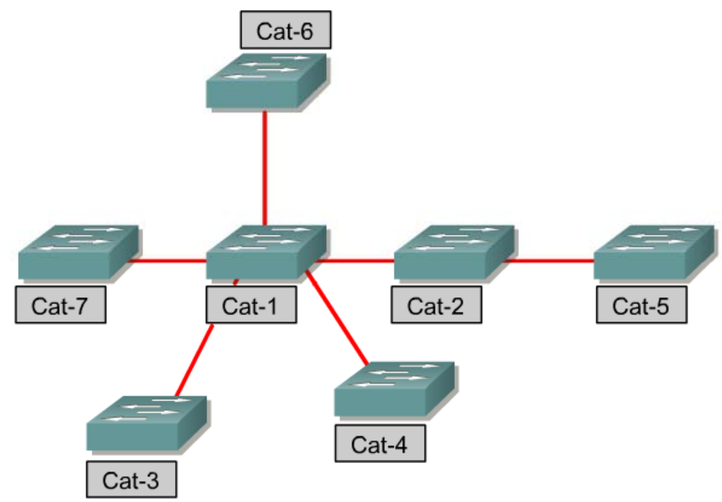
The loop free **logical topology created is called a tree.**

This topology is a star or extended star logical topology, the **spanning tree of the network.**



Redundant topology and spanning tree





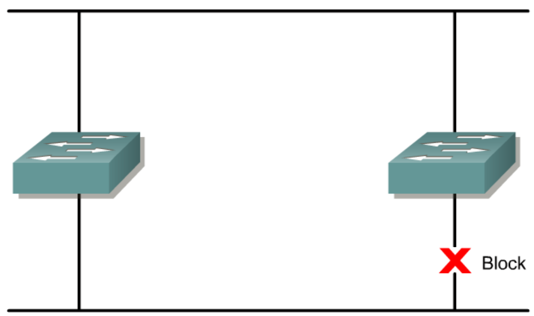
It is a spanning tree because all devices in the network are reachable or spanned.

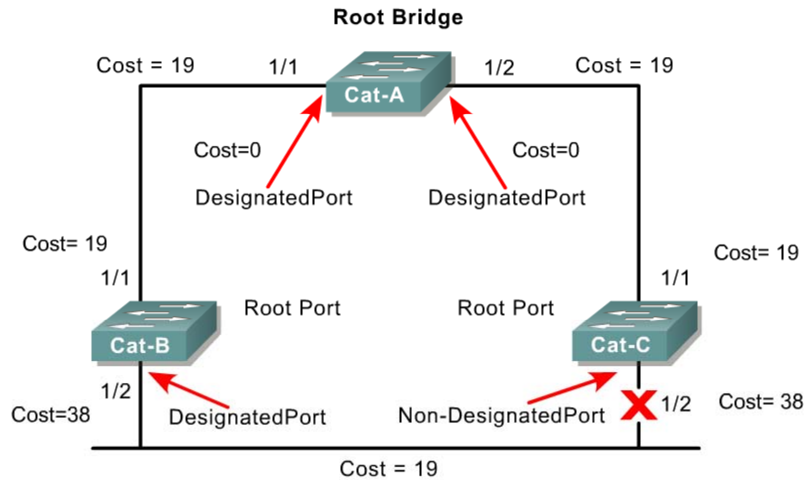
The algorithm used to create this loop free logical topology is the **spanning-tree algorithm**.

This algorithm can take a “relatively” long time to converge.

A new algorithm called the **rapid spanning-tree algorithm** is being introduced to reduce the time for a network to compute a loop free logical topology. (later)

Spanning-Tree Protocol (STP)





We will see how this works in a moment.

Shortest path is based on cumulative link costs.

Link costs are **based on the speed of the link**.

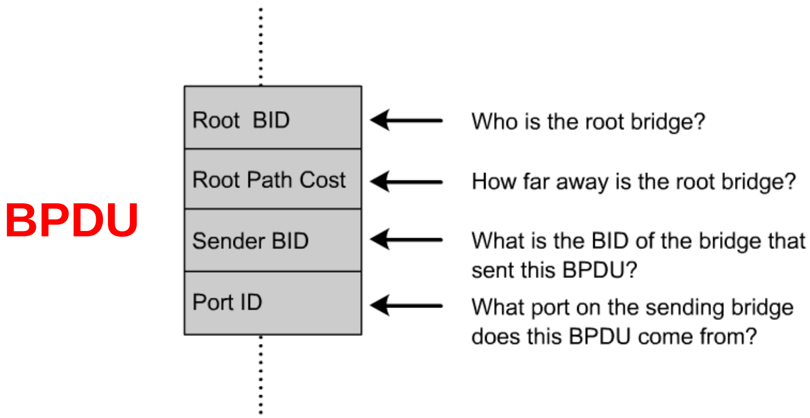
The Spanning-Tree Protocol establishes a root node, called the root bridge.

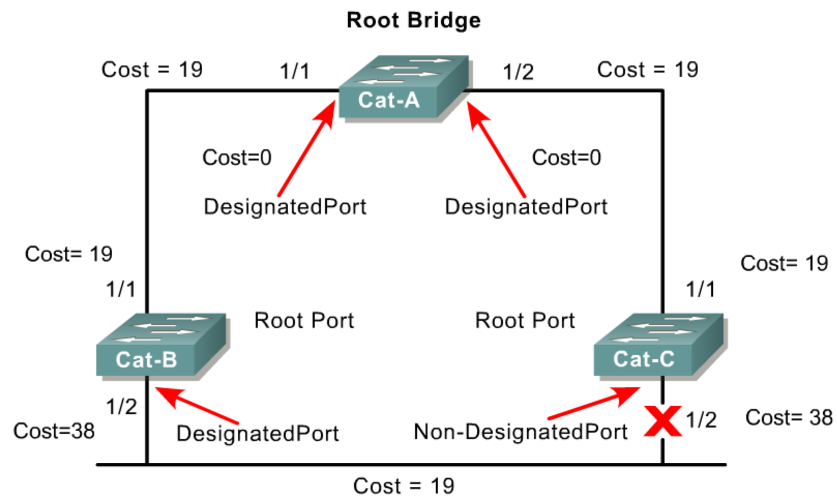
The Spanning-Tree Protocol constructs a topology that has one path for reaching every network node.

The resulting tree originates from the **root bridge**.

Redundant links that are not part of the shortest path tree are **blocked**.

Spanning-Tree Protocol (STP)





It is because certain paths are blocked that a loop free topology is possible.

Data frames received on blocked links are dropped.

The Spanning-Tree Protocol requires network devices to exchange messages to prevent bridging loops, called Bridge Protocol Data Unit (BPDU).

Links that will cause a loop are put into a blocking state.

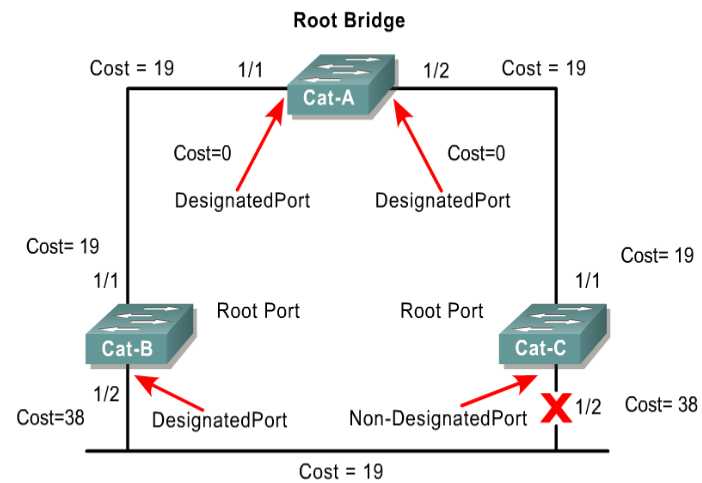
BPDUs continue to be received on blocked ports.

This ensures that if an active path or device fails, a new spanning tree can be calculated.

Spanning-Tree Protocol (STP)

BPDUs contain enough information so that all switches can do the following:

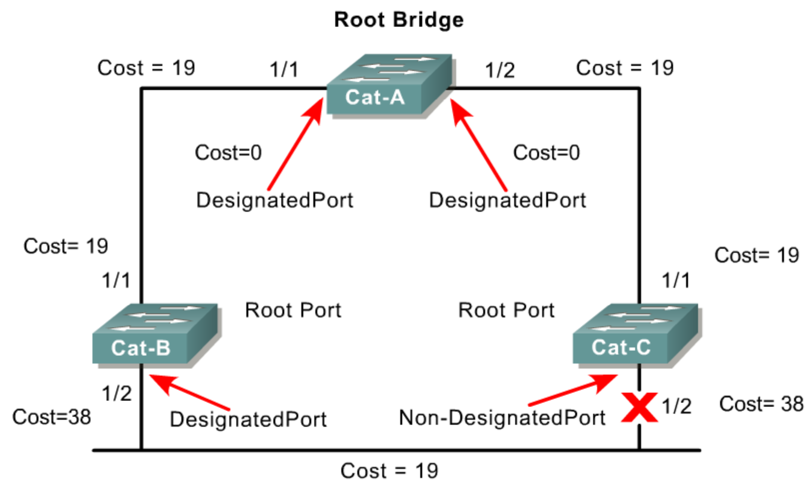
- Select a **single switch that will act as the root** of the spanning tree
- Calculate the **shortest path from itself to the root switch**
- **Designate one of the switches as the closest one to the root**, for each LAN segment. This bridge is called the "**designated switch**".
  - The designated switch handles all communication from that LAN towards the root bridge.
- Choose one of its ports as its root port, for each non-root switch.
  - This is the interface that gives the best path to the root switch.
- Select ports that are part of the spanning tree, the designated ports. Non-designated ports are blocked.



Let's see how this is done!

Some of this is extra information or information explained that is not explained fully in the curriculum.

Two Key Concepts: BID and Path Cost



STP executes an algorithm called Spanning Tree Algorithm (STA).

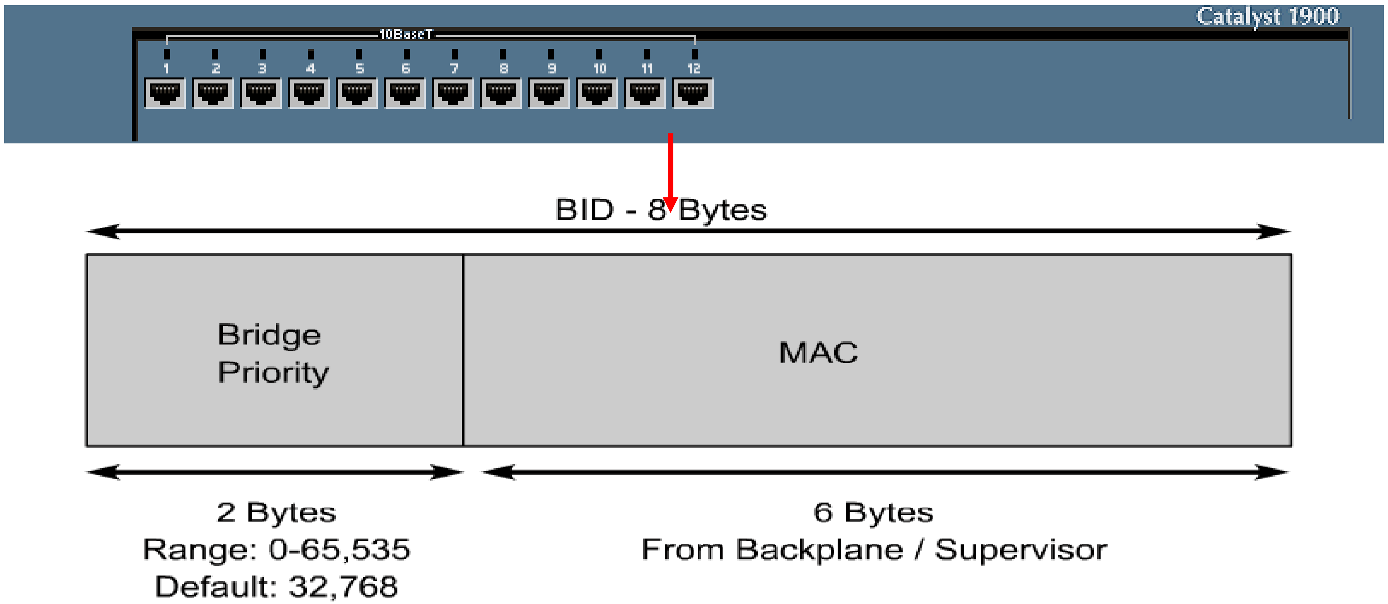
STA chooses a reference point, called a root bridge, and then determines the available paths to that reference point.

- If more than two paths exists, STA picks the best path and blocks the rest

STP calculations make extensive use of two key concepts in creating a loop-free topology:

- **Bridge ID**
- **Path Cost**

Bridge ID (BID)



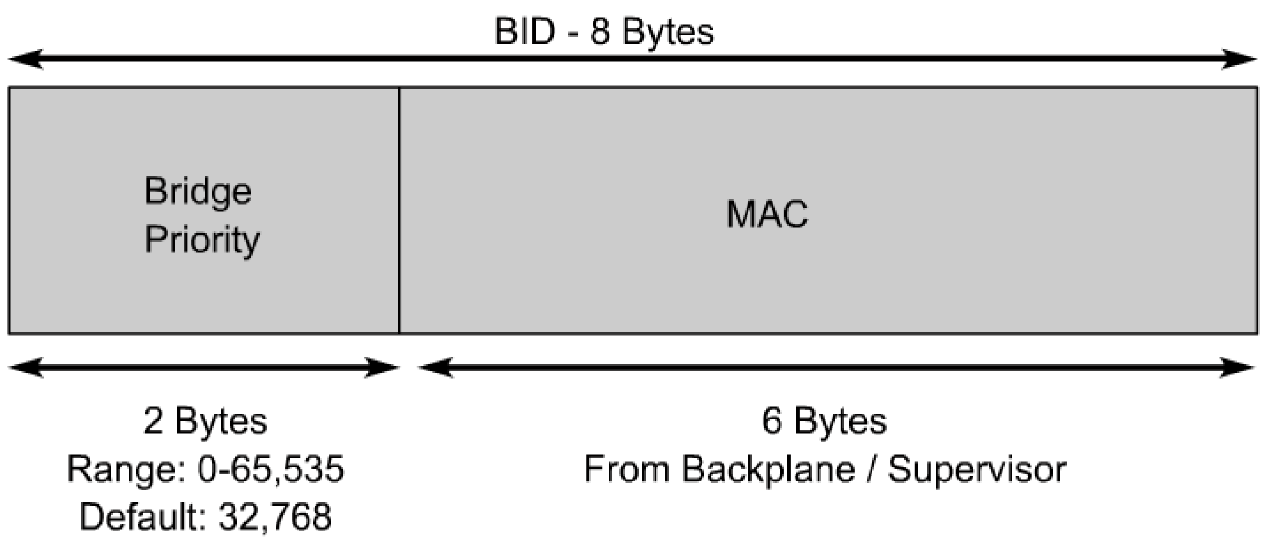
Bridge ID (BID) is used to identify each bridge/switch.

The BID is **used in determining the center of the network**, in respect to **STP**, known as the root bridge.

Consists of two components:

- **A 2-byte Bridge Priority**: Cisco switch defaults to **32,768** or 0x8000.
- **A 6-byte MAC address**

Bridge ID (BID)



Bridge Priority is usually expressed in **decimal format** and the **MAC address** in the BID is usually expressed in **hexadecimal format**.

BID is used to elect a root bridge (coming)

Lowest Bridge ID is the root.

If all devices have the same priority, the bridge with the lowest MAC address becomes the root bridge. (Yikes!)

Bridge ID (BID)

```
ALSwitch#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32768
             Address     0003.e334.6640
             Cost        19
             Port        23 (FastEthernet0/23)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     000b.fc28.d400
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface        Port ID                     Designated                   Port ID
Name             Prio.Nbr      Cost Sts      Cost Bridge ID               Prio.Nbr
---------------- -------- --------- --- --------- -------------------- --------
Fa0/23           128.23          19 FWD         0 32768 0003.e334.6640 128.25

ALSwitch#
```

Path Cost

Link Speed	Cost(Revised IEEE Spec)	Cost (Previous IEEE Spec)
10 Gbps	2	1
1 Gbps	4	1
100 Mbps	19	10
10 Mbps	100	100

Bridges use the concept of cost to evaluate how close they are to other bridges.
This will be used in the STP development of a loop-free topology .
Originally, 802.1d defined cost as **1000/bandwidth** of the link in Mbps.

Cost of 10Mbps link = 100 or 1000/10

Cost of 100Mbps link = 10 or 1000/100

Cost of 1Gbps link = 1 or 1000/1000

Running out of room for faster switches including 10 Gbps Ethernet.

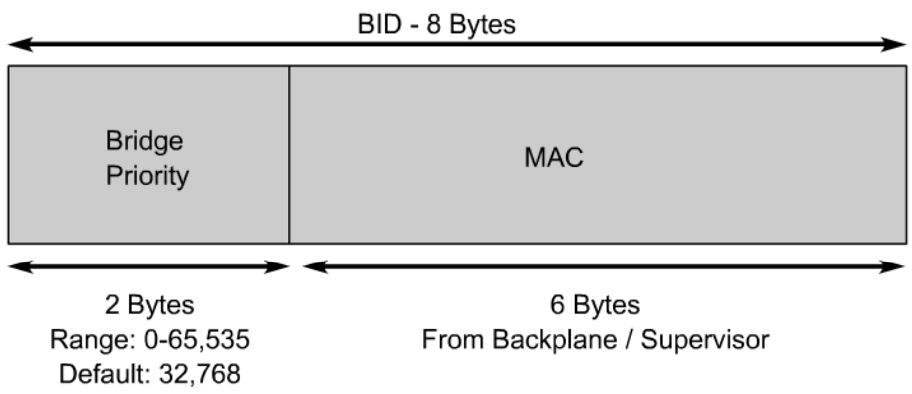
Path Cost

Link Speed	Cost(Revised IEEE Spec)	Cost (Previous IEEE Spec)
10 Gbps	2	1
1 Gbps	4	1
100 Mbps	19	10
10 Mbps	100	100

IEEE modified the most to use a **non-linear scale** with the new values of:

4 Mbps	250	(cost)
10 Mbps	100	(cost)
16 Mbps	62	(cost)
45 Mbps	39	(cost)
100 Mbps	19	(cost)
155 Mbps	14	(cost)
622 Mbps	6	(cost)
1 Gbps	4	(cost)
10 Gbps	2	(cost)

Path Cost



Link Speed	Cost(Revised IEEE Spec)	Cost (Previous IEEE Spec)
10 Gbps	2	1
1 Gbps	4	1
100 Mbps	19	10
10 Mbps	100	100

You can modify the path cost by modifying the cost of a port.

`Switch(config-if)# spanning-tree cost` *`value`*

Exercise caution when you do this!

BID and Path Cost are used to develop a loop-free topology .

Coming very soon!

But first the **Four-Step STP Decision Sequence**

Three Steps of Initial STP Convergence

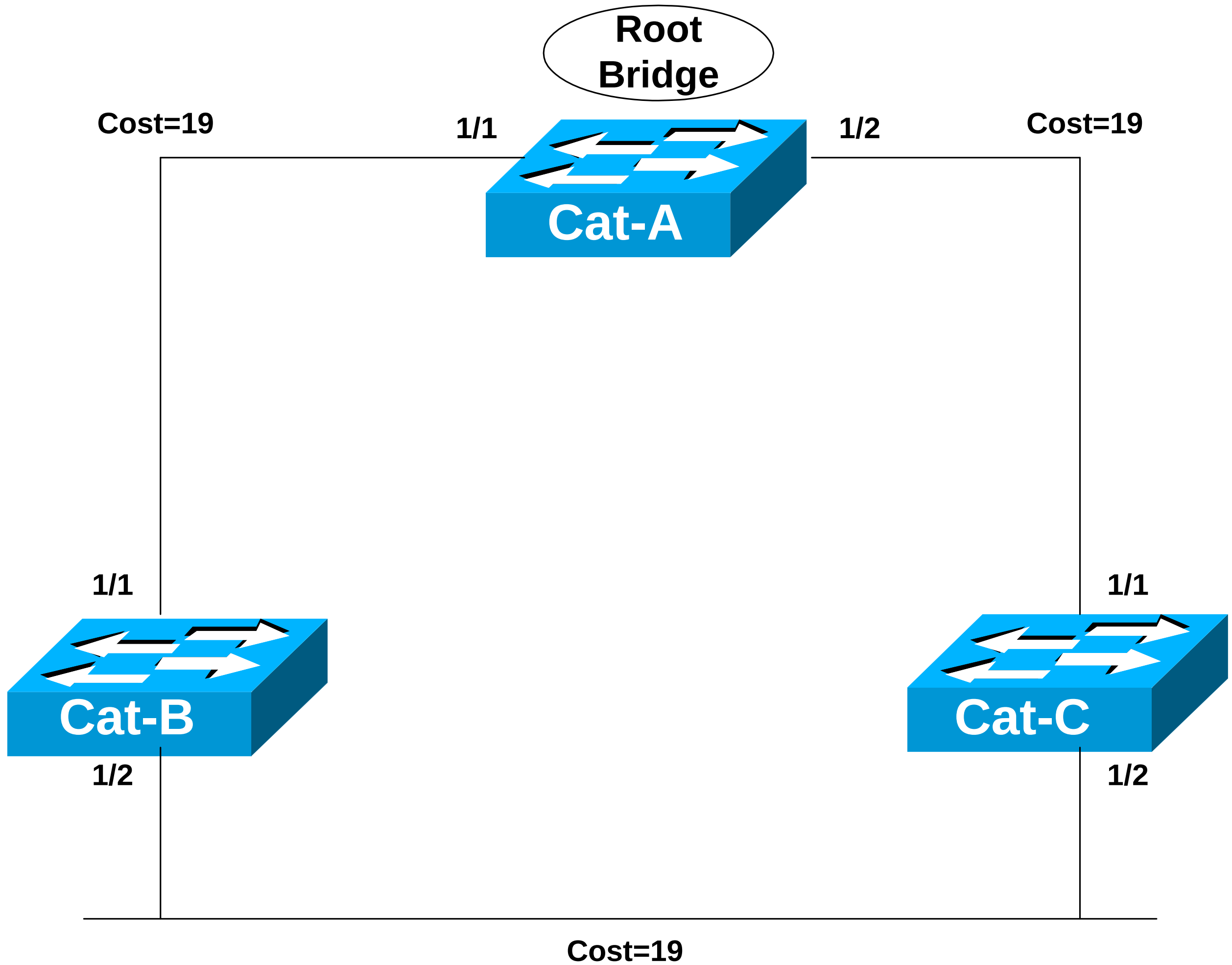
<u>STP Convergence</u>

Step 1 Elect one Root Bridge

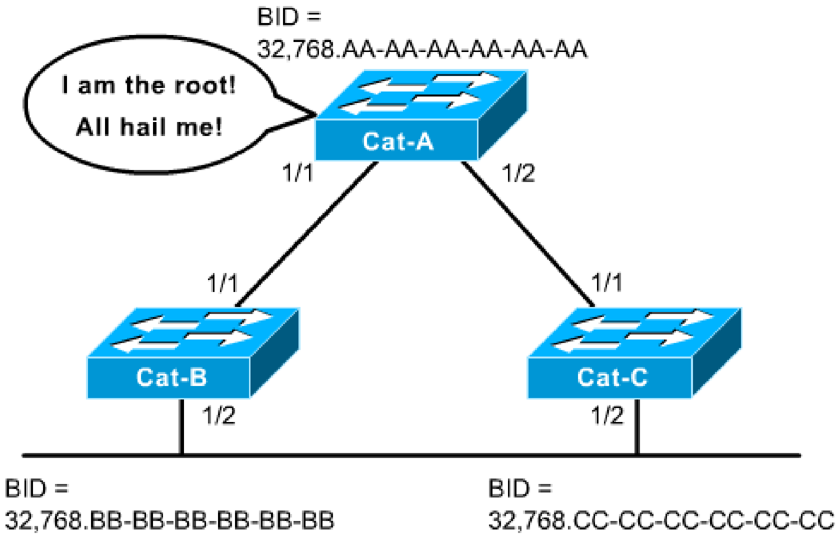
Step 2 Elect Root Ports

Step 3 Elect Designated Ports

Step 1 Elect one Root Bridge



Step 1   Elect one Root Bridge



Four-Step decision Sequence

Step 1 - Lowest BID
Step 2 - Lowest Path Cost to Root Bridge
Step 3 - Lowest Sender BID
Step 4 - Lowest Port ID

When the network first starts, all bridges are announcing a chaotic mix of BPDUs.

All bridges immediately begin applying the four-step sequence decision process.

Switches need to elect a single Root Bridge.

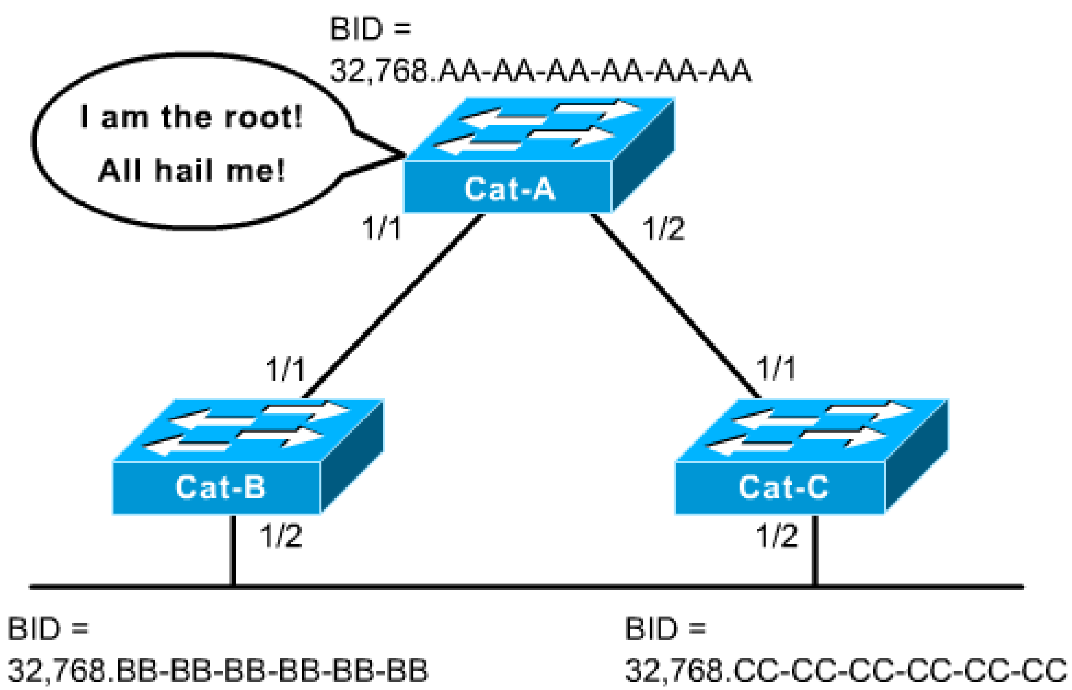
Switch with the **lowest BID** wins!

Note: Many texts refer to the term “highest priority” which is the “lowest” BID value.

This is known as the “Root War.”

Step 1   Elect one Root Bridge

Cat-A has the lowest Bridge MAC Address, so it wins the Root War!



All 3 switches have the same default Bridge Priority value of 32,768

Step 1 Elect one Root Bridge

Its all done with BPDUs!

BPDU

802.3 Header

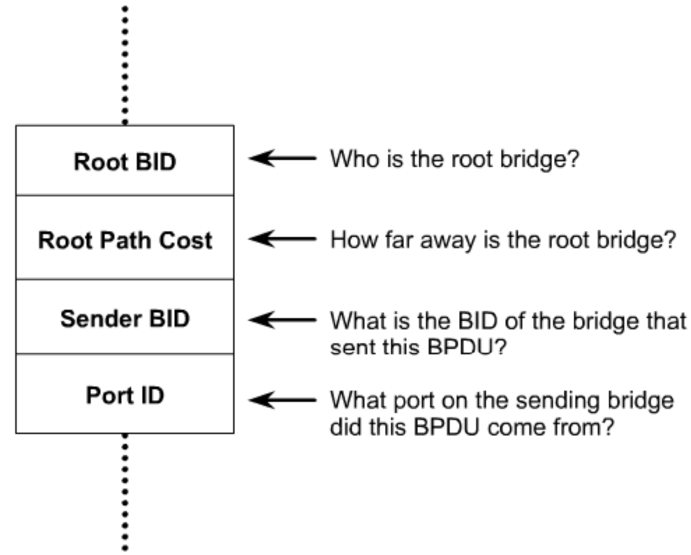
```
Destination:   01:80:C2:00:00:00  Mcast 802.1d Bridge g
Source:        00:D0:C0:F5:18:D1
LLC Length:    38
```

802.2 Logical Link Control (LLC) Header

```
Dest. SAP:     0x42  802.1 Bridge Spanning Tree
Source SAP:    0x42  802.1 Bridge Spanning Tree
Command:       0x03  Unnumbered Information
```

802.1 - Bridge Spanning Tree

```
Protocol Identifier:   0
Protocol Version ID:   0
Message Type:          0  Configuration Message
Flags:                 %00000000
Root Priority/ID:      0x8000/ 00:D0:C0:F5:18:C0
Cost Of Path To Root:  0x00000000  (0)
Bridge Priority/ID:    0x8000/ 00:D0:C0:F5:18:C0
Port Priority/ID:      0x80/ 0x1D
Message Age:           0/256 seconds (exactly 0  seconds)
Maximum Age:           5120/256 seconds (exactly 20  seconds)
Hello Time:            512/256 seconds (exactly 2  seconds)
Forward Delay:         3840/256 seconds (exactly 15  seconds)
```



Configuration BPDUs are sent every 2 seconds by default.

Step 1   Elect one Root Bridge

In a real network, you do not want the placement of the root bridge to rely on the random placement of the switch with the lowest MAC address.

A misplaced root bridge can have significant effects on your network including less than optimum paths within the network.

It is better to configure a switch to be the root bridge:

```
Switch(config)# spanning-tree [vlan vlan-list] priority priority *
```

- Priority
  - Default = 32,768
  - Range 0=65,535
  - Lowest wins

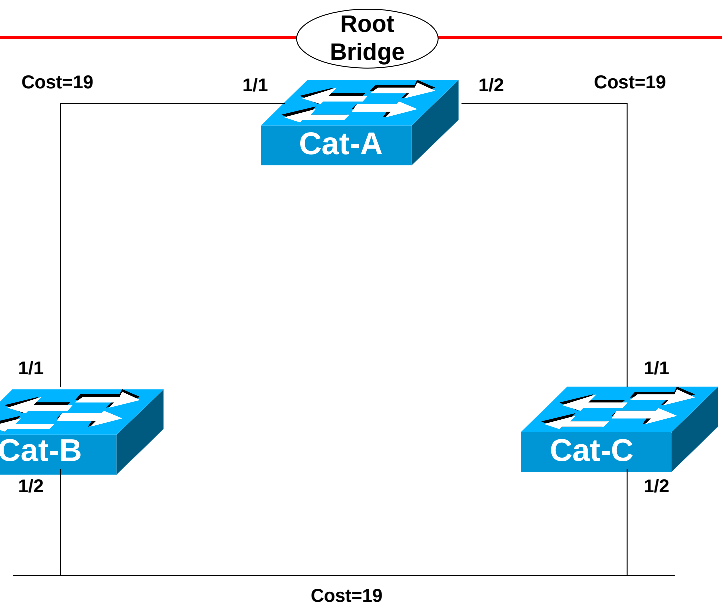
Step 1 Elect one Root Bridge

```
2950#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32768
             Address     0003.e334.6640
             Cost        19
             Port        23 (FastEthernet0/23)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     000b.fc28.d400
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface        Port ID                     Designated                Port ID
Name             Prio.Nbr      Cost Sts      Cost Bridge ID            Prio.Nbr
---------------- -------- --------- --- --------- -------------------- --------
Fa0/23           128.23          19 FWD         0 32768 0003.e334.6640 128.25

ALSwitch#
```

Step 1   Elect one Root Bridge

```
2900#show spanning-tree

Spanning tree 1 is executing the IEEE compatible Spanning Tree protocol
  Bridge Identifier has priority 32768, address 0003.e334.6640
  Configured hello time 2, max age 20, forward delay 15
  We are the root of the spanning tree
  Topology change flag not set, detected flag not set, changes 1
  Times:  hold 1, topology change 35, notification 2
          hello 2, max age 20, forward delay 15
  Timers: hello 0, topology change 0, notification 0

Interface Fa0/1 (port 13) in Spanning tree 1 is down
   Port path cost 19, Port priority 128
   Designated root has priority 32768, address 0003.e334.6640
   Designated bridge has priority 32768, address 0003.e334.6640
   Designated port is 13, path cost 0
   Timers: message age 0, forward delay 0, hold 0
   BPDU: sent 1, received 0
```

Step 2   Elect Root Ports



Now that the Root War has been won, switches move on to selecting **Root Ports**.

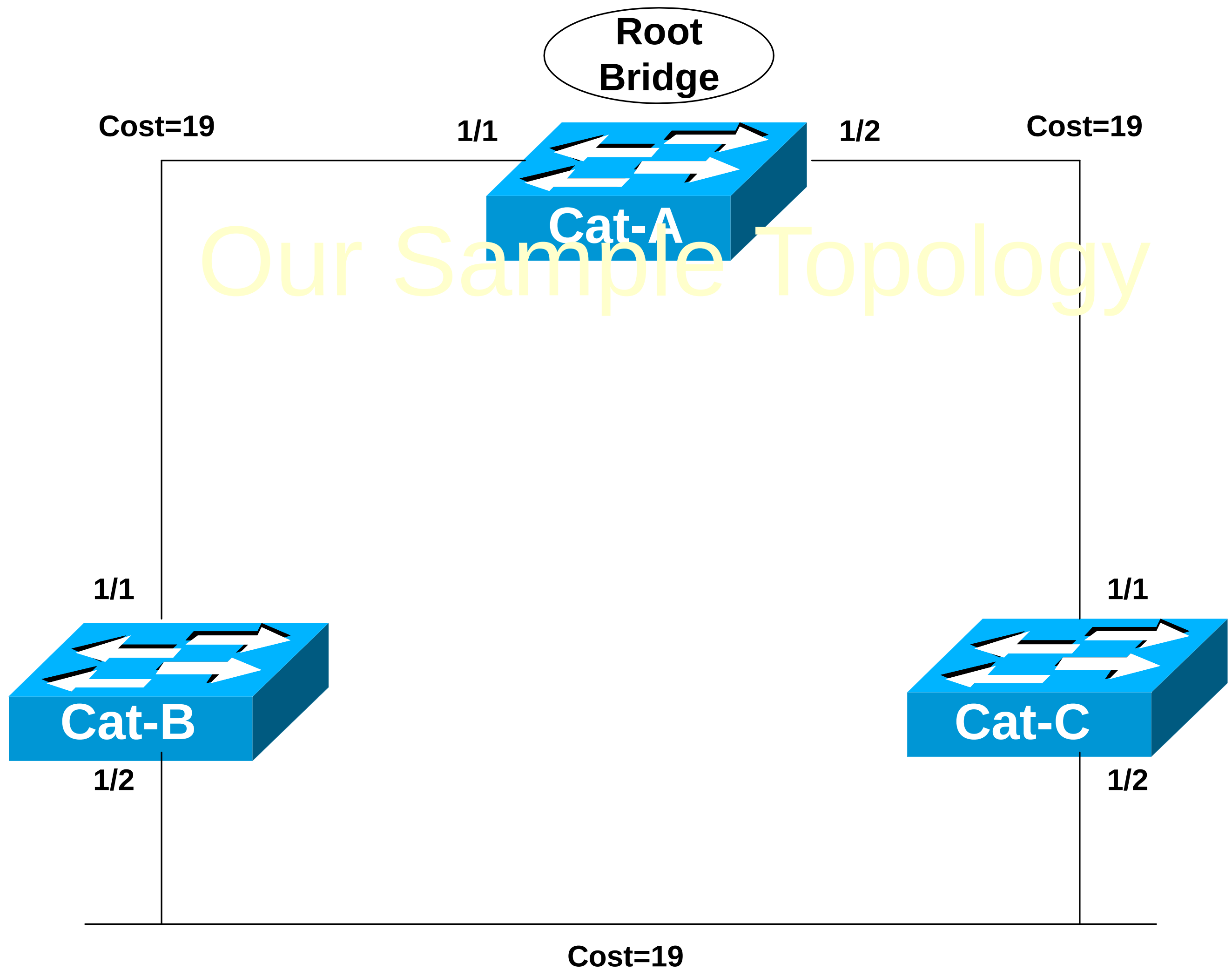
A bridge's **Root Port** is the ***port closest to the Root Bridge***.

Bridges use the **cost** to determine closeness.

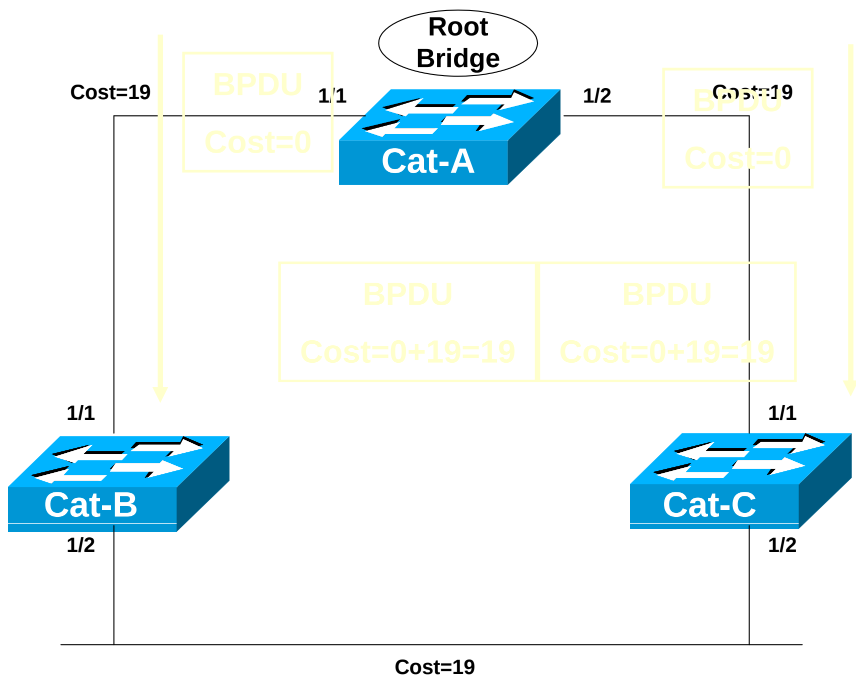
Every non-Root Bridge will select one Root Port!

Specifically, bridges track the **Root Path Cost**, the cumulative cost of all links to the Root Bridge.

Step 2 Elect Root Ports



Step 2 Elect Root Ports



Step 1

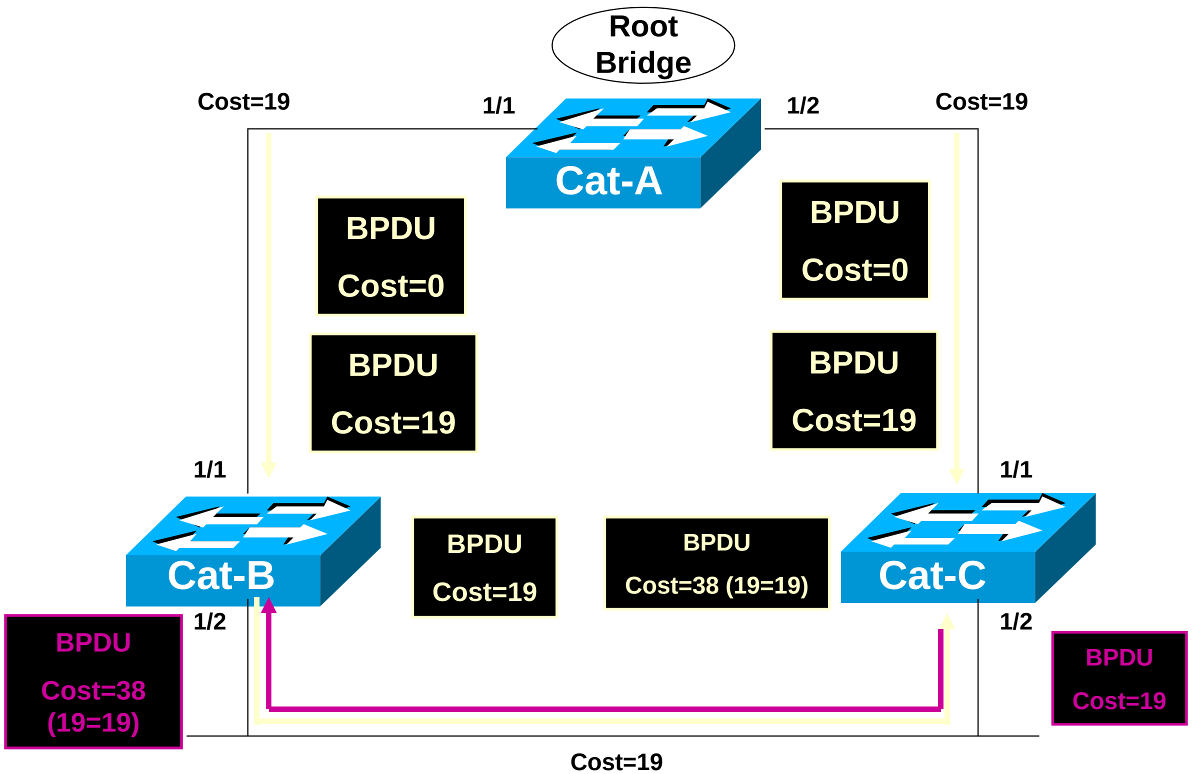
Cat-A sends out BPDUs, containing a Root Path Cost of 0.

Cat-B receives these BPDUs and adds the Path Cost of Port 1/1 to the Root Path Cost contained in the BPDU.

Step 2

Cat-B adds Root Path Cost 0 PLUS its Port 1/1 cost of 19 = 19

Step 2   Elect Root Ports



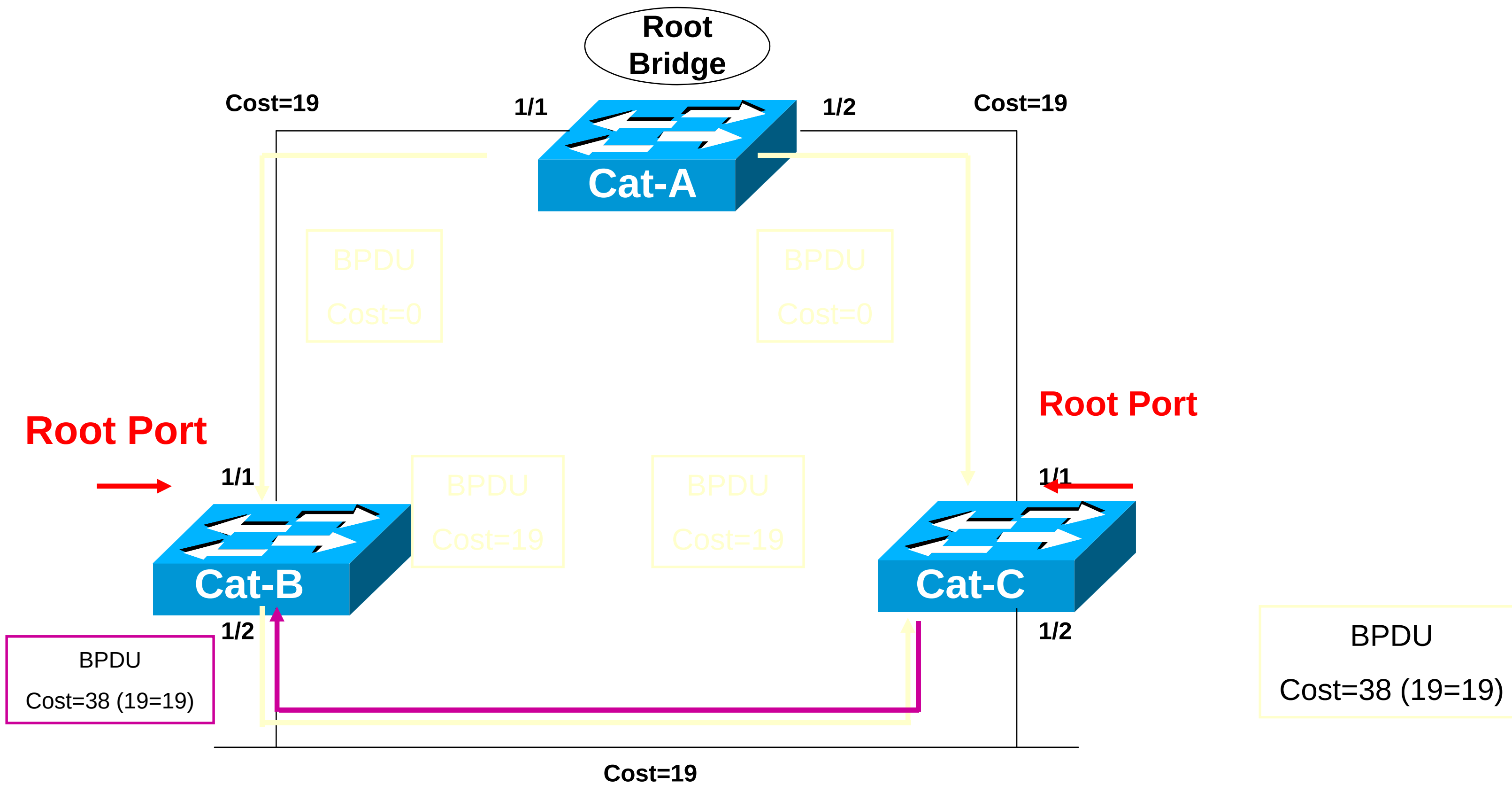
Step 3

Cat-B uses this value of 19 internally and sends BPDUs with a Root Path Cost of 19 out Port 1/2.

Step 4

Cat-C receives the BPDU from Cat-B, and increased the Root Path Cost to 38 (19+19). (Same with Cat-C sending to Cat-B.)

Step 2   Elect Root Ports



Step 5

Cat-B calculates that it can reach the Root Bridge at a cost of 19 via Port 1/1 as opposed to a cost of 38 via Port 1/2.

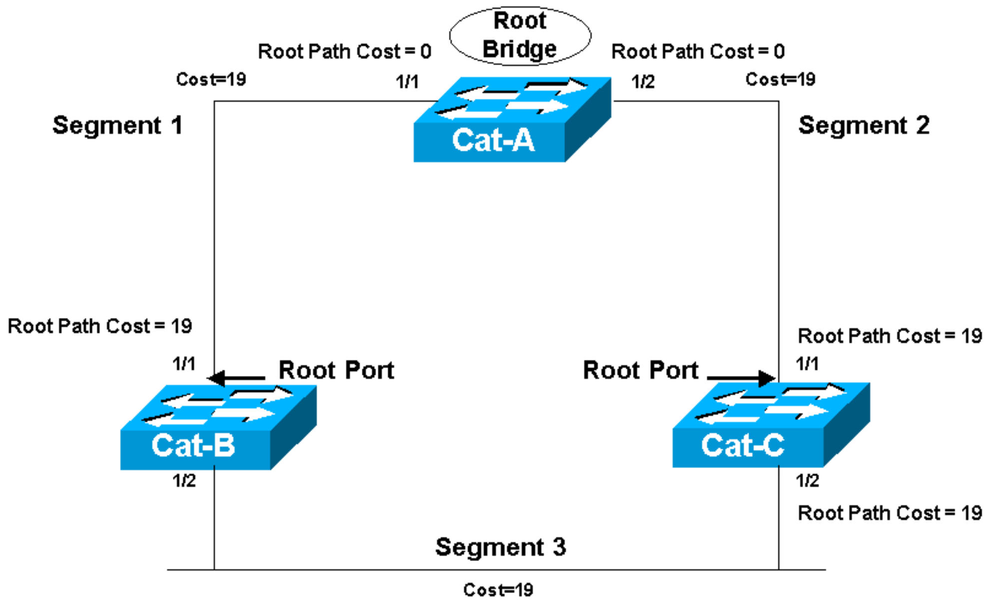
Port 1/1 becomes the Root Port for Cat-B, the port closest to the Root Bridge.

Cat-C goes through a similar calculation. Note: Both Cat-B:1/2 and Cat-C:1/2 save the best BPDU of 19 (its own).

Step 2 Elect Root Ports

```
2950#show spanning-tree

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    32768
             Address     0003.e334.6640
             Cost        19
             Port        23 (FastEthernet0/23)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     000b.fc28.d400
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface        Port ID                     Designated                Port ID
Name             Prio.Nbr      Cost Sts      Cost Bridge ID            Prio.Nbr
---------------- -------- --------- --- --------- -------------------- --------
Fa0/23           128.23          19 FWD         0 32768 0003.e334.6640 128.25

ALSwitch#
```

Step 3   Elect Designated Ports



The loop prevention part of STP becomes evident during this step, electing designated ports.

A **Designated Port** functions as ***the single bridge port that both sends and receives traffic to and from that segment and the Root Bridge.***

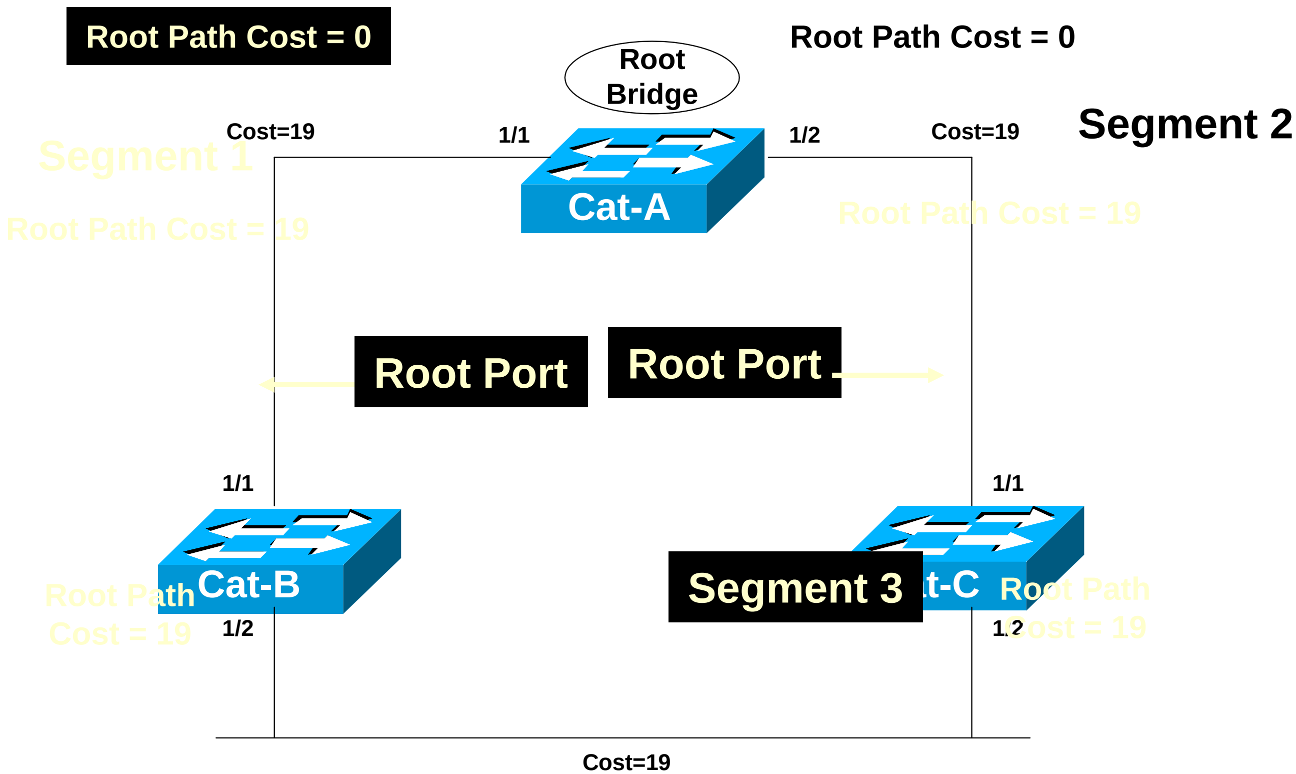
Each segment in a bridged network has one Designated Port, chosen based on cumulative Root Path Cost to the Root Bridge.

The switch containing the Designated Port is referred to as the **Designated Bridge** for that segment.

To locate Designated Ports, lets take a look at each segment.

Root Path Cost, the cumulative cost of all links to the Root Bridge.

Step 3 Elect Designated Ports

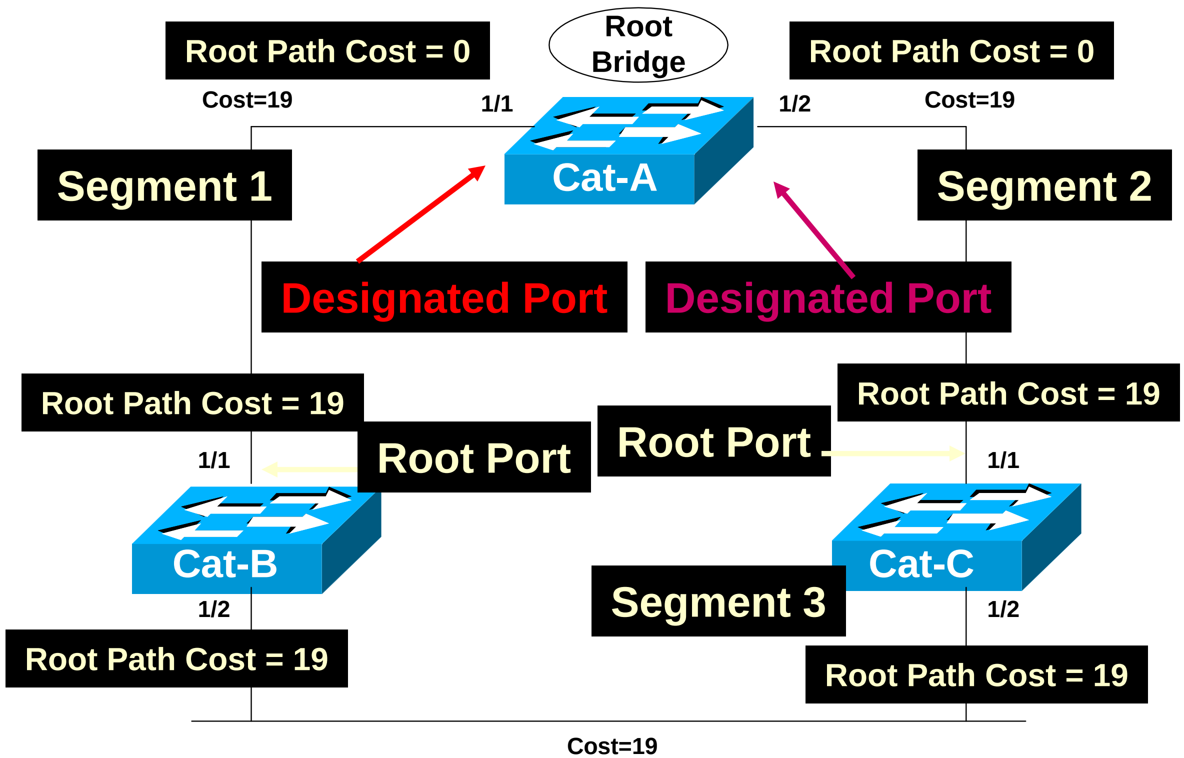


Segment 1: Cat-A:1/1 has a Root Path Cost = 0 (after all it has the Root Bridge) and Cat-B:1/1 has a Root Path Cost = 19.

Segment 2: Cat-A:1/2 has a Root Path Cost = 0 (after all it has the Root Bridge) and Cat-C:1/1 has a Root Path Cost = 19.

Segment 3: **Cat-B:1/2** has a **Root Path Cost = 19** and **Cat-C:1/2** has a **Root Path Cost = 19**. ***It's a tie!***

Step 3 Elect Designated Ports

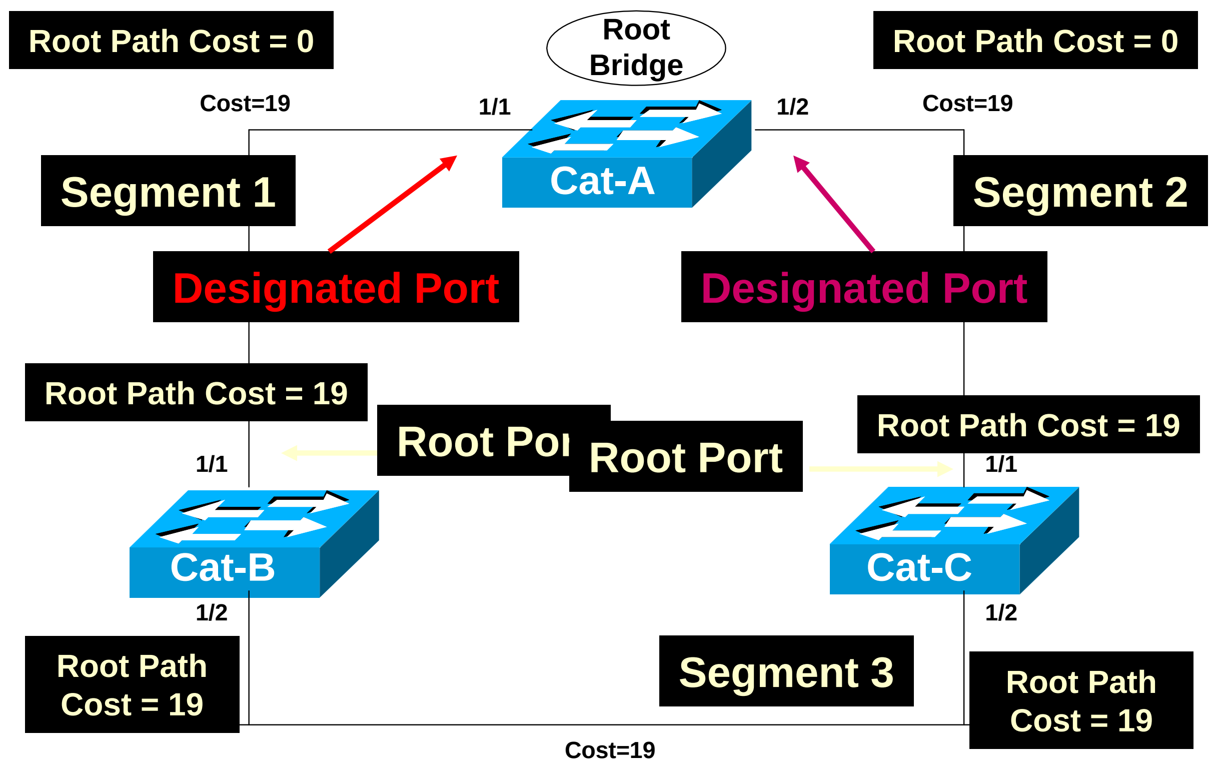


Segment 1

Because Cat-A:1/1 has the lower Root Path Cost it becomes the **Designate Port for Segment 1**.

Segment 2

Because Cat-A:1/2 has the lower Root Path Cost it becomes the **Designate Port for Segment 2**.



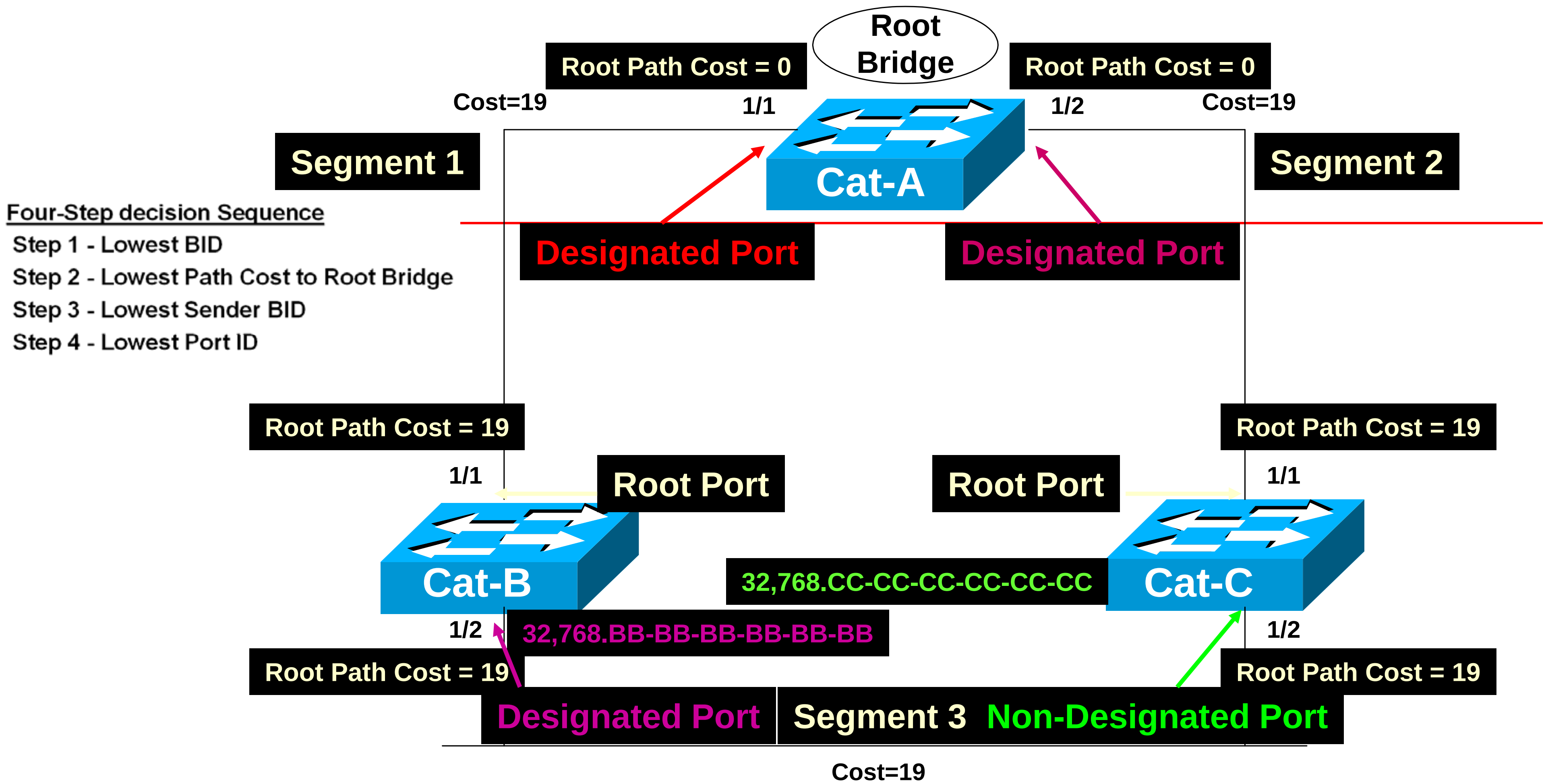
Segment 3

Both Cat-B and Cat-C have a **Root Path Cost of 19**, a tie!

When faced with a tie (or any other determination) STP always uses the four-step decision process:

<u>Four-Step decision Sequence</u>

- Step 1 - Lowest BID
- Step 2 - Lowest Path Cost to Root Bridge
- Step 3 - Lowest Sender BID
- Step 4 - Lowest Port ID



Segment 3 (continued)

1) All three switches agree that Cat-A is the Root Bridge, so this is a tie.

2) Root Path Cost for both is 19, also a tie.

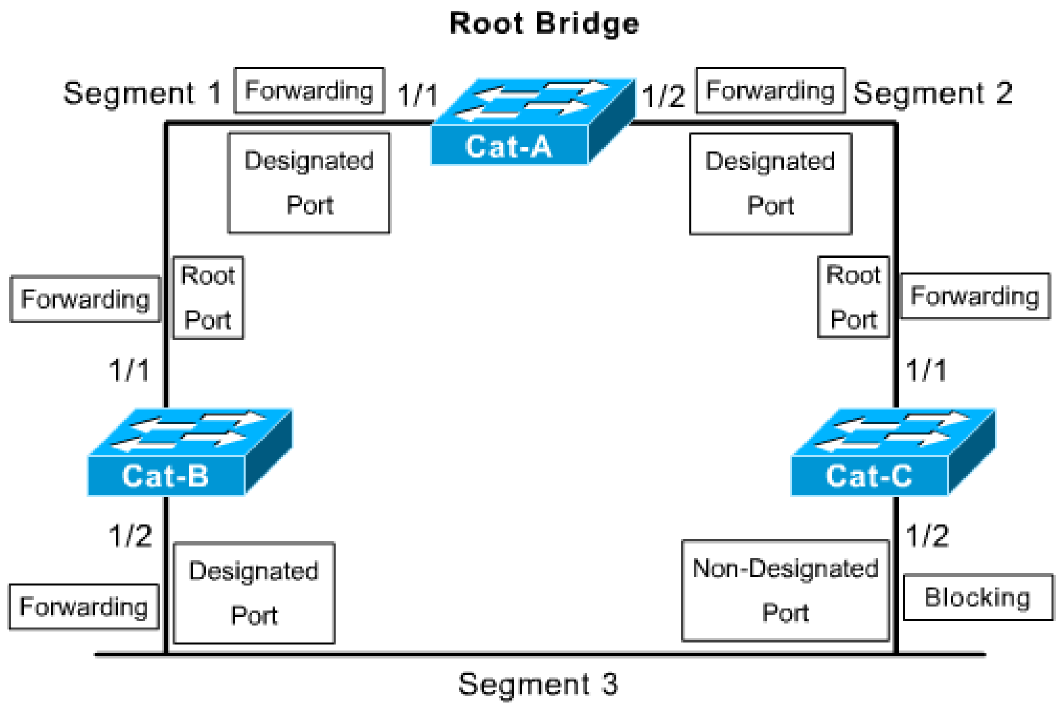
3) The sender's BID is lower on Cat-B, than Cat-C, so Cat-B:1/2 becomes the **Designated Port for Segment 3**. Cat-C:1/2 therefore becomes the **non-Designated Port for Segment 3.**

We will first only look at switch ports that have connections to other switches.

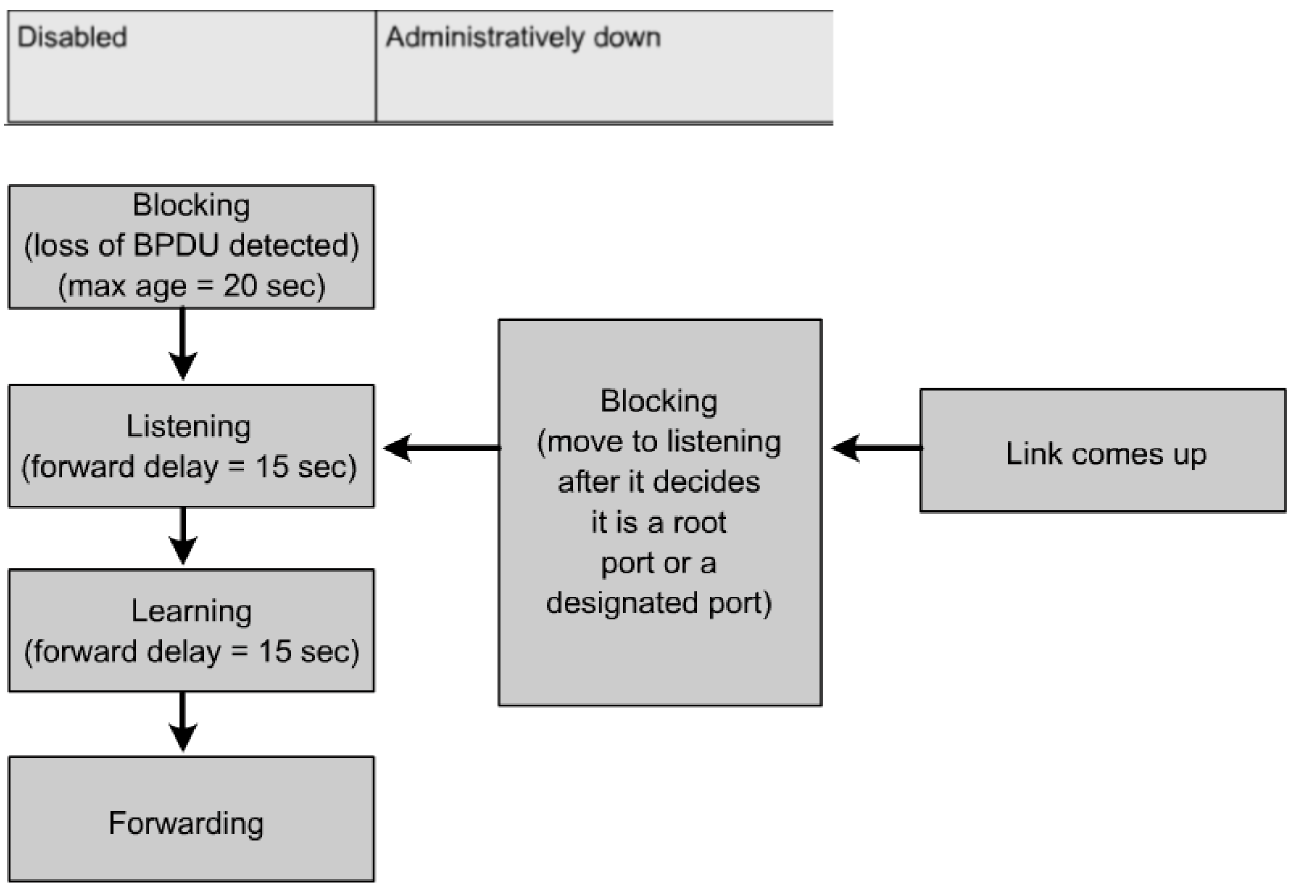
State	Purpose
Forwarding	Sending / receiving user data
Learning	Building bridging table
Listening	Building "active" topology
Blocking	Receives BPDUs only
Disabled	Administratively down

Designated Ports & Root Ports

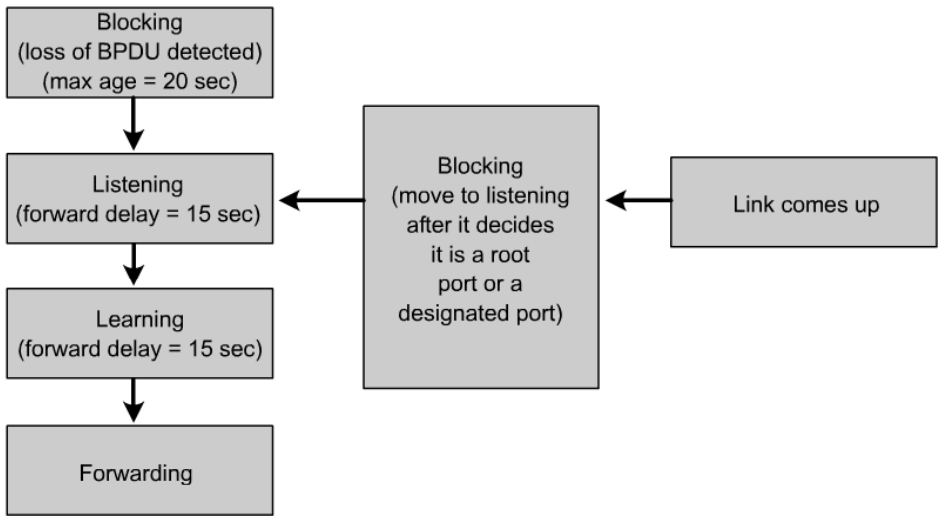
Non-Designated Ports



Stages of spanning-tree port states



Stages of spanning-tree port states



Time is required for (BPDU) protocol information to propagate throughout a switched network.

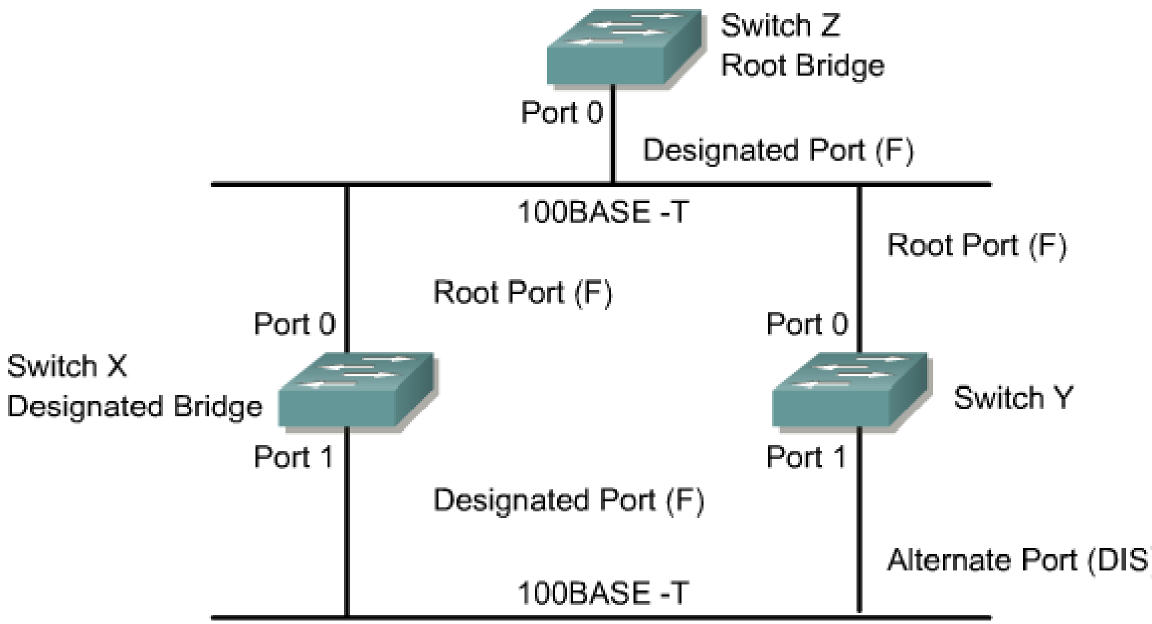
Topology changes in one part of a network are not instantly known in other parts of the network.

There is propagation delay.

A switch should not change a port state from inactive (Blocking) to active (Forwarding) immediately, as this may cause data loops.

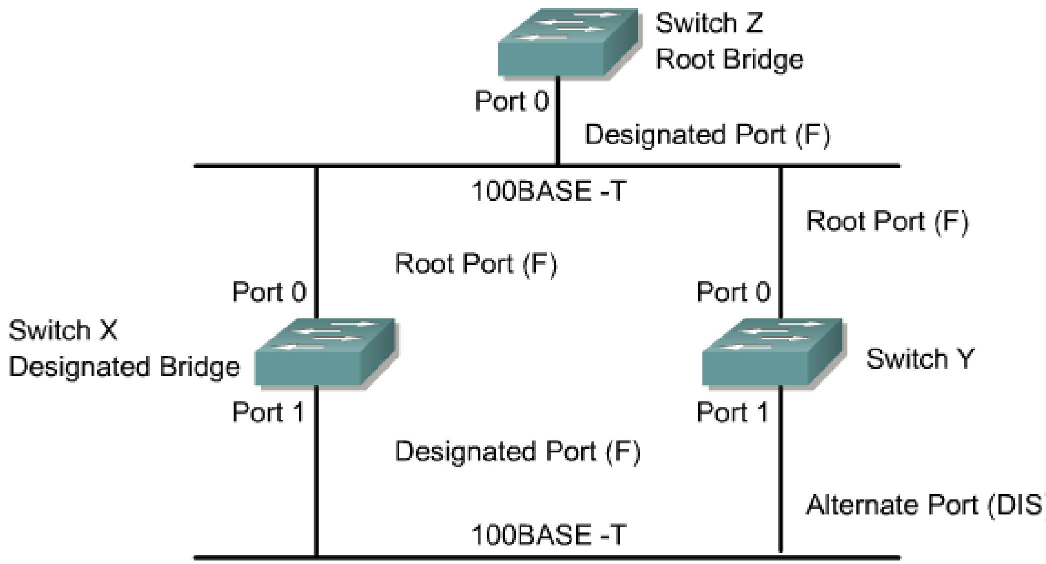
Each port on a switch that is using the Spanning-Tree Protocol has one of five states,

Rapid Spanning Tree Protocol (RSTP)



It is difficult to explain RSTP in just a few slides. RSTP is discussed in detail in CCNP 3.

Rapid Spanning Tree Protocol (RSTP)



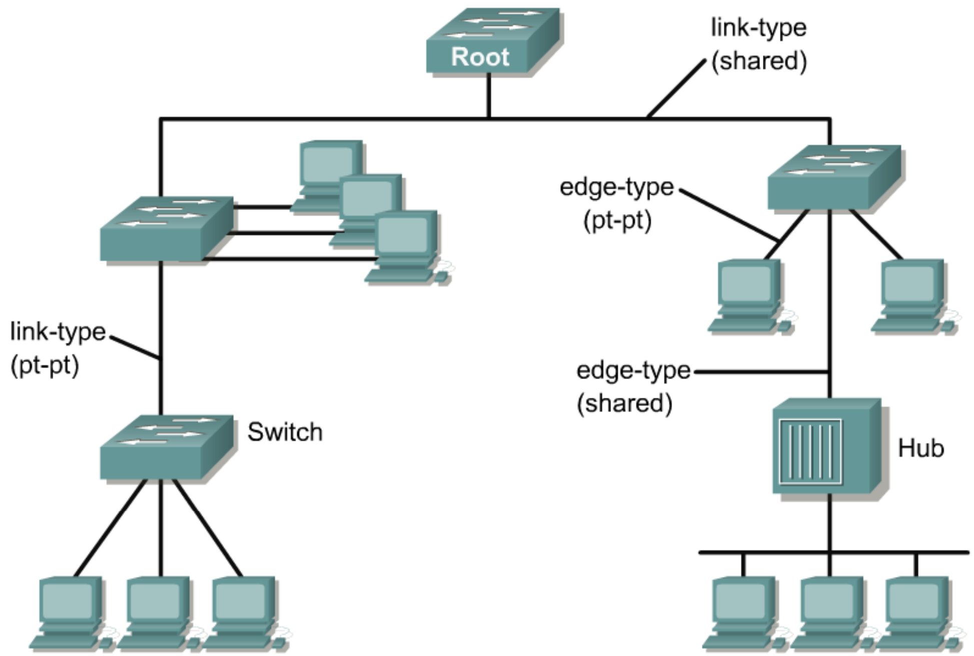
The Rapid Spanning-Tree Protocol is defined in the **IEEE 802.1w** LAN standard.

The standard and protocol introduce the following:

- Clarification of port states and roles
- Definition of a set of link types that can go to forwarding state rapidly
- Concept of allowing switches, in a converged network, to generate their own BPDUs rather than relaying root bridge BPDUs

The “blocked” state of a port has been renamed as the “discarding” state.

RSTP Link Types



Link types have been defined as **point-to-point, edge-type, and shared.**

These changes allow failure of links in switched network to be learned rapidly.

Point-to-point links and edge-type links can go to the forwarding state immediately.

Network convergence does not need to be any longer than 15 seconds with these changes.

The Rapid Spanning-Tree Protocol, IEEE 802.1w, will eventually replace the Spanning-Tree Protocol, IEEE 802.1D

RSTP Port States

STP (802.1D) Port State	RSTP (802.1w) Port State	Is Port Included in Active Topology?	Is Port Learning Mac Addresses?
Disabled	Discarding	No	No
Blocking	Discarding	No	No
Listening	Discarding	No	No
Learning	Learning	No	Yes
Forwarding	Forwarding	Yes	Yes

LAB

Simulate by Packet Tracer

Questions

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