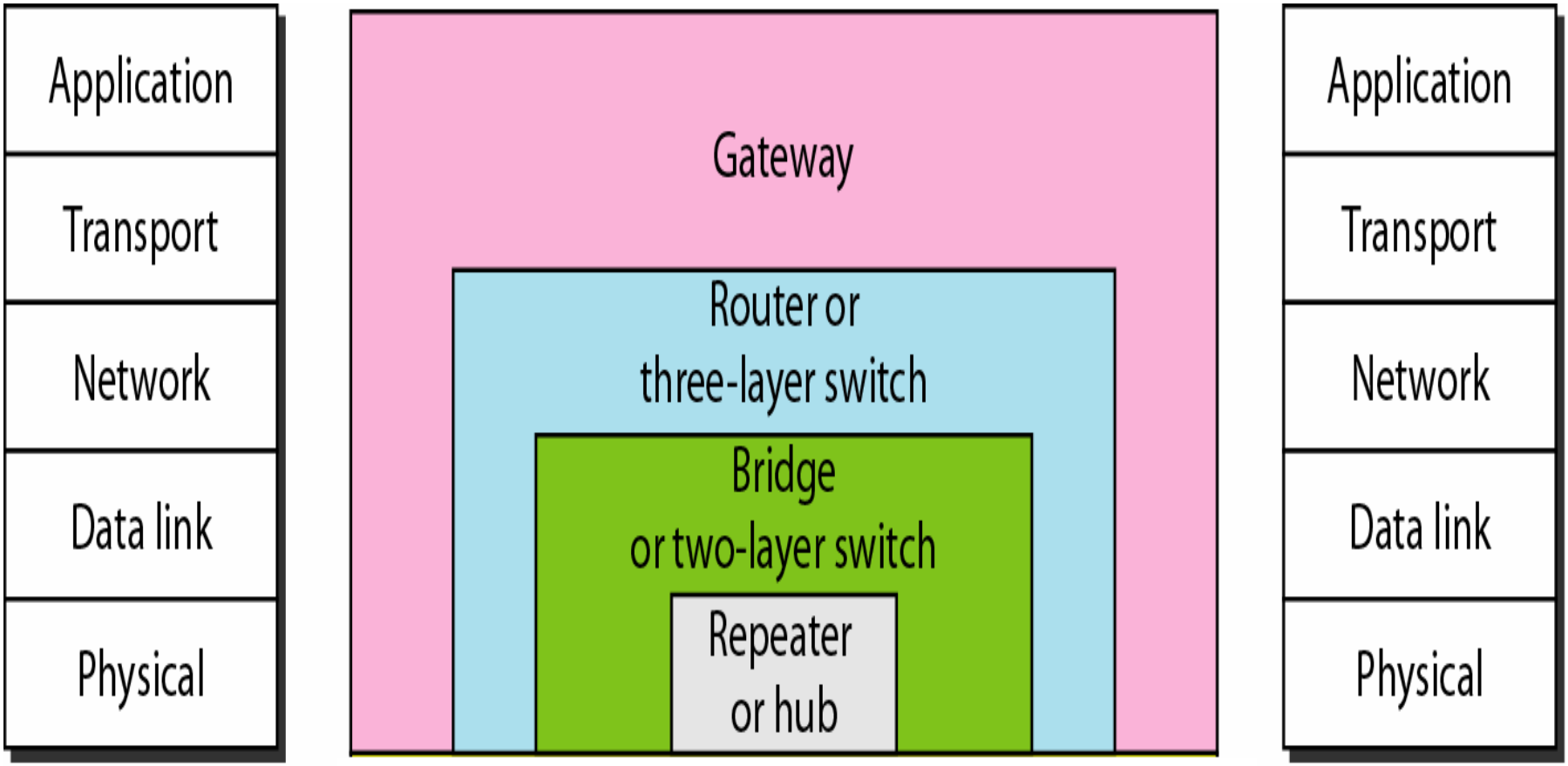
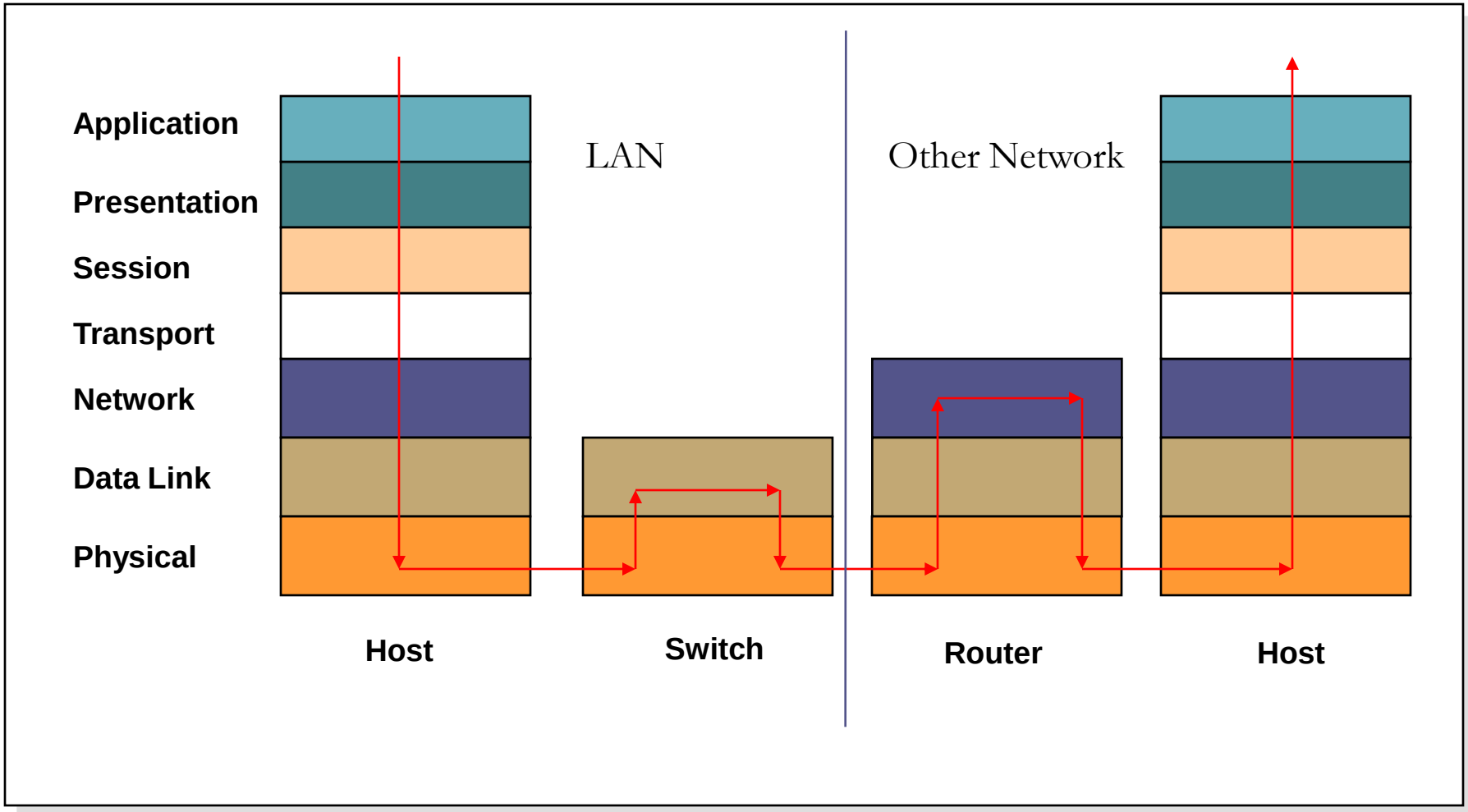
LAN Devices

Five categories of connecting devices



OSI Layers and Locations

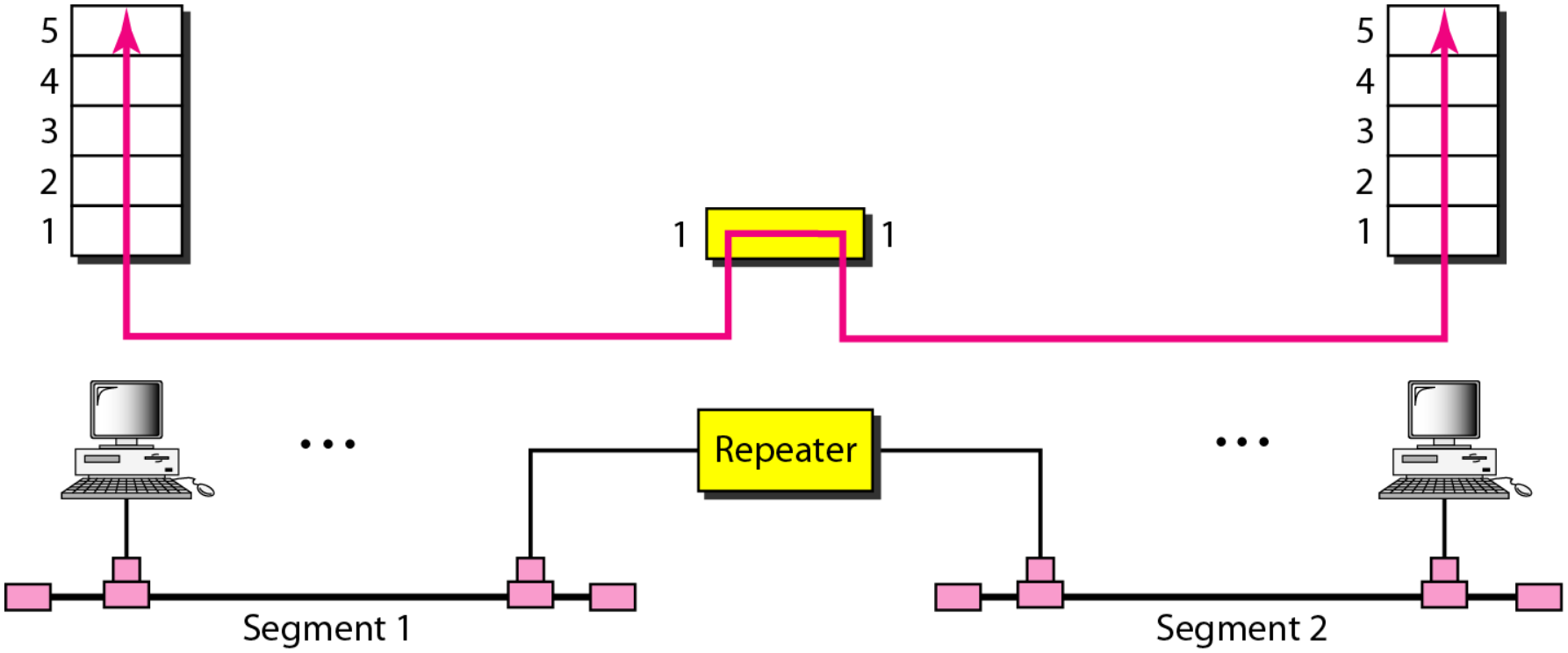


Repeater

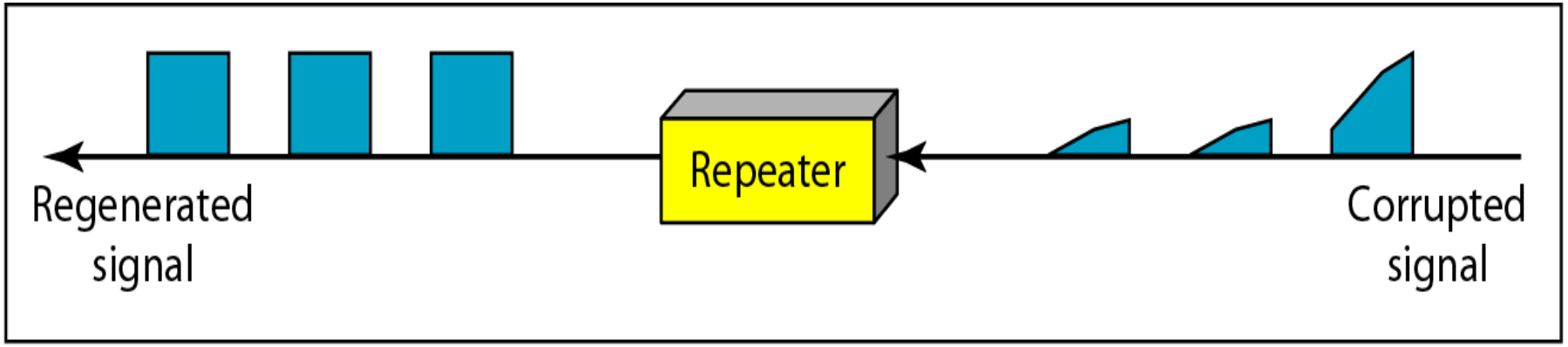
- Operates only in physical Layer
- A repeater connects segments of a LAN (ie a pair of Ethernet)
- A repeater forwards every frame; it has no filtering capability.
- Has 2 ports
- A repeater is a regenerator, not an amplifier.

Repeater Cont…

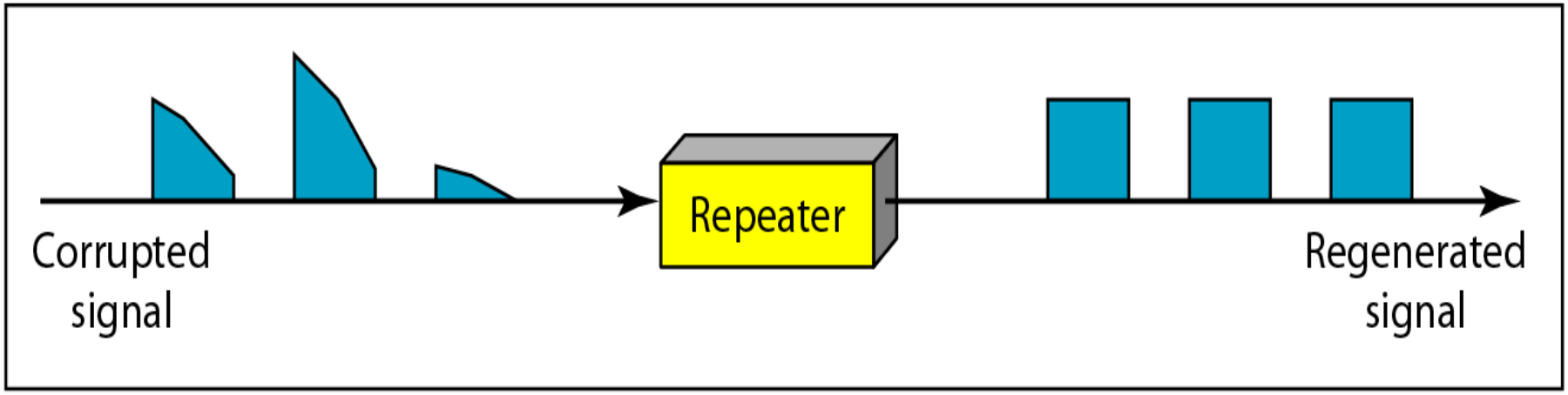
- A repeater installed on a link receives the signal before it becomes weak, regenerates the original bit pattern, and put the refreshed copy back onto the link.



Repeater Cont…



a. Right-to-left transmission.



b. Left-to-right transmission.

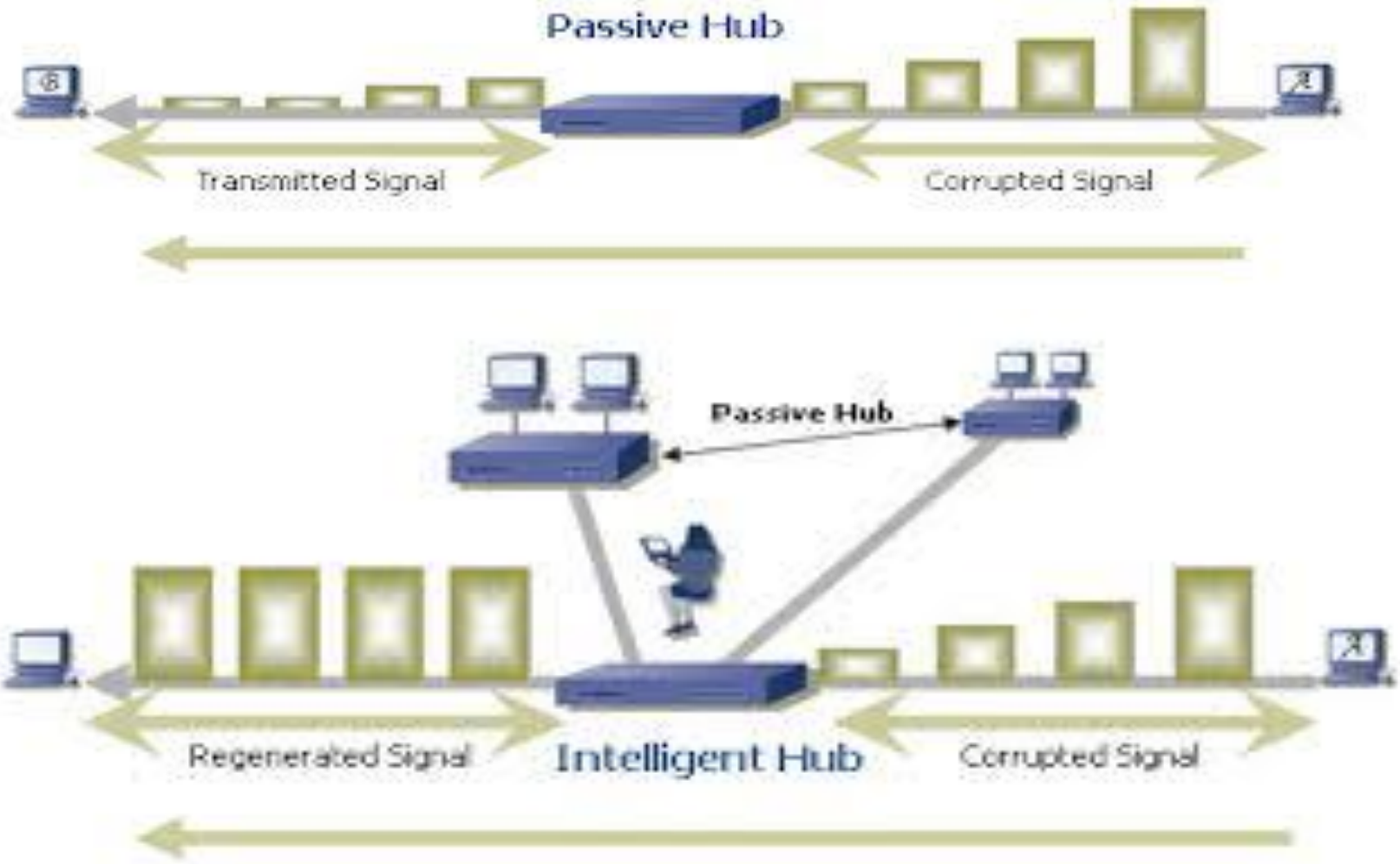
Hub

- Similar to Repeater, hub forwards the data
- More than 2 ports
- Allows multiple machines to connect to the same network, by broadcasting traffic to all of its ports.
- Passive Hub
- Active Hub

Passive Hub Vs Active Hub

- A Passive Hub is just a connector.
- It connects the wires coming from different hubs.
- Passive hub will not regenerate the signal
- An active hub acts as a multiport repeater.
- Active hub will regenerate the signal. so active hub is better.
- Hub can be used Hierarchically

Passive Hub Vs Active Hub



Bridges

- Layer 2 Device
- Bridges are used to connect LANs
- Class of switches that is used to forward packets between shared-media LANs such as Ethernets

Bridges

- A pair of Ethernets to be interconnect is done in 2 ways:

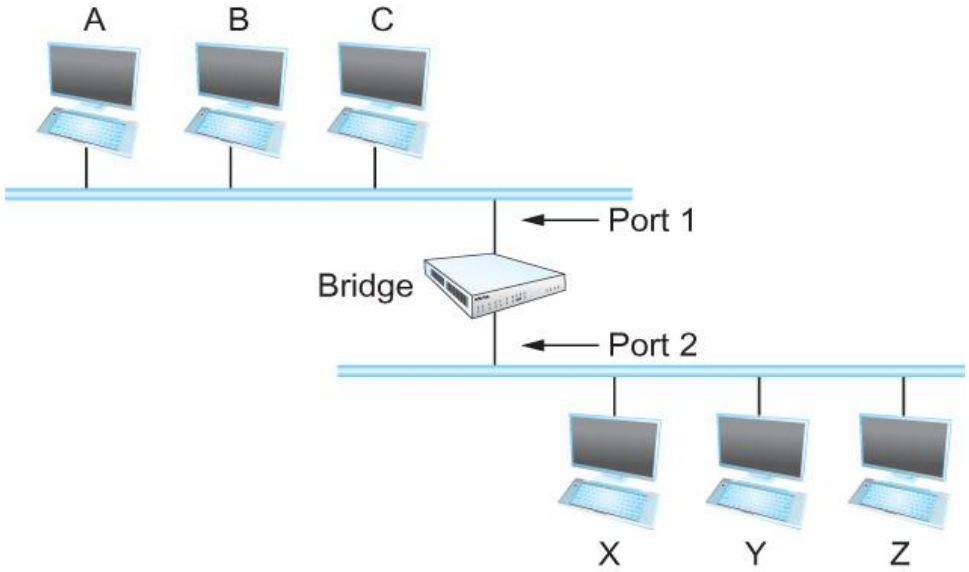
1. Put a repeater in between them
   - It might exceed the physical limitation of the Ethernet
     - No more than four repeaters between any pair of hosts
     - No more than a total of 2500 m in length is allowed
2. Put a node between the two Ethernets and make the node to forward frames from one Ethernet to the other
   - This node is called a **Bridge**
   - A collection of LANs connected by one or more bridges is usually said to form an **Extended LAN**

Bridges

- Simplest Strategy for Bridges
  - Accept LAN frames on their inputs and forward them out to all other outputs
  - Used by early bridges
- Learning Bridges
  - Observe that there is no need to forward all the frames that a bridge receives

Bridges

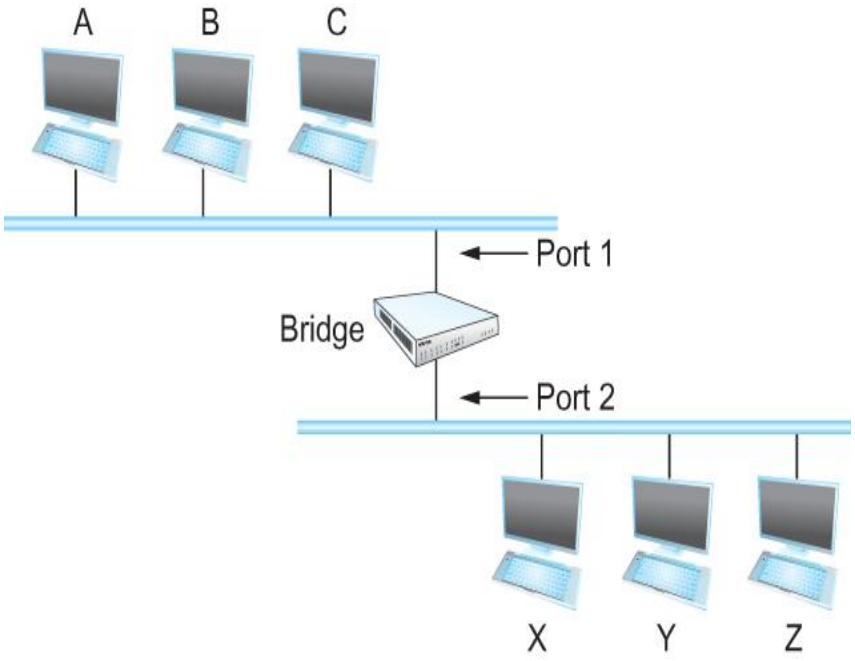
- When a frame from host A that is addressed to host B arrives on port 1, there is no need for the bridge to forward the frame out over port 2.



- How does a bridge come to learn on which port the various hosts reside?

Bridges

- Maintain a table in the bridge



Host	Port
A	1
B	1
C	1
X	2
Y	2
Z	2

- Who does the manipulation?
  - Human
    - Too much work for maintenance

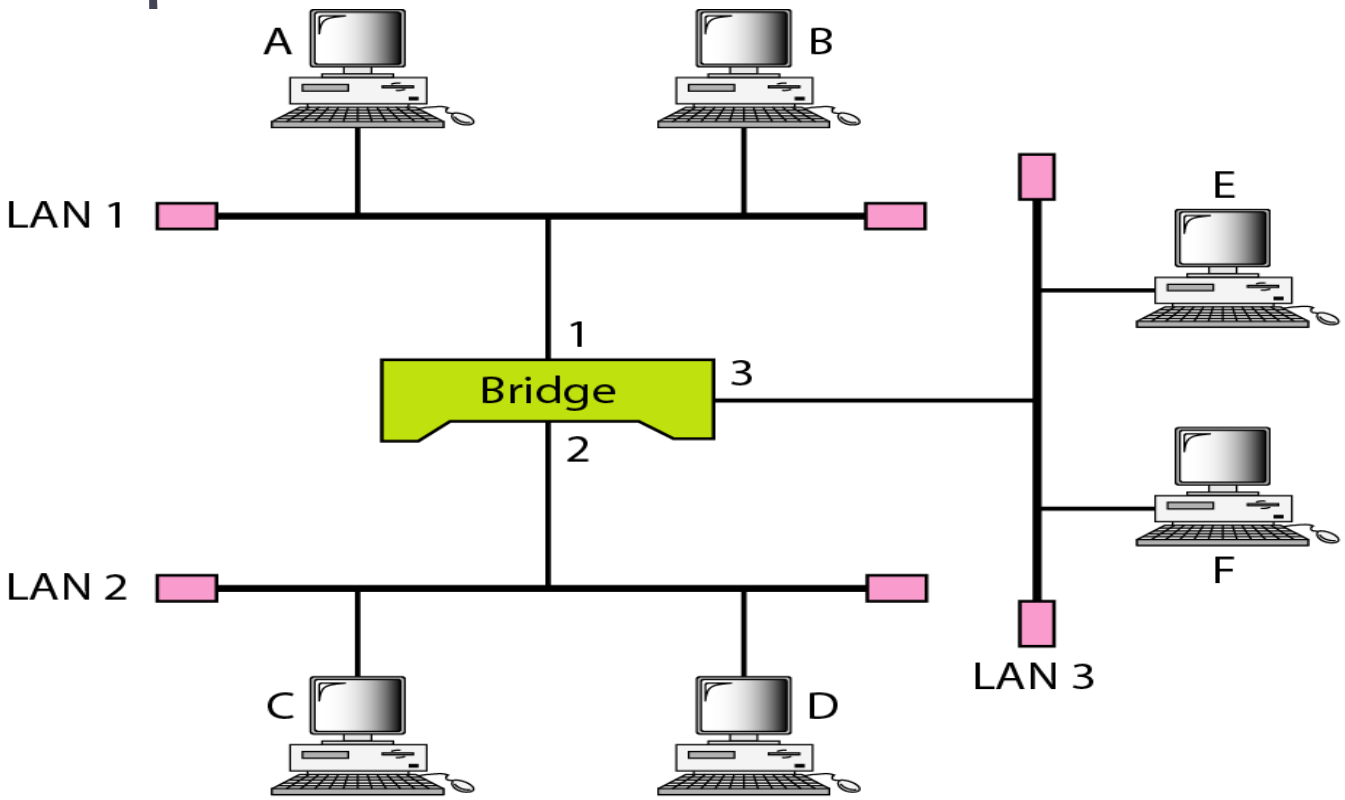
Learning Bridge

- Can the bridge learn this information by itself?
  - Yes
- Each bridge inspects the source address in all the frames it receives
- Initially the bridge is empty, and entries are added overtime.
- Time out is associated with each entry. Therefore discards the entry after a specific period of time.
- This is to avoid the situation such as , host moved to another network.

Learning Bridge

- If the bridge receives a frame that is addressed to host not currently in the table
  - Forward the frame out on all other ports
- When host A sends a frame to a host on either side of the bridge, the bridge receives this frame and records the fact that a frame from host A was just received on port 1.
- This way the bridge can built the table.

Example



Address	Port

a. Original

Address	Port
A	1

b. After A sends a frame to D

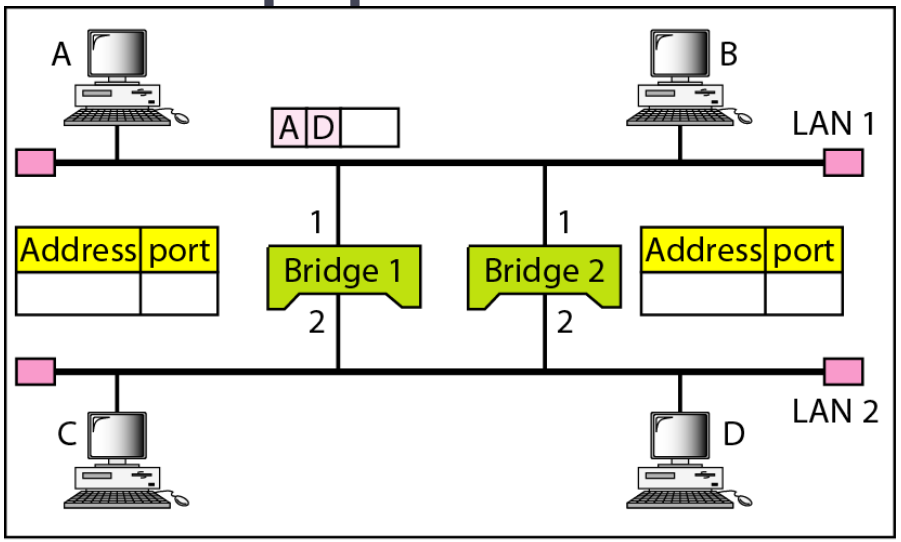
Address	Port
A	1
E	3

c. After E sends a frame to A

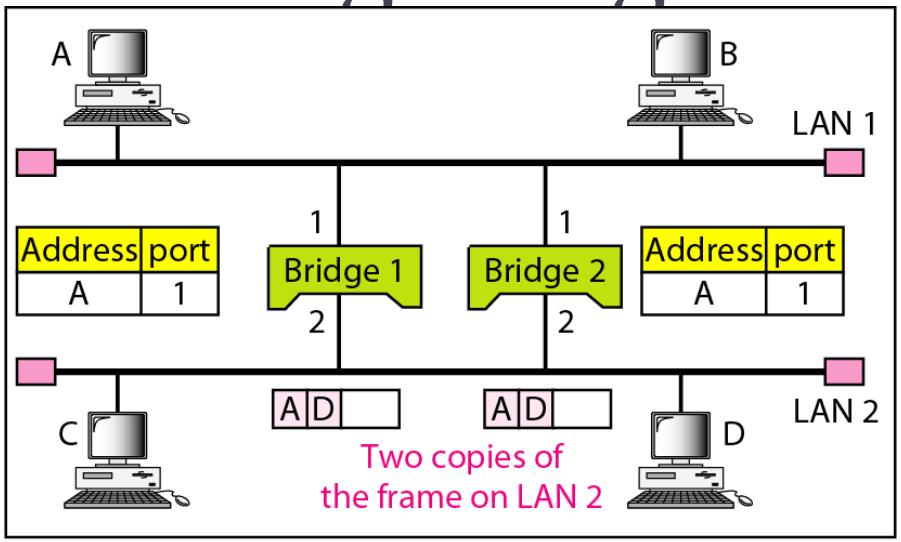
Address	Port
A	1
E	3
B	1

d. After B sends a frame to C

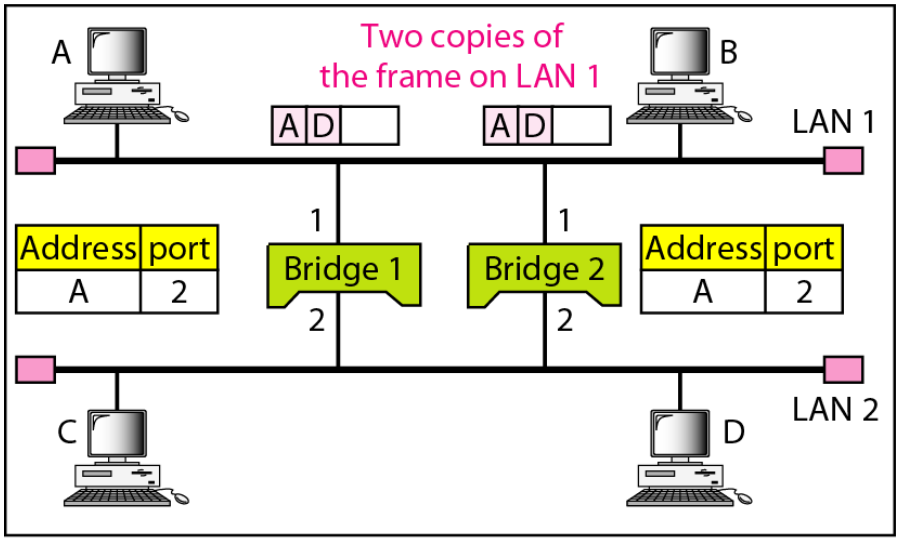
Loop problem in a learning bridge



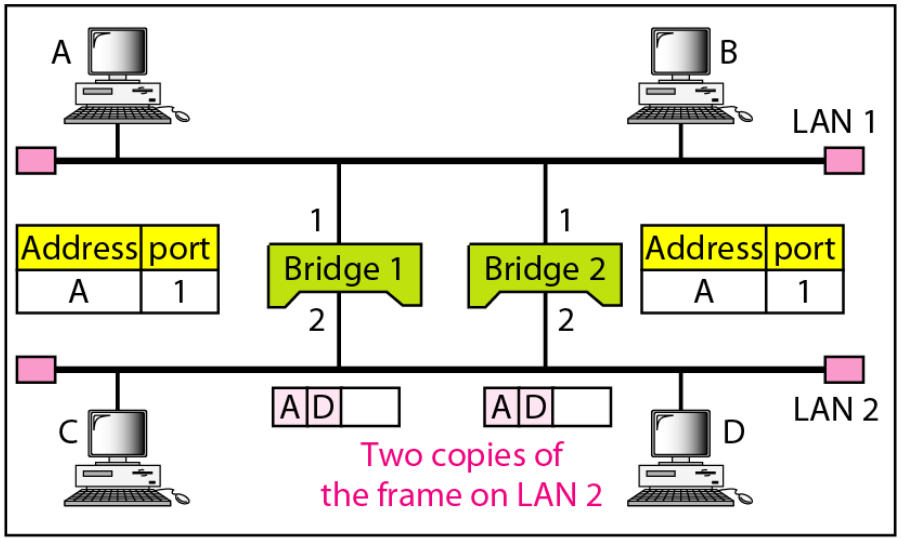
a. Station A sends a frame to station D



b. Both bridges forward the frame



c. Both bridges forward the frame



d. Both bridges forward the frame

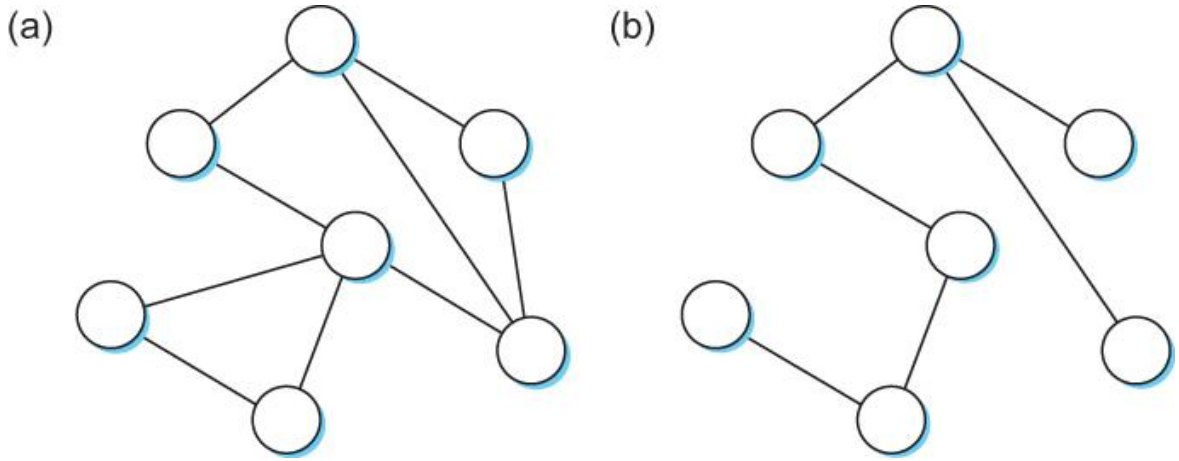
Loop problem in a learning bridge

- How does an extended LAN come to have a loop in it?
  - Network is managed by more than one administrator
    - For example, it spans multiple departments in an organization
    - It is possible that no single person knows the entire configuration of the network
      - A bridge that closes a loop might be added without anyone knowing
  - Loops are built into the network to provide redundancy in case of failures

- Solution
  - Distributed Spanning Tree Algorithm

Spanning Tree Algorithm

- The extended LAN as being represented by a graph that possibly has loops (cycles)
- A spanning tree is a sub-graph of this graph that covers all the vertices but contains no cycles
  - Spanning tree keeps all the vertices of the original graph but throws out some of the edges



Example of (a) a cyclic graph; (b) a corresponding spanning tree.

Spanning Tree Algorithm

- Each bridge decides the ports over which it is willing and is not willing to forward frames
  - It is by removing ports from the topology that the extended LAN is reduced to an acyclic tree
  - It is even possible that an entire bridge will not participate in forwarding frames
- Algorithm is dynamic
  - The bridges are always prepared to reconfigure themselves into a new spanning tree if some bridges fail

- Main idea
  - Each bridge selects the ports over which they will forward the frames

Port Selection

- Each bridge has a unique identifier.
  - The labels are B1, B2, B3, and so on
- Elect the bridge with the smallest id as the root of the spanning tree
- The root bridge always forwards frames out of its ports.

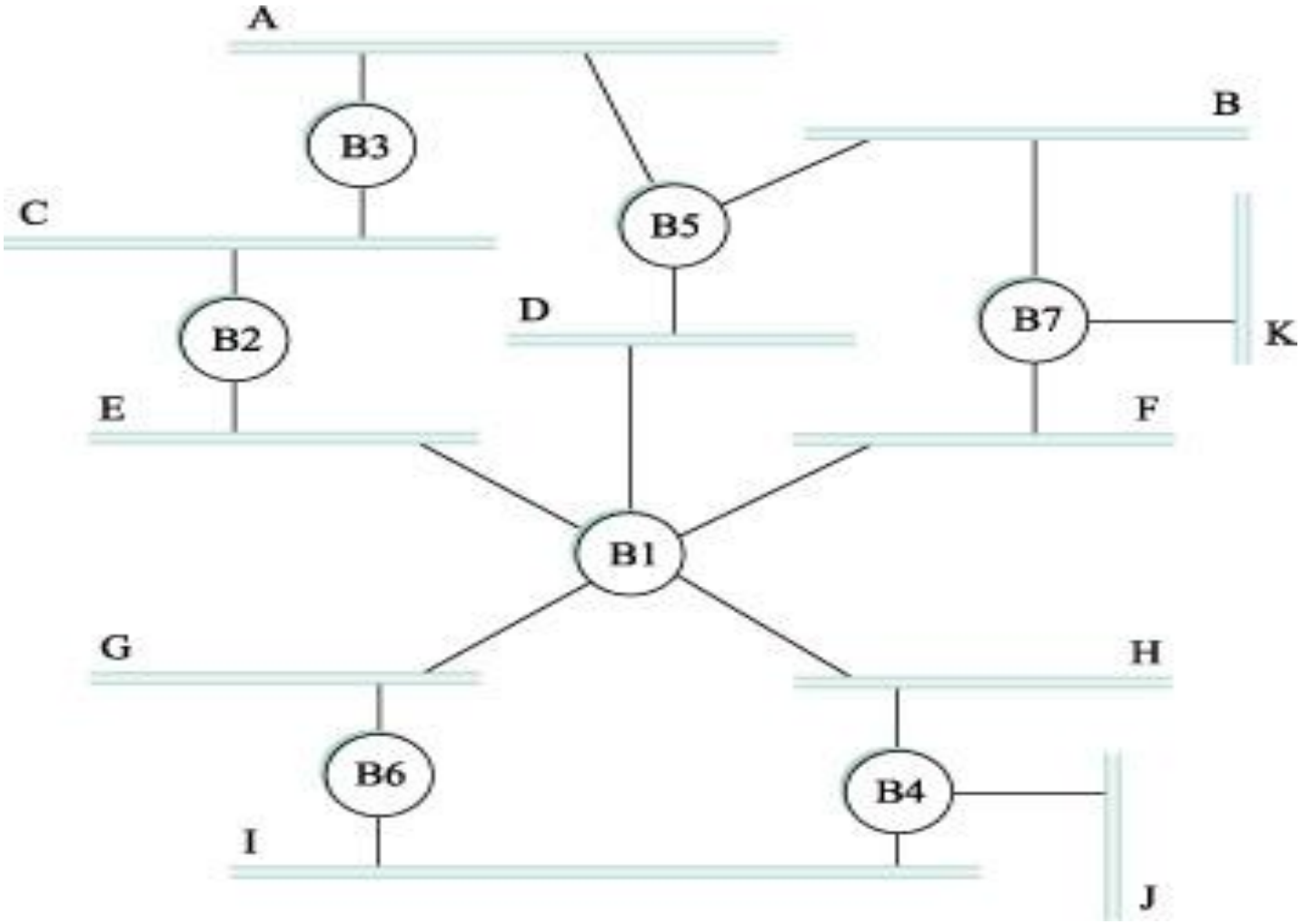
Port Selection

- Each bridge computes the shortest path to the root and make a note of its port in this path.
  - This port is also selected as the bridge's preferred path to the root.
- Finally, all the bridges connected to a given LAN elect a single designated bridge which is responsible for forwarding frames toward the root bridge

Port Selection

- Each LAN's designated bridge is the one that is closest to the root
- If two or more bridges are equally close to the root,
  - Then select bridge with the smallest id
- Each bridge is connected to more than one LAN
  - So it participates in the election of a designated bridge for each LAN it is connected to.
  - Each bridge decides if it is the designated bridge relative to each of its ports
  - The bridge forwards frames over those ports for which it is the designated bridge

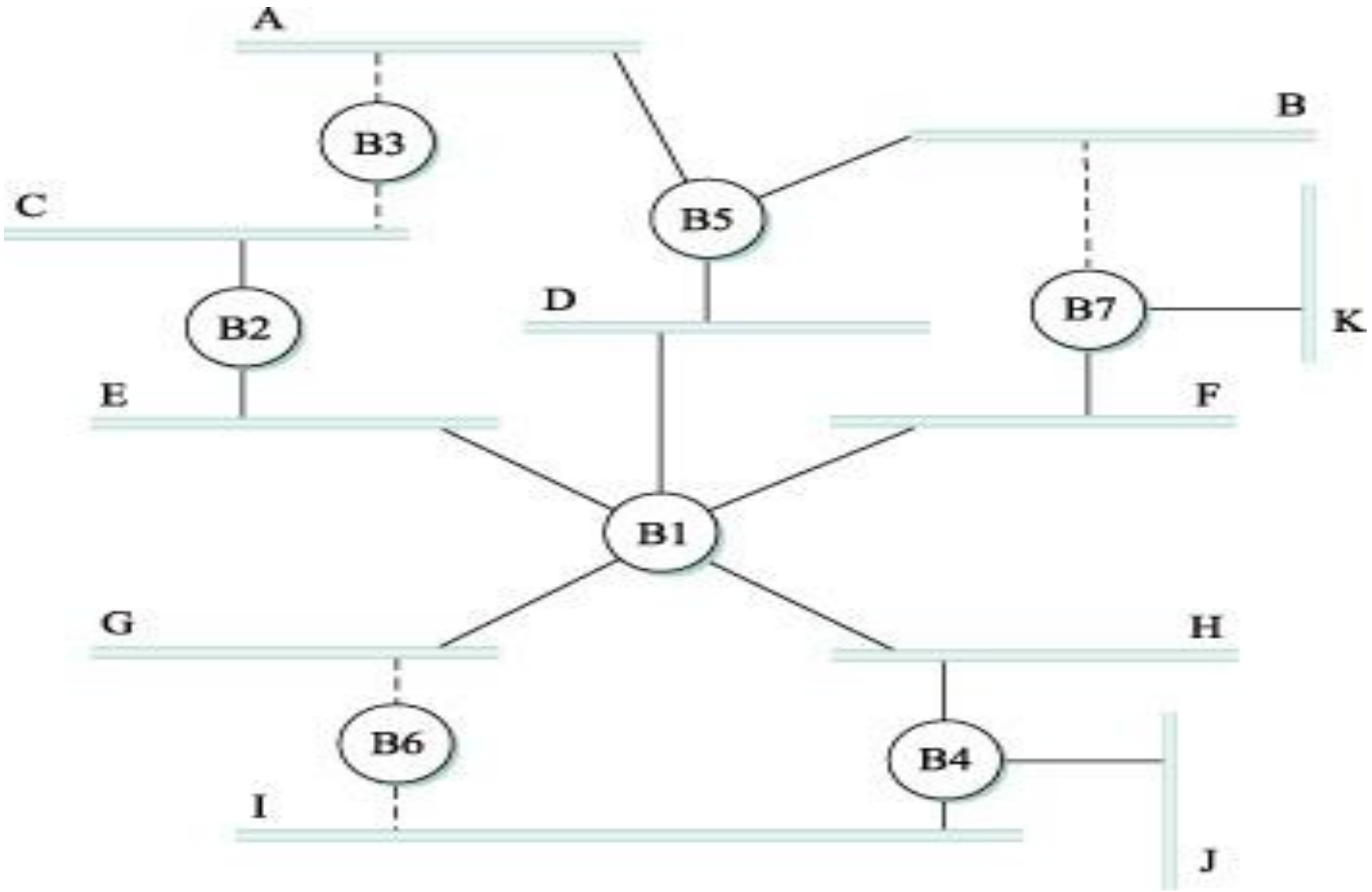
Example



Port Selection

- B1 is the root bridge, since it has the smallest id.
- Both B3 and B5 are connected to LAN A, but B5 is the designated bridge since it is closer to the root.
- Both B5 and B7 are connected to LAN B, but in this case, B5 is the designated bridge since it has the smaller id; both are an equal distance from B1.

Port Selection



Root Bridge Selection

- If the entire extended LAN is large, how the bridges selects the root bridge???
- The bridges has to communicate between them.
  - send some configuration messages to all the bridges in the extended LAN

Root Bridge Selection

- The configuration messages contain three pieces of information:
  1. The id for the bridge that is sending the message
  2. The id for what the sending bridge believes to be the root bridge
  3. The distance, measured in hops, from the sending bridge to the root bridge

Root Bridge Selection

- The bridge checks, if that new message is better than the current best configuration message recorded for that port.
- The new configuration message is considered "better" than the currently recorded information if
  1. It identifies a root with a smaller id or
  2. It identifies a root with an equal id but with a shorter distance or
  3. The root id and distance are equal, but the sending bridge has a smaller id
- If the new message is better than the currently recorded information, the bridge discards the old information and saves the new information

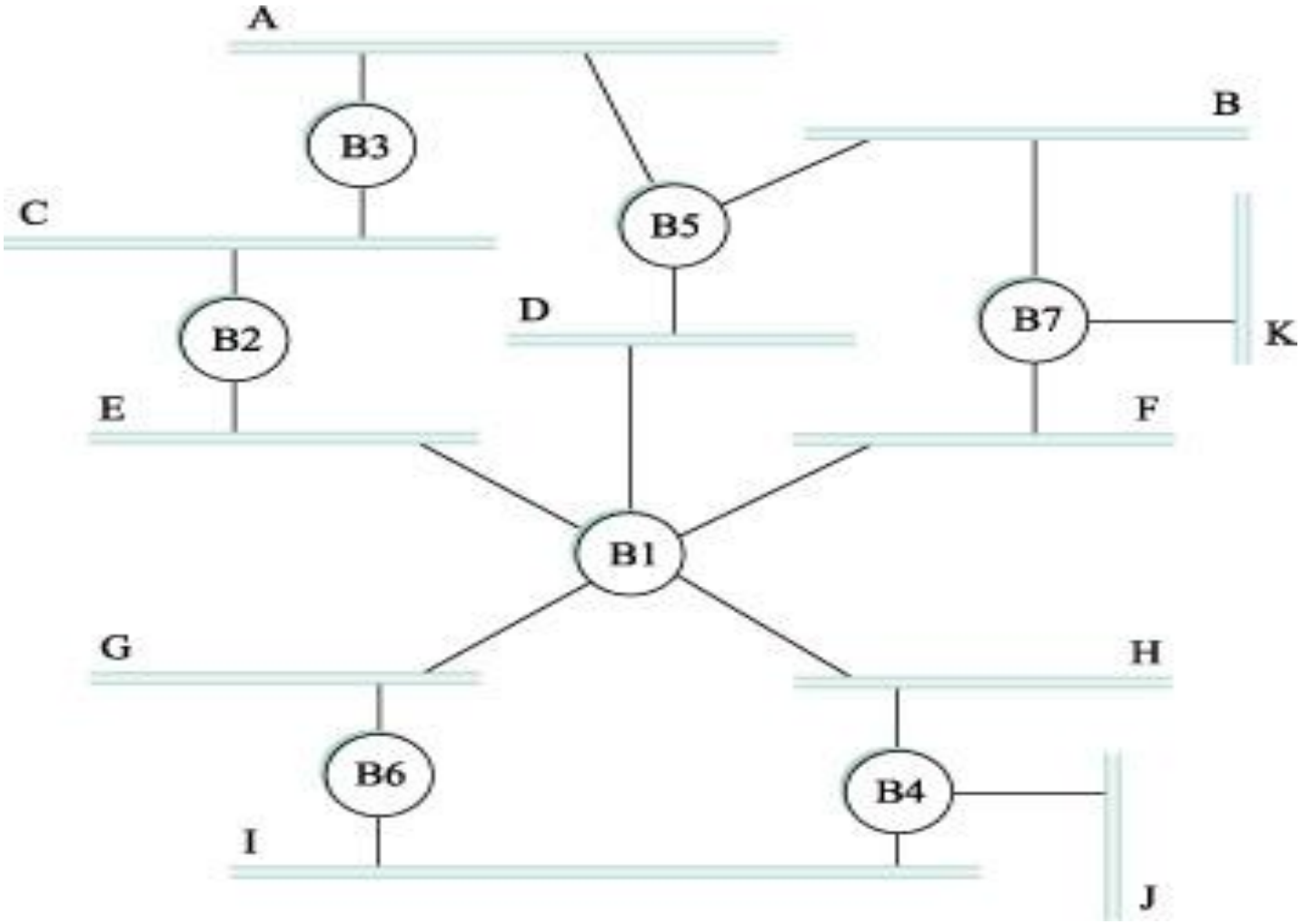
Example

- If the power had just been restored to the this network, so that all the bridges boot at about the same time.
- All the bridges would start off by claiming to be the root.
- Denote a configuration message from node *X in which it claims to* be distance *d from root node Y as (Y, d, X). Focusing on the activity at node B3.*
- A sequence of events would unfold as follows:

Example

1. B3 receives (B2, 0, B2).
2. Since 2 < 3, B3 accepts B2 as root.
3. B3 adds one to the distance advertised by B2 (0) and thus sends (B2, 1, B3) toward B5.
4. Meanwhile, B2 accepts B1 as root because it has the lower id, and it sends (B1, 1, B2) toward B3.
5. B5 accepts B1 as root and sends (B1, 1, B5) toward B3.
6. B3 accepts B1 as root, and it notes that both B2 and B5 are closer to the root than it is.
   - Thus B3 stops forwarding messages on both its interfaces.
   - This leaves B3 with both ports not selected

Example



Spanning Tree Algorithm

- Even after the system has stabilized, the root bridge continues to send configuration messages periodically
  - Other bridges continue to forward these messages
- When a bridge fails, the downstream bridges will not receive the configuration messages
- After waiting a specified period of time, they will once again claim to be the root and the algorithm starts again

- Note
  - Although the algorithm is able to reconfigure the spanning tree whenever a bridge fails, it is not able to forward frames over alternative paths for the sake of routing around a congested bridge

Bridging versus LAN Switching

- Layer-2 switches are really just bridges with more ports. However, there are some important differences you should be aware of:
  - Bridges are software based, while switches are hardware based
  - Bridges can only have one spanning-tree instance per bridge, while switches can have many.
  - Bridges can only have up to 16 ports, whereas a switch can have hundreds.