SLIIT

Discover Your Future

IE2050 – Computer Networks

Lecture 10

Spanning Tree Protocol

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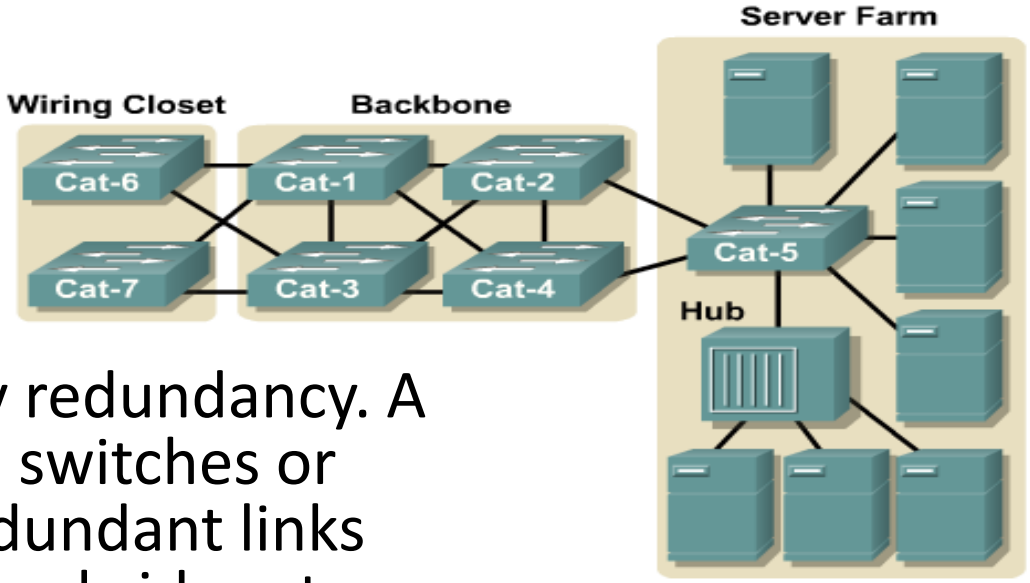
Redundant Topologies

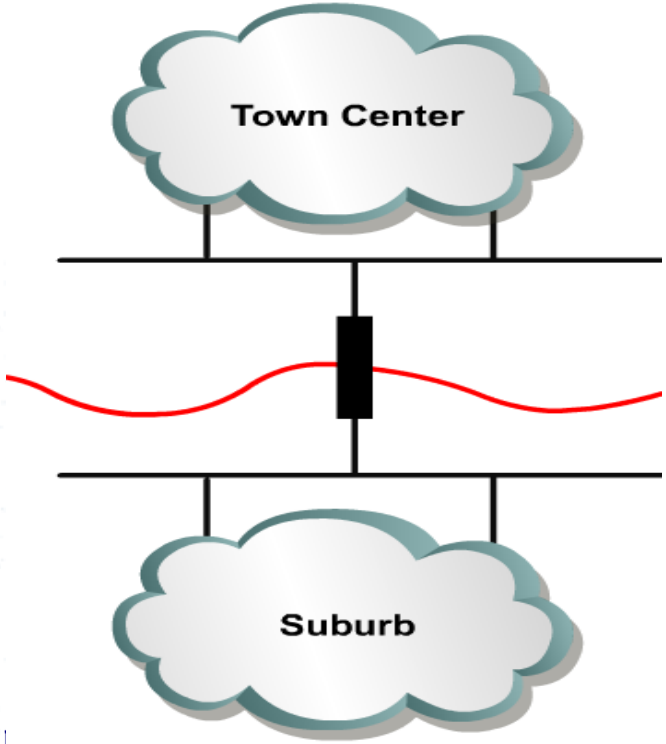
- Many companies and organizations increasingly rely on computer networks for their operations.
- Access to file servers, databases, the Internet, intranets and extranets is critical for successful businesses.
- If the network is down, productivity and customer satisfaction decline.

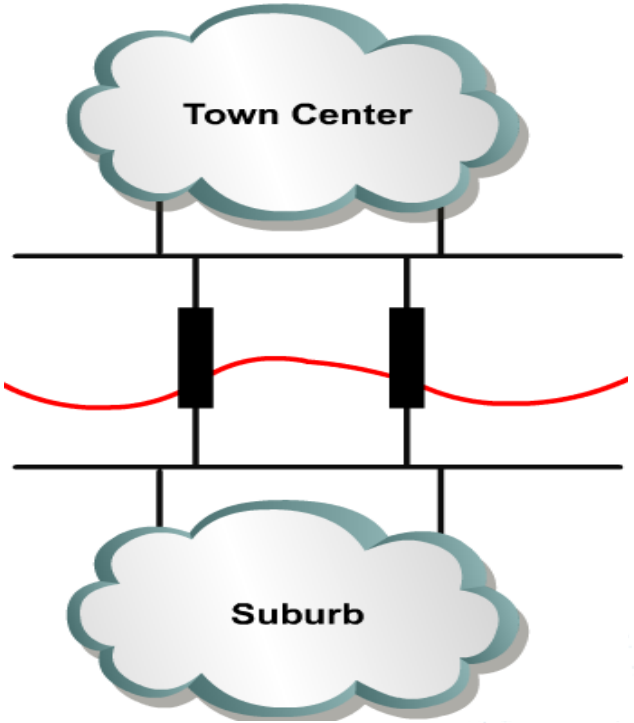
- This is interpreted to mean one hour of downtime on average, for every 4000 days, or approximately 5.25 minutes of downtime per year.
- To achieve such a goal ,extremely reliable networks are required.



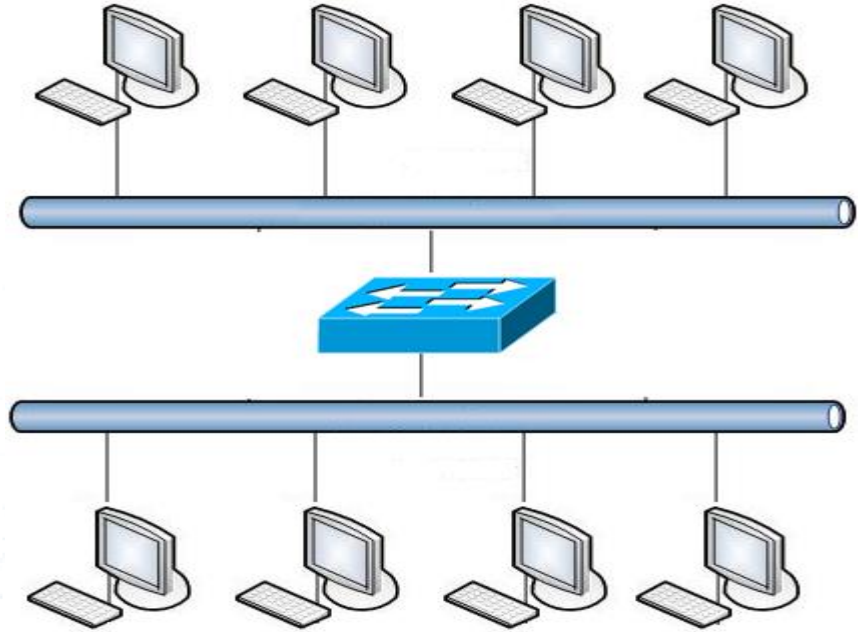
- Reliability is increased by redundancy. A network that is based on switches or bridges will introduce redundant links between those switches or bridges to overcome the failure of a single link.

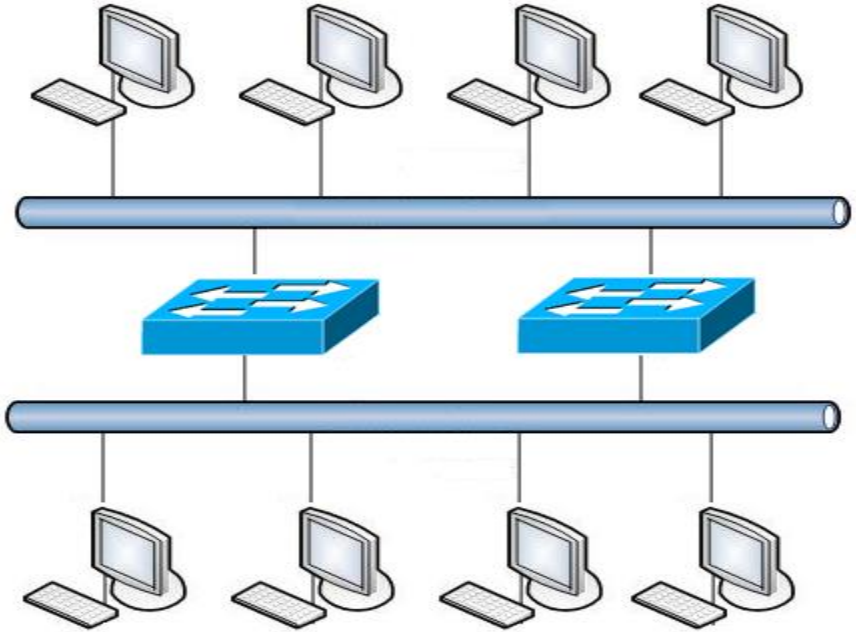
Redundancy



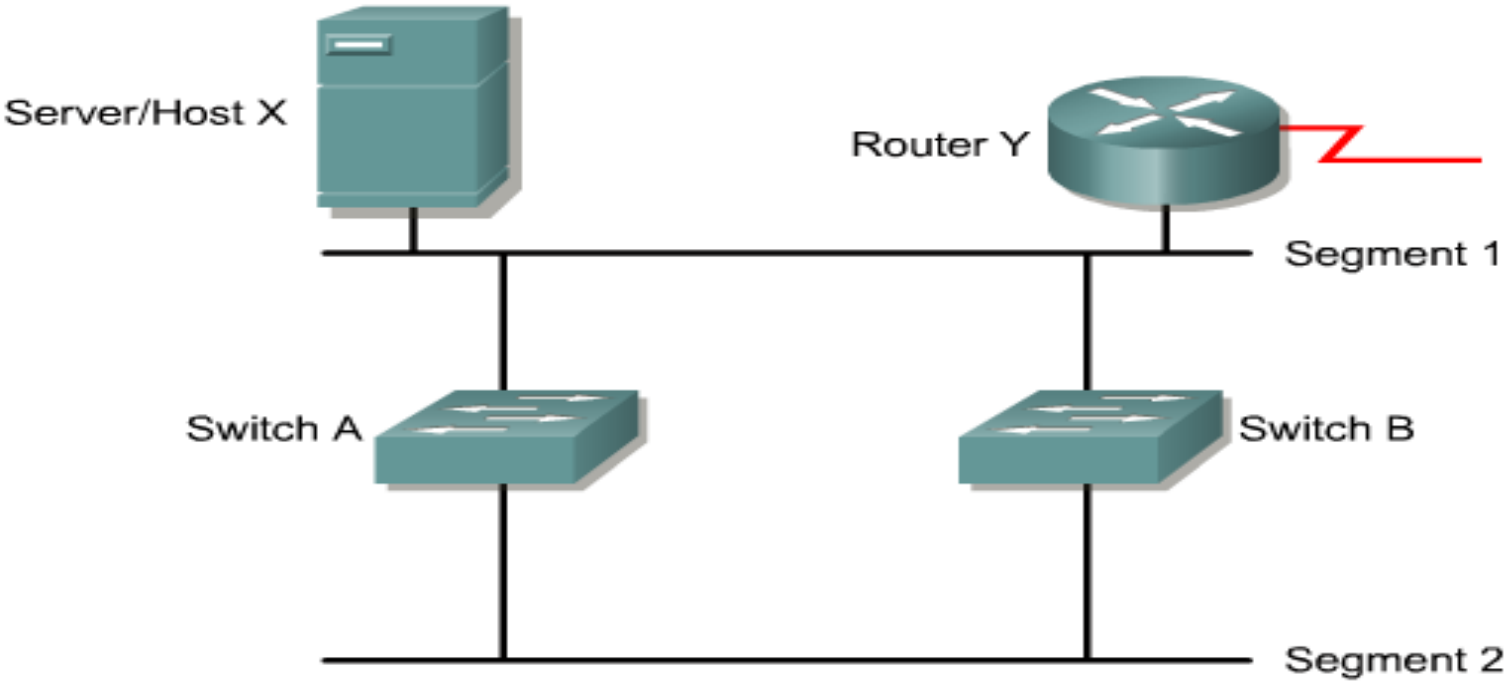


Redundancy





Redundancy Creates Loops

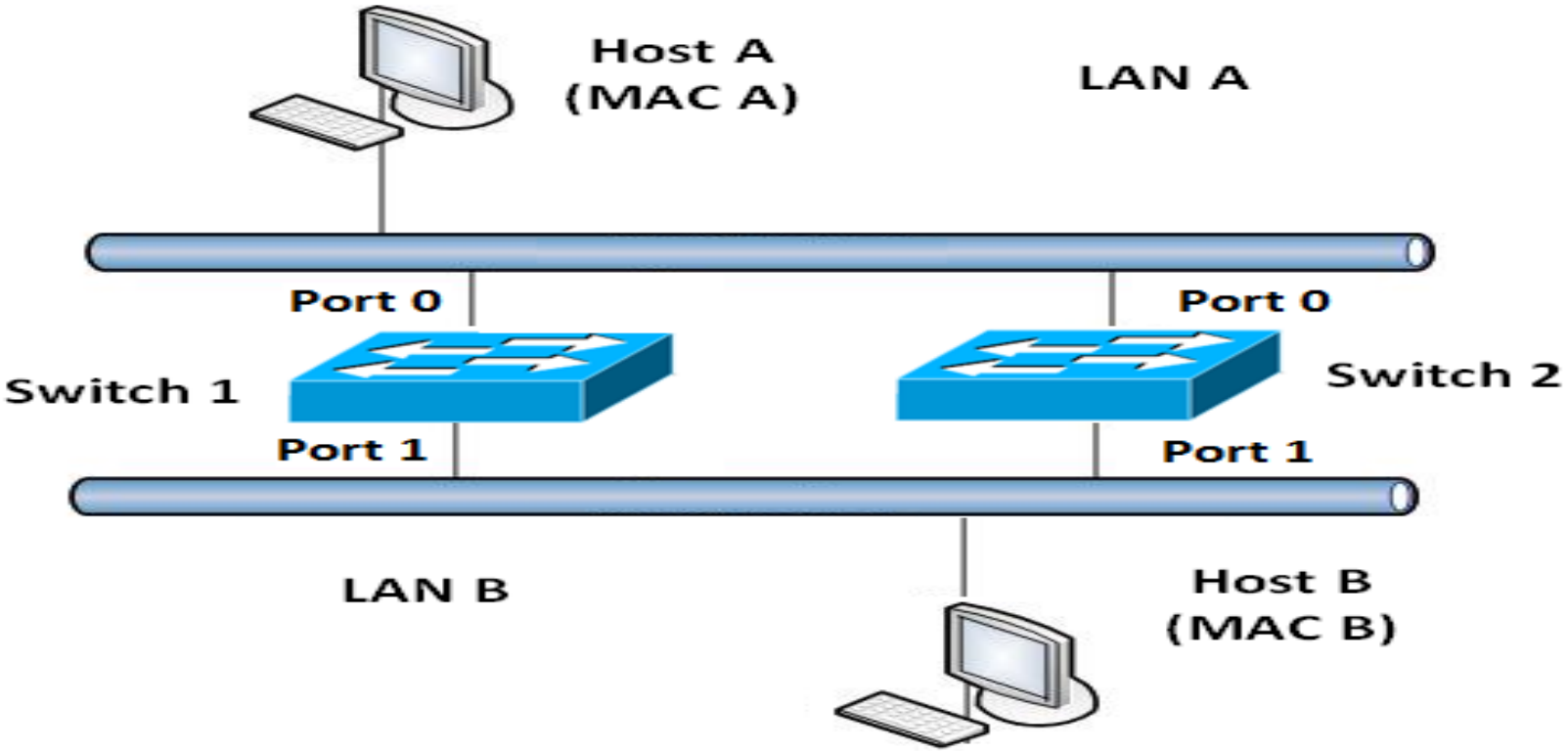


- Loops may occur in a network as part of a design strategy for redundancy.
- STP is not needed if there are no loops the network.
- However, DO NOT disable STP!
- Loops can occur accidentally from network staff or even users!

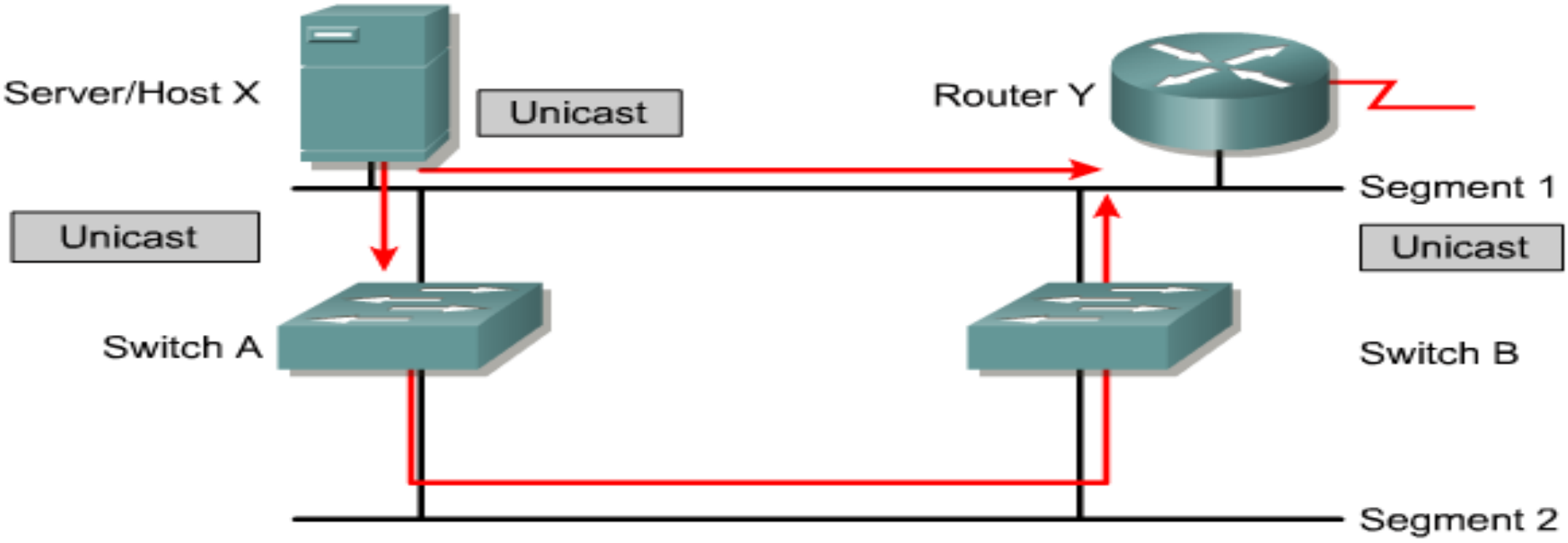
L2 Loops

- Broadcasts and Layer 2 loops can be a dangerous combination.
- Ethernet frames have no TTL field
- After an Ethernet frame starts to loop, it will probably continue until someone shuts off one of the switches or breaks a link.

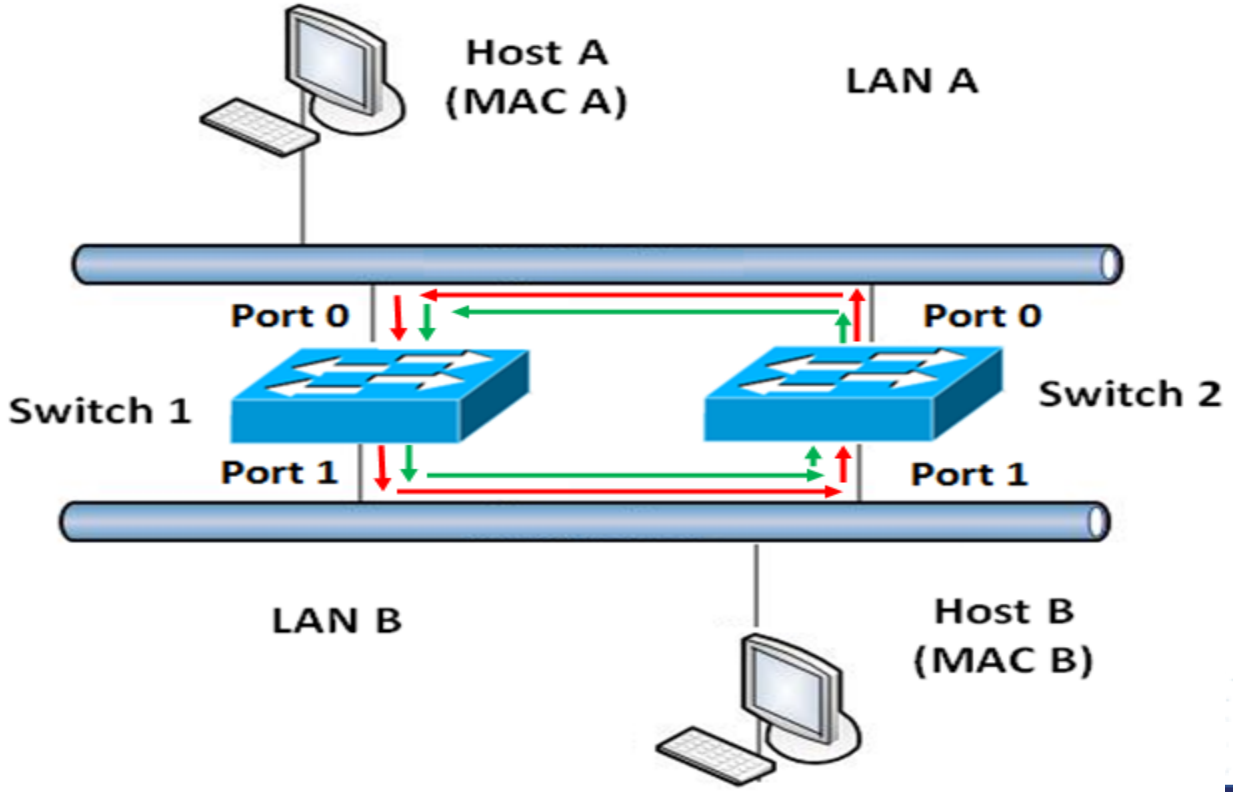
Looping Problems



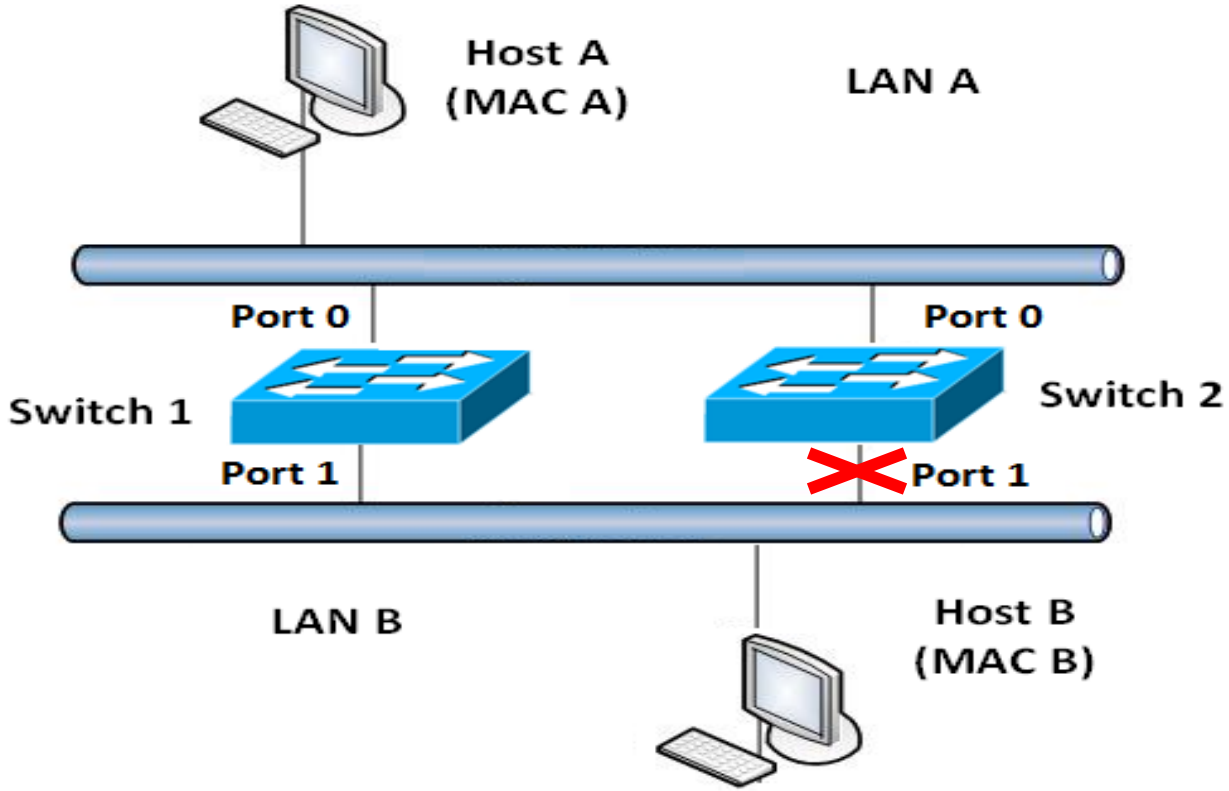
Multiple frame transmissions



Looping Problems cont.



Avoid Looping Problems



Avoid Looping Problems cont.

- To avoid loops, all switches use Spanning Tree Protocol (STP)

Spanning-Tree Protocol

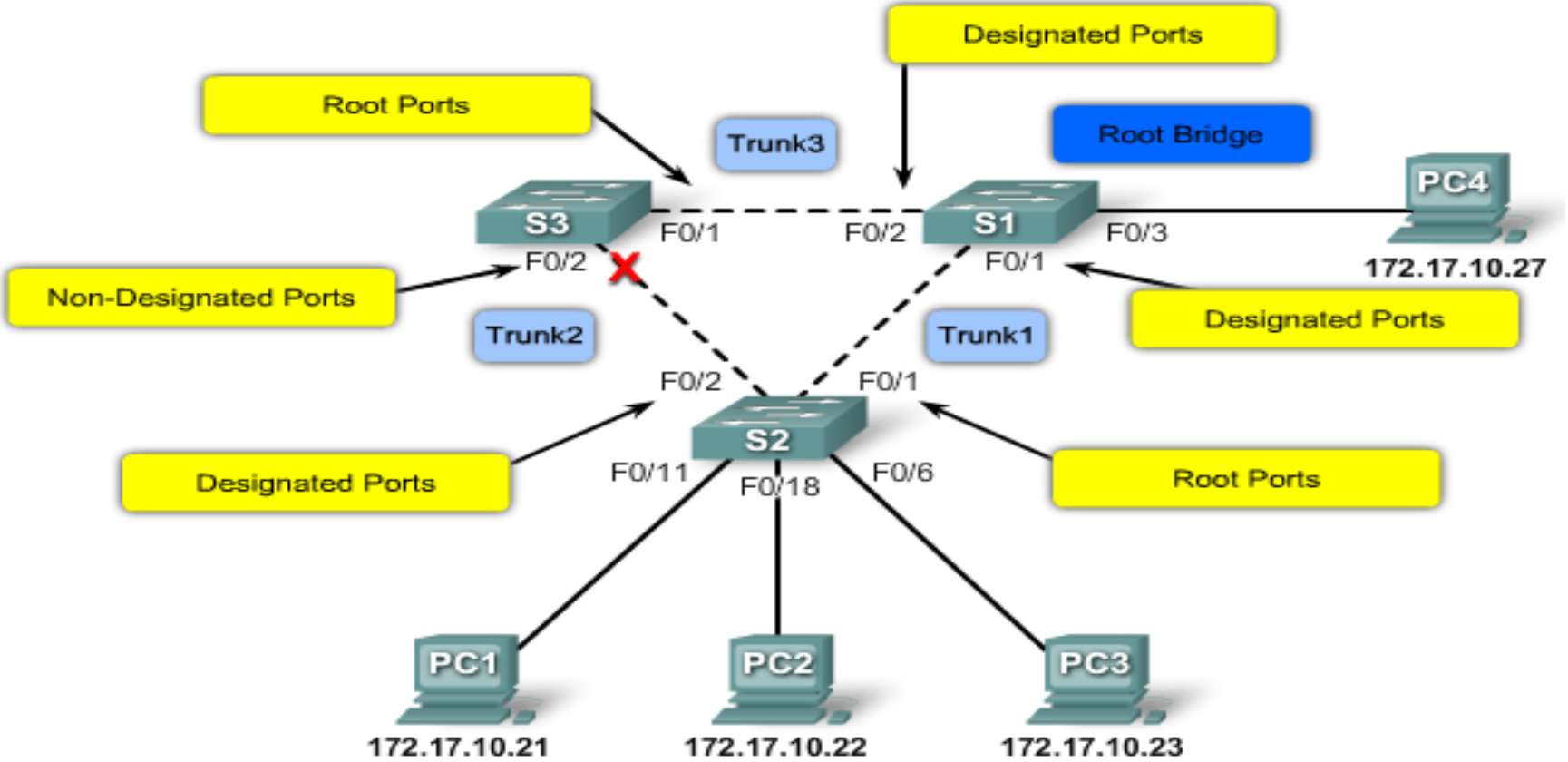
- Ethernet bridges and switches can implement the IEEE 802.1d Spanning-Tree Protocol and use the spanning-tree algorithm to construct a loop free shortest path network.
- Shortest path is based on cumulative link costs. Link costs are based on the speed of the link.

- STP ensures that there is only one logical path between all destinations on the network by intentionally blocking redundant paths that could cause a loop.
- A port is considered blocked when network traffic is prevented from entering or leaving that port.

Spanning Tree Algorithm

- STP uses the Spanning Tree Algorithm (STA) to determine which switch ports on a network need to be configured for blocking to prevent loops from occurring. The STA designates a single switch as the **root bridge** and uses it as the reference point for all path calculations
- All switches participating in STP exchange **BPDU** frames to determine which switch has the lowest bridge ID (BID) on the network. The switch with the lowest BID automatically becomes the root bridge for the STA calculations..

STP Algorithm



Spanning Tree Protocol (STP)

- STP blocks some ports so that only one active path exists between any pair of LAN segments
- STP causes each interface on a bridging device to settle into a ***blocking* state** or a ***forwarding* state**
- Blocking means that the interface cannot forward or receive data frames, but it can send and receive bridge protocol data units (BPDUs)
- Forwarding means that the interface can both send and receive data frames as well as BPDUs

Pros & Cons.

Advantages

- Frames do not loop infinitely, which makes the LAN usable

Disadvantages

- Network does not actively take advantage of some of the redundant links because they are blocked
- Some users' traffic travels a seemingly longer path through the network because a shorter physical path is blocked.

Bridge Protocol Data Unit (BPDU)

- STP uses a special frame called BPDU to exchange information about BridgeIDs and root path costs
- Each BPDU contains
  - Bridge ID of the source
  - Accumulated root path cost
  - Source bridge
  - Other information
- When a BPDU is initiated from a bridge the accumulated root path cost is 0

- Exchange of BPDU messages results in the following:
  - The election of a unique root switch for the stable spanning-tree network topology.
  - The election of a designated switch for every switched LAN segment.
  - The removal of loops in the switched network by placing redundant switch ports in a blocking state.

How STP works

I. Elects a root bridge
II. Elects a root port for Each non root bridge
III. Elects a designated bridge for LAN segment
IV. Elects a designated port for each designated bridge

I. Elects a root bridge

- An identification number is given to each bridge
- Assigned manually or by the manufacturer
- Sometimes Bridge's MAC address is considered as the bridge ID
- **The bridge with the least BridgeID is selected as root bridge**
- BridgeID ➔ 8 Bytes

  ➔ MAC Address + Bridge priority value

I. Elects a root bridge cont.

- The election process begins with every switch sending out BPDUs with a Root Bridge ID equal to its own Bridge ID
- Received BPDU messages are analyzed for a lower Root Bridge ID value
- If the BPDU message has a Root Bridge ID of the lower value than the switch's own Root Bridge ID, it replaces its own Root Bridge ID with the Root Bridge ID announced in the BPDU
- The switch is then nominates the new Root Bridge ID in its own BPDU messages
- Once the process has converged, all switches will agree on the Root Bridge until a new switch is added

II. Elect 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.

II. Elects a root port for Each non root bridge

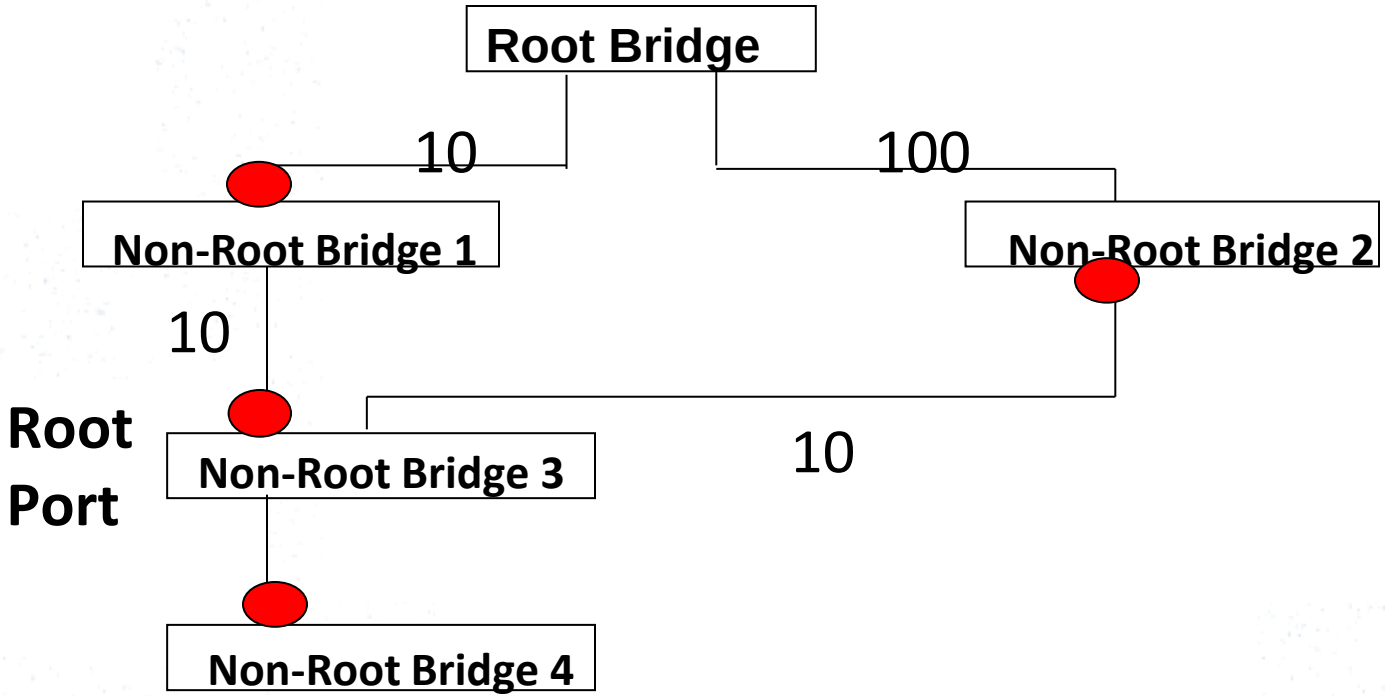
- **The port which has the least cost path to the root bridge** is considered as the root port of that particular non root bridge
- Each path is given a “cost”
- Cost is inversely proportionate to bandwidth

  10 mbps – 100

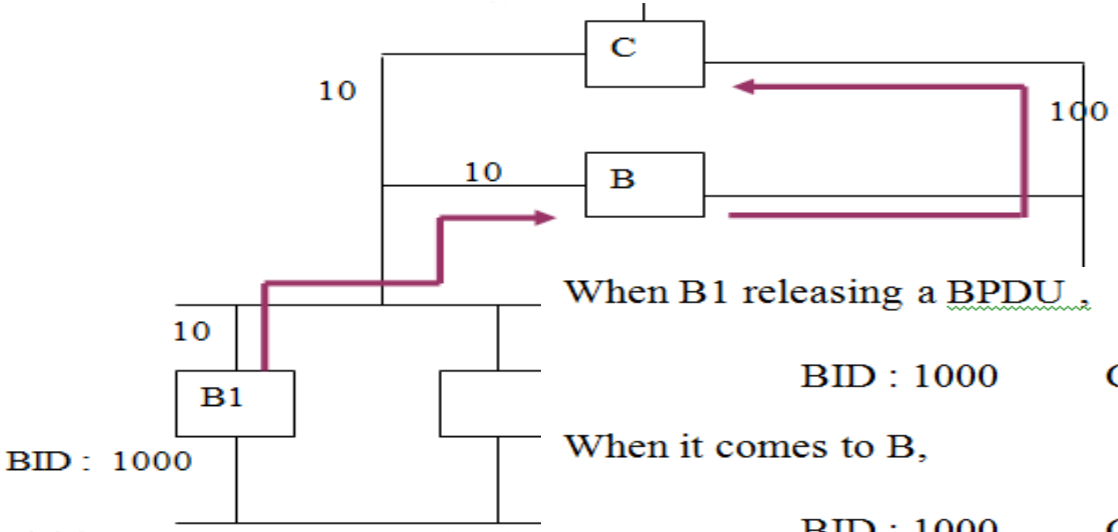
  100 mbps – 10

  1Gbps – 2
- Root Bridge does not have a root port

II. Elects a root port for Each non root bridge cont.



- The Root port of a bridge is the port who's BPDU has the minimum accumulated root cost



When B1 releasing a BPDU ,

BID : 1000 Cost : 0

When it comes to B,

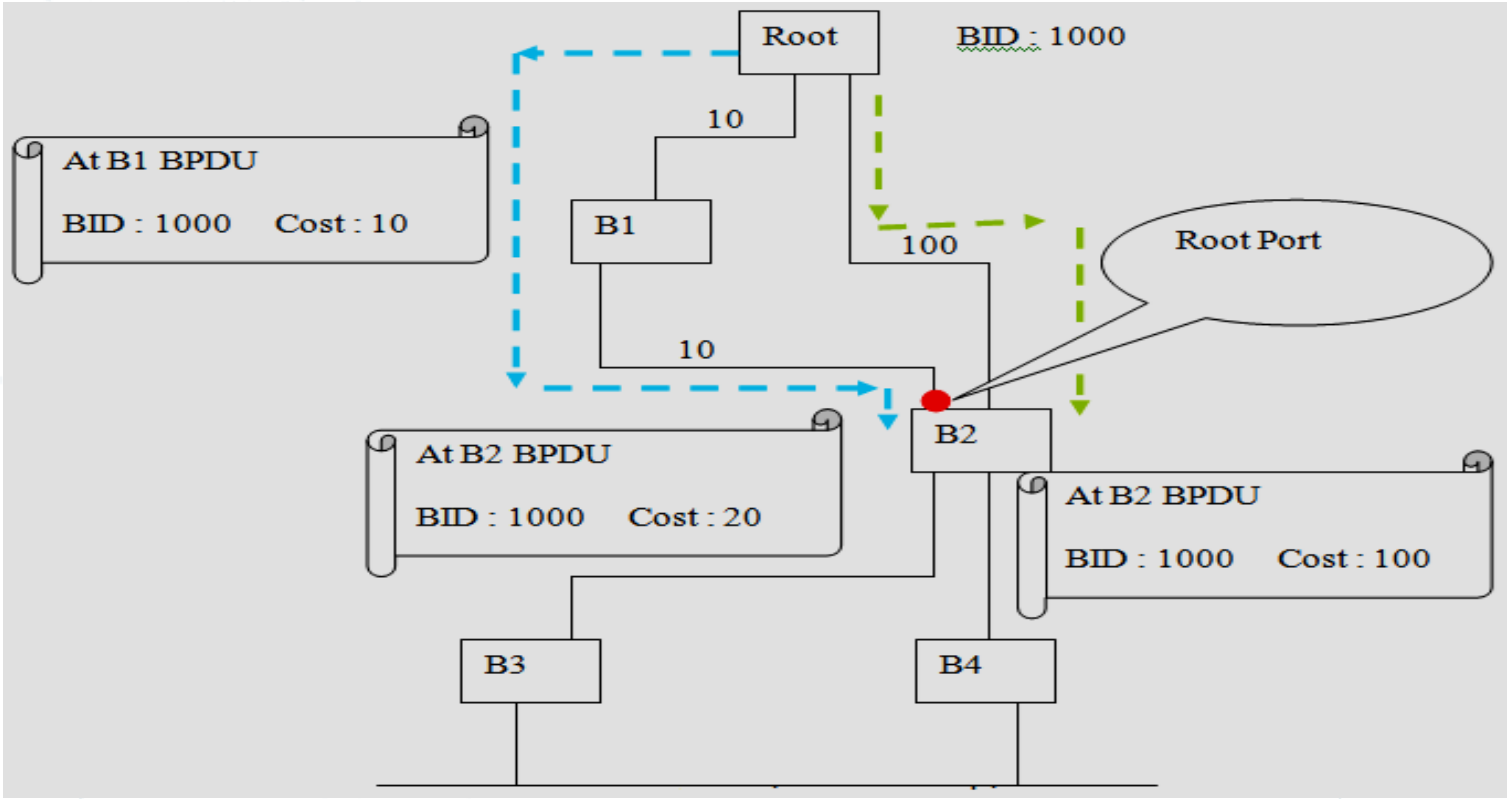
BID : 1000 Cost : 20

When BPDU comes to C,

BID : 1000 Cost : 120

Cost is accumulating

II. Elects a root port for Each non root bridge cont.



III. Elect Designated Bridge for LAN segment

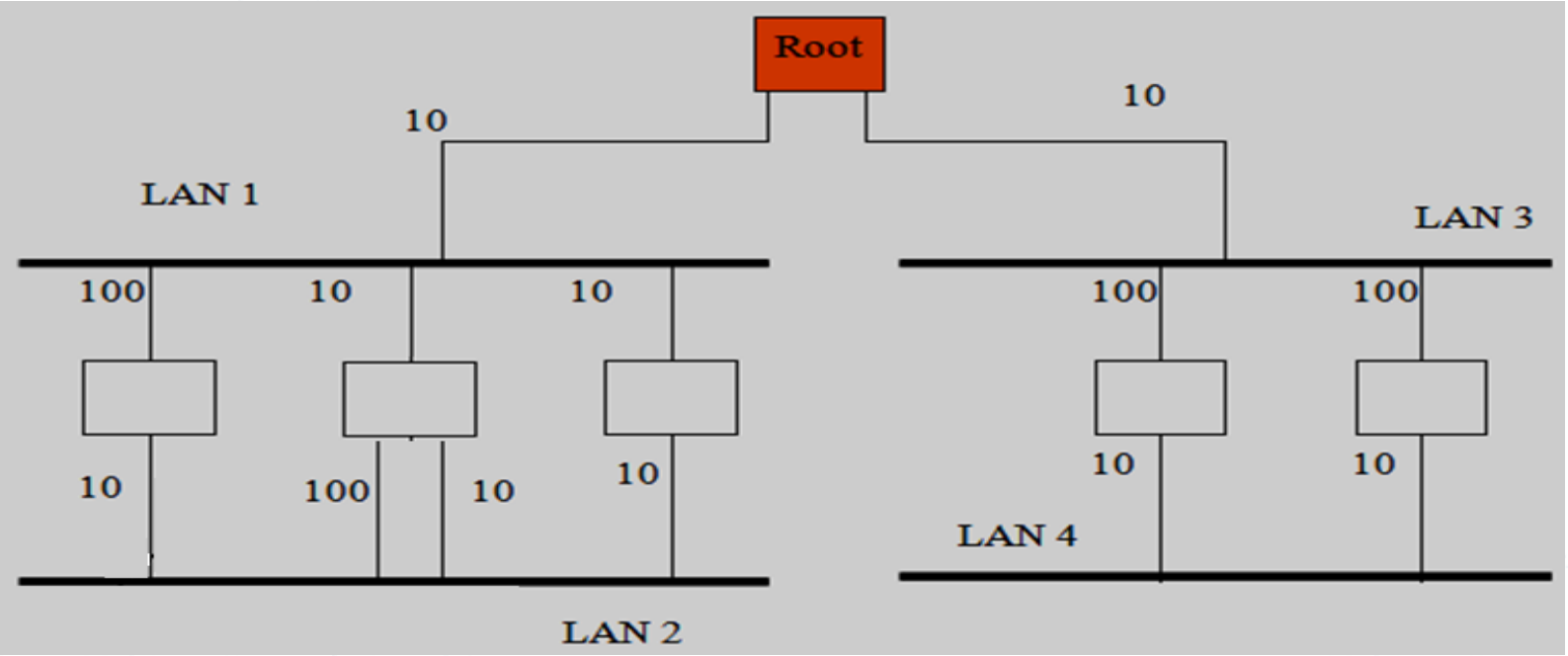
- A Designated Port is elected for every segment. The Designated Port is the only port that sends and receives traffic to/from that segment to the Root Bridge, the best port towards the root bridge.
- Each segment in a bridged network has one Designated Port, chosen based on cumulative Root Path Cost to the Root Bridge.

III. Elects a designated bridge for LAN segment

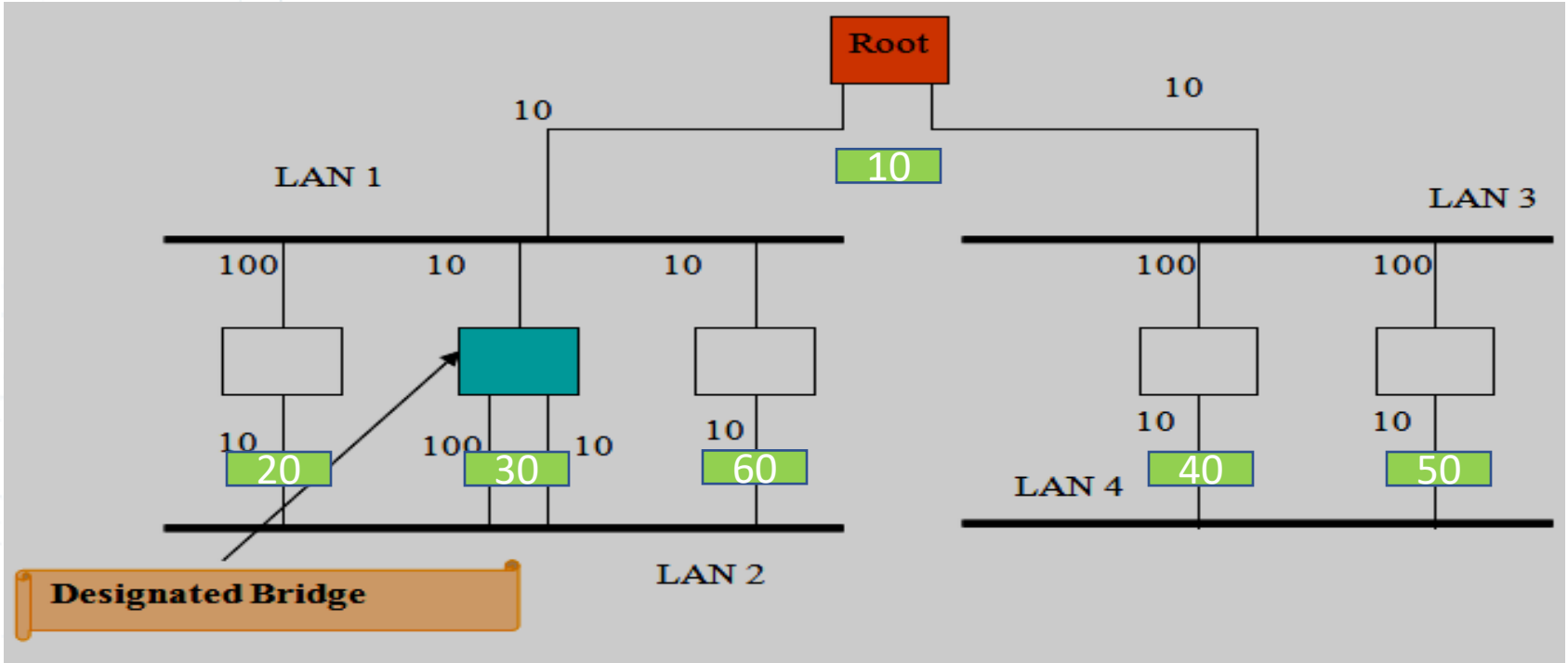
- Designated Bridge is the bridge with the least cost to the root in each LAN segment
- If two LAN segments are have several paths with same cost to the Root Bridge
  - Then select the low BridgeID Bridge as the Designated Bridge
- Designated ports are open and others are blocked

III. Elects a designated bridge for LAN segment

- Designated Bridge is the bridge with the least cost to the root in each LAN segment

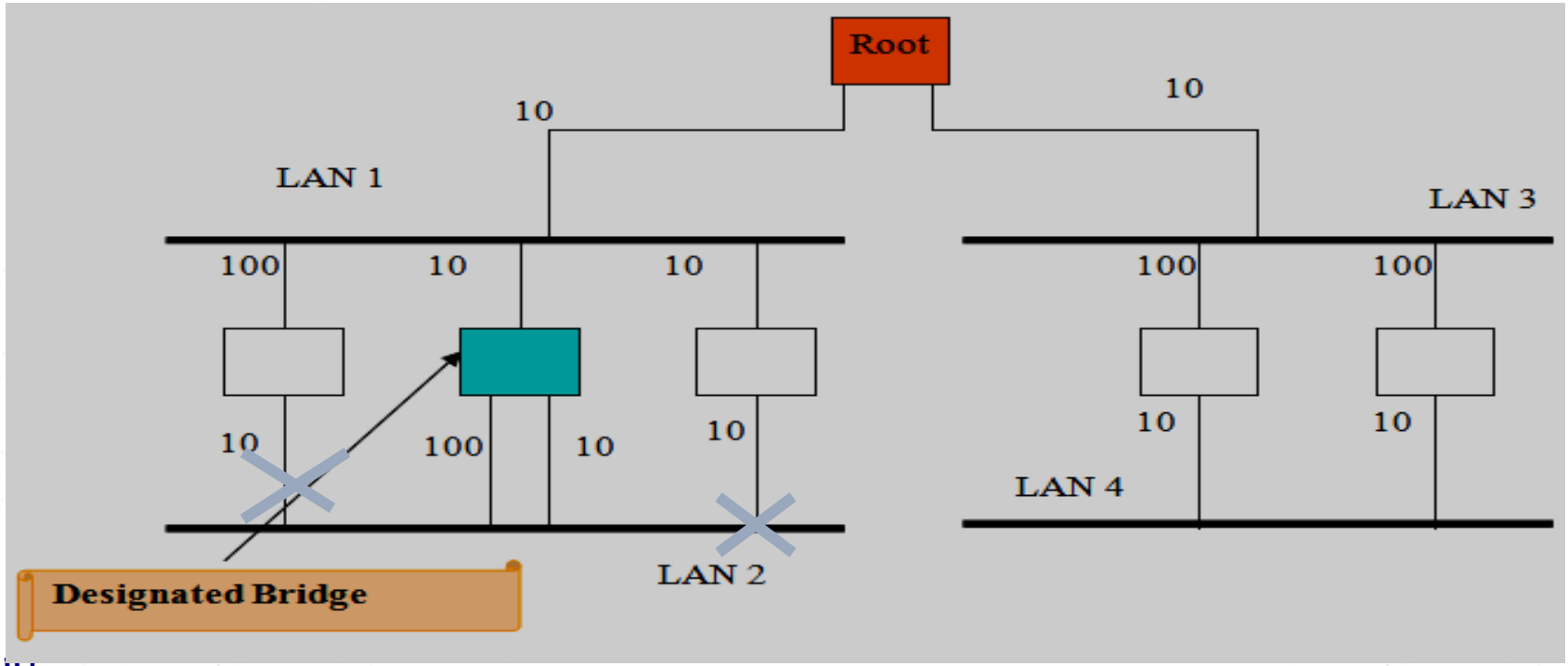


III. Elects a designated bridge for LAN segment cont.



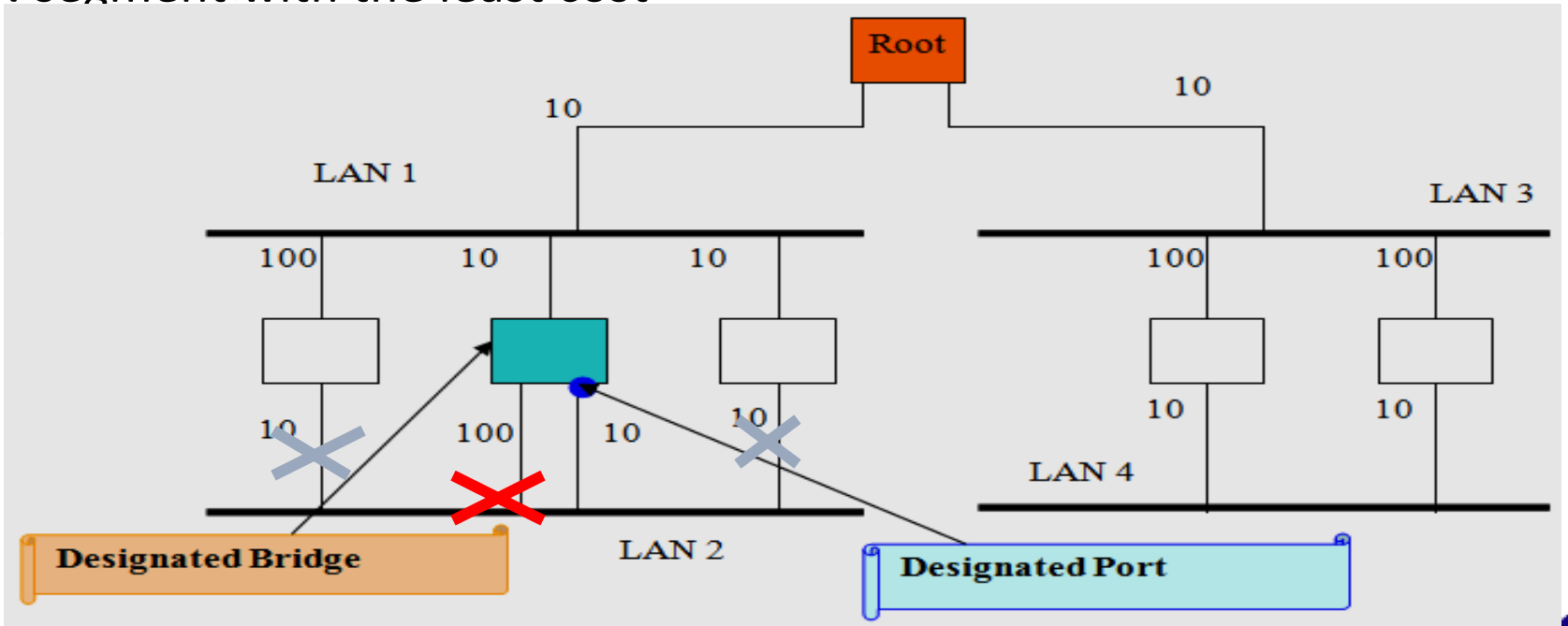
III. Elects a designated bridge for LAN segment cont.

- Path through the designated bridge is open and other paths are blocked



IV. Elects a designated port for designated bridge of LAN segment

- Designated Port is the Port in the designated bridge connected to the LAN segment with the least cost



- Each port on a switch using Spanning-Tree Protocol exists in one of the following five states:
  - Blocking
  - Listening
  - Learning
  - Forwarding
  - Disabled

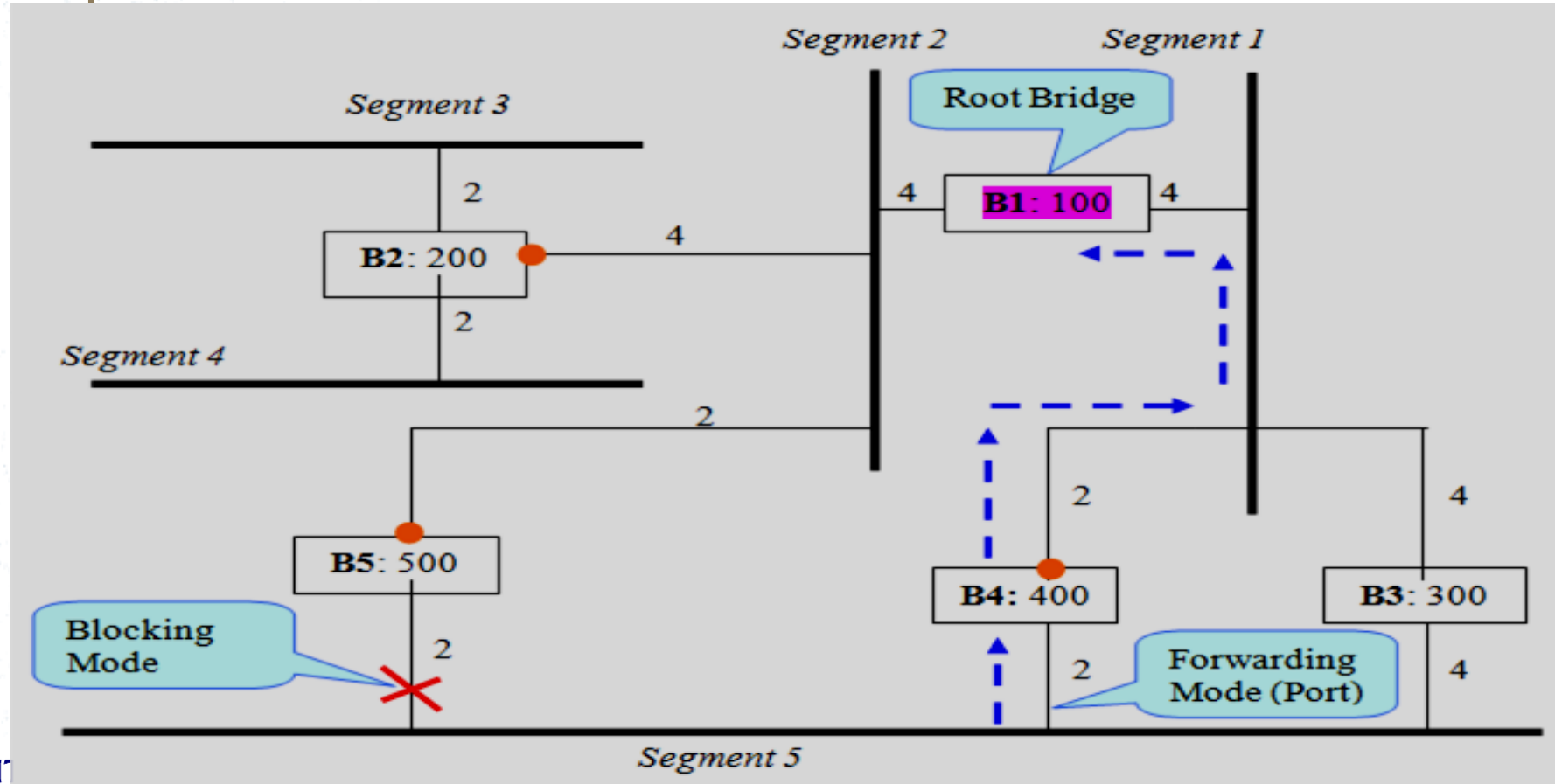
- In the blocking state
  - ports can only receive BPDUs. Data frames are discarded and no addresses can be learned. It may take up to 20 seconds to change from this state.
- In the listening state
  - Ports transition from the blocking state to the listening state. The listening period is called the forward delay and lasts for 15 seconds. In the listening state, data is not forwarded and MAC addresses are not learned. BPDUs are still processed.
- In the learning state
  - Data is not forwarded, but MAC addresses are learned from traffic that is received. The learning state lasts for 15 seconds and is also called the forward delay. BPDUs are still processed.

- In the forwarding state.
  - User data is forwarded and MAC addresses continue to be learned. BPDUs are still processed.
- A port can be in a disabled state. This disabled state can occur when an administrator shuts down the port or the port fails.

Processes	Blocking	Listening	Learning	Forwarding	Disable
Receives and process BPDUs	✓	✓[1]	✓	✓	✗
Forward data frames received on interface	✗	✗	✗	✓	✗
Forward data frames switched from another interface	✗	✗	✗	✓	✗
Learn MAC addresses	✗	✗	✓	✓	✗

[1]Return to blocking if not lowest cost path to root bridge

Example


Segment 2
Segment 1
Segment 3
Root Bridge
2
4
B1: 100
4
B2: 200
4
2
Segment 4
2
2
4
B5: 500
B4: 400
B3: 300
Blocking Mode
2
2
Forwarding Mode (Port)
4
Segment 5