DATA COMMUNICATIONS AND NETWORKING

Connecting LANs, Backbone Networks, and Virtual LANs

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2ndYear, 1st Semester

Outline

- Connecting devices
- Backbone networks
- Virtual LANs
- Summary

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CONNECTING DEVICES

- LANs do not normally operate in isolation. They are connected to one another or to the Internet. To connect LANs, or segments of LANs, we use connecting devices. Connecting devices can operate in different layers of the Internet model. we discuss only those that operate in the physical and data link layers.

➢ CONNECTING DEVICES

- The connecting devices divide into five different categories based on layer in which they operate in a network, as shown in figure 1.

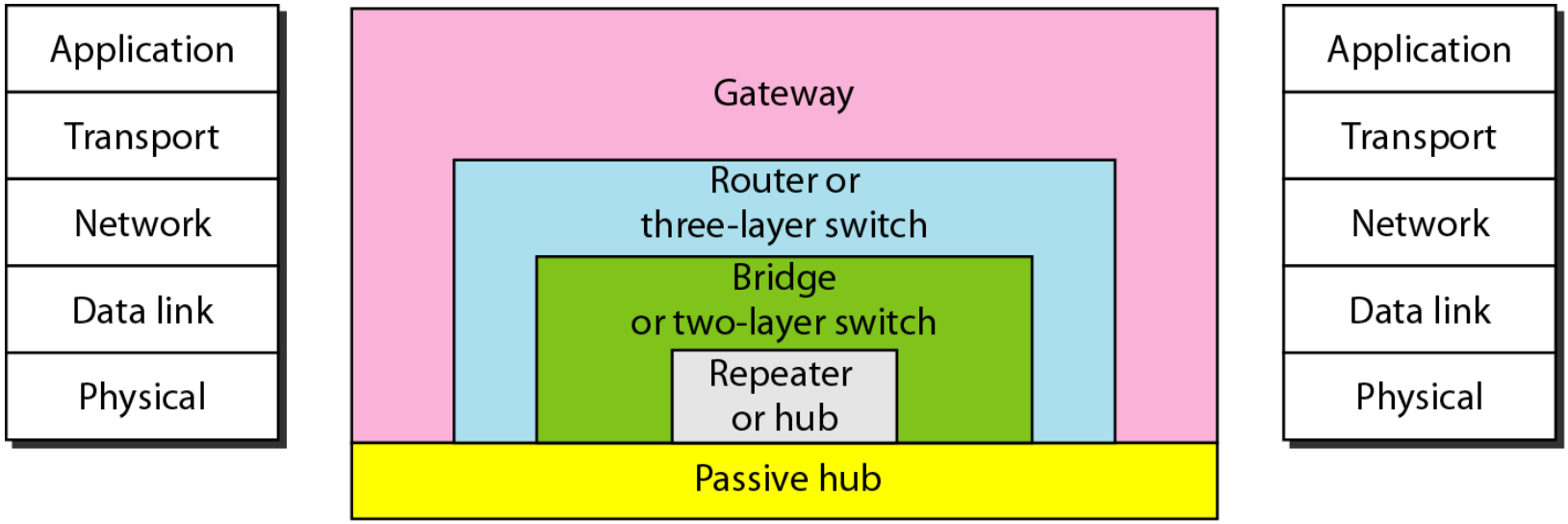

Figure 1. Five categories of connecting devices

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CONNECTING DEVICES (continue…)

- The five categories contain devices which can be defined as:
- 1. Those which operate below the physical layer such as a passive hub.
- 2. Those which operate at the physical layer (a repeater or an active hub).
- 3. Those which operate at the physical and data link layers (a bridge or a two-layer switch).
- 4. Those which operate at the physical, data link, and network layers (a router or a three-layer switch).
- 5. Those which can operate at all five layers (a gateway).

➢ Passive Hubs

- A passive hub is just a connector. It connects the wires coming from different branches. In a star-topology Ethernet LAN, a passive hub is just a point where the signals coming from different stations collide; the hub is the collision point. This type of a hub is part of the media; its location in the Internet model is below the physical layer.

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CONNECTING DEVICES (continue…)

➢ Repeaters

- A repeater operates only in the physical layers
- A repeater does not actually connect two LANs; it connects two segments of same LAN. A repeater is not a device that can connect two LANs of different protocols. A repeater connects segments of a LAN, as shown in figure 2.
- A repeater forwards every frame; it has no filtering capability.
- The repeater is a two-port device that extends the LANs' physical length.
- A repeater is a regenerator, not an amplifier, as shown in figure 3.

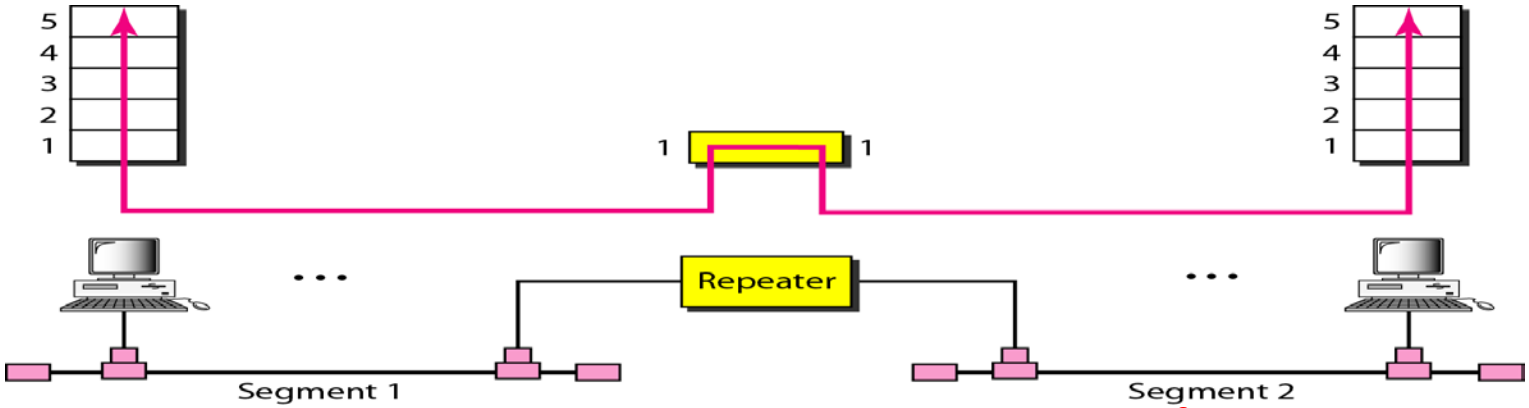

Figure 2. A repeater connecting two segments of a LAN

- Note: An amplifier cannot discriminate between the intended signal and noise; it amplifies equally everything fed into it. A repeater does not amplify the signal; it regenerates the signal. When it receives a weakened or corrupted signal, it creates a copy, bit for bit, at the original strength.

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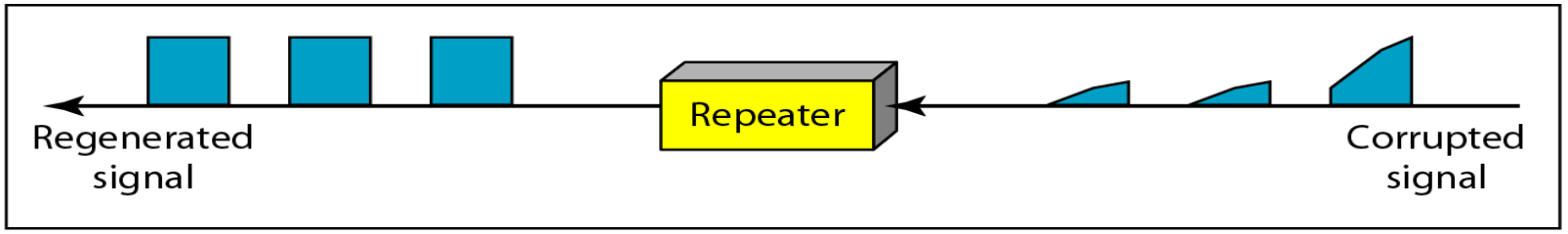
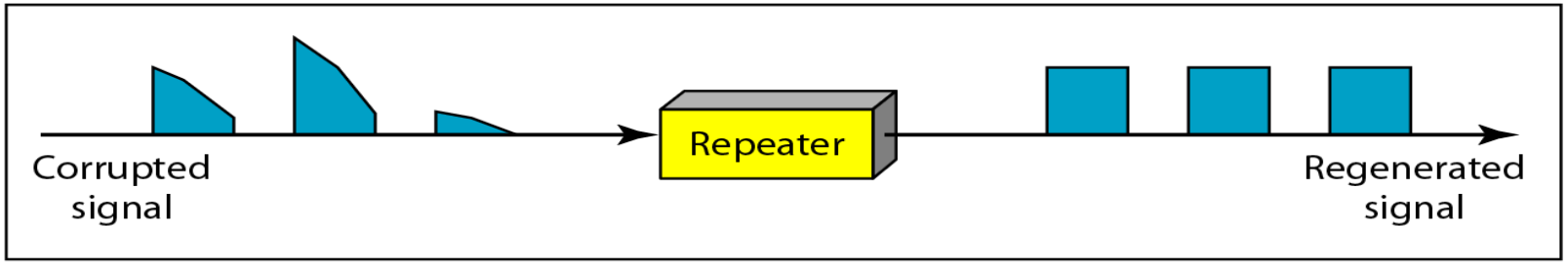
CONNECTING DEVICES (continue…)

➢ Repeaters (continue…)



a. Right-to-left transmission.



b. Left-to-right transmission.

Figure 3. Function of a repeater

➢ Active Hubs

- An active hub is actually a multiport repeater.
- It is normally used to create connections between stations in a star topology.
- Hubs can also be used to create multiple levels of hierarchy; removing the length limitation of 10Base-T (100m).

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CONNECTING DEVICES (continue…)

- Active Hubs (continue…)

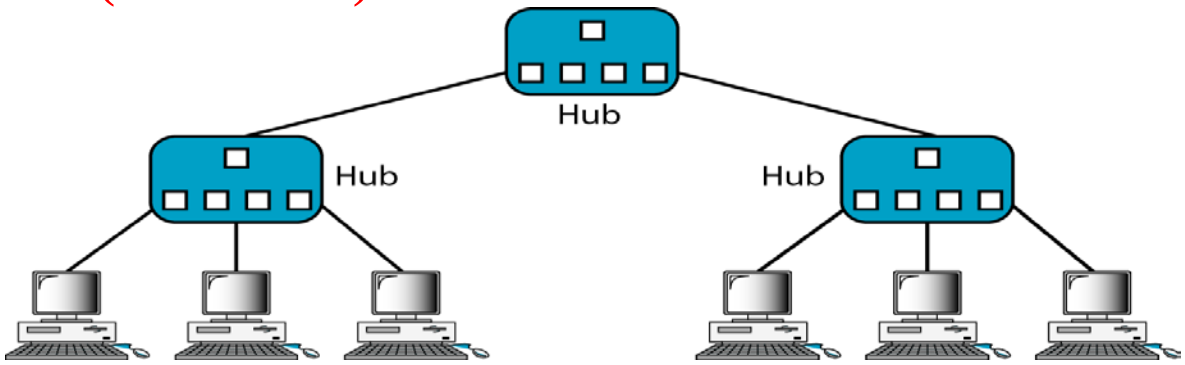
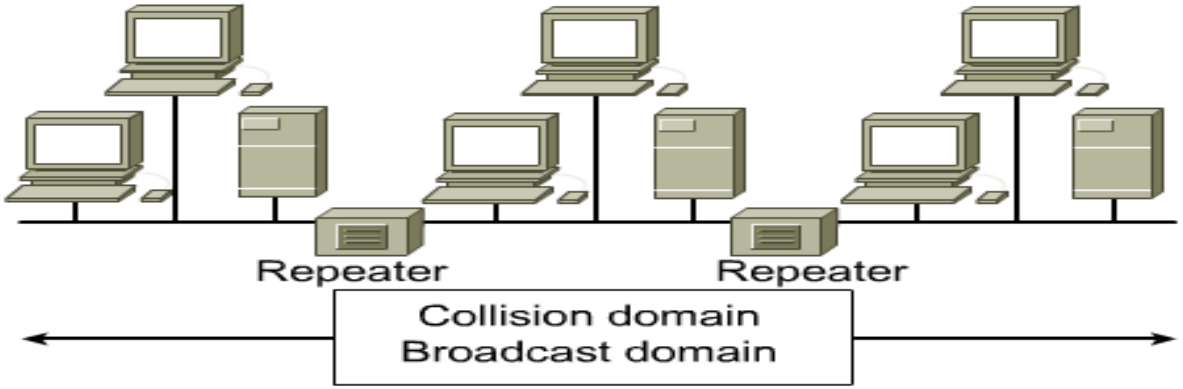


Figure 4. A hierarchy of hubs

- Repeaters/Hubs



- Repeaters are a Layer 1 device that regenerates the signal, and passes it on
- Repeaters allow a longer end to end distance
- Repeaters increase the collision domain size
- Repeaters increase the broadcast domain size

Figure 5. Repeaters and Hubs

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CONNECTING DEVICES (continue…)

- Bridges
- A bridge operates in both physical and data link layers.
- Filtering
- What is the difference in functionality between a bridge and a repeater?
- A bridge has filtering capability. It can check the destination address of a frame and decide if the frame should be forwarded or dropped. If the frame is to be forwarded, the decision must specify the port. A bridge has a table that maps addresses to ports, as shown in figure 6.
- A bridge has filtering capability: Having a table used in filtering decisions.
- A bridge can check, does not change physical (MAC) addresses in a frame.

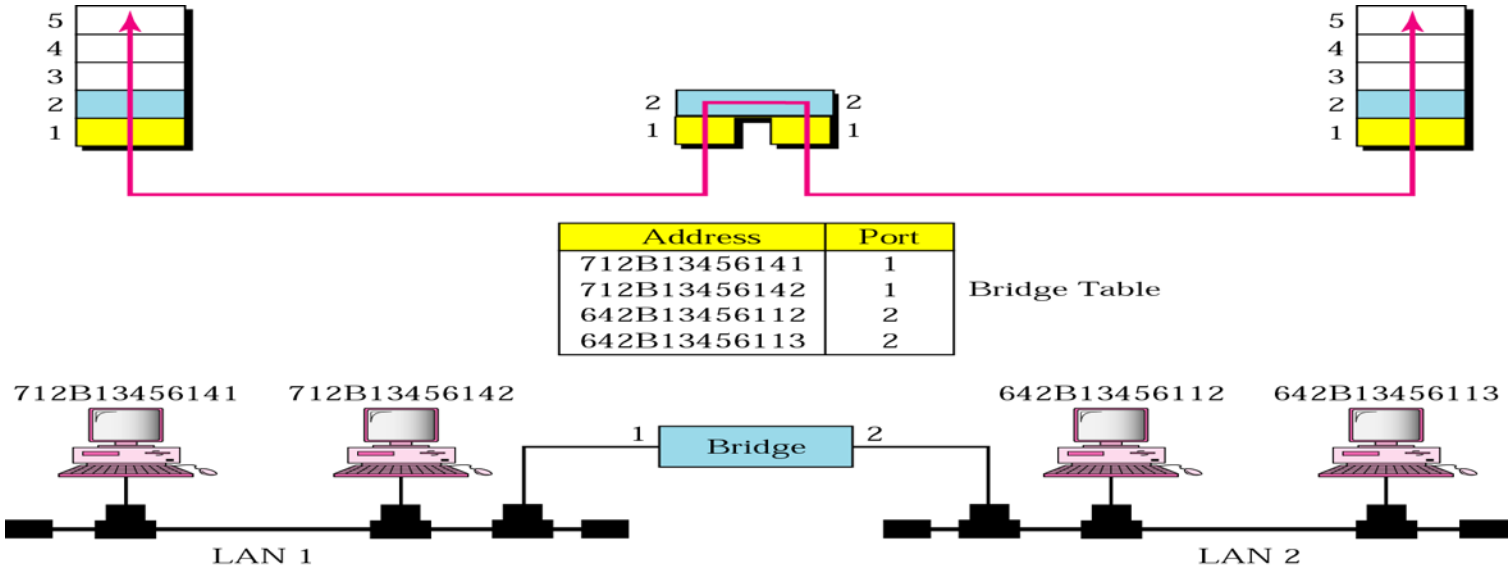

Figure 6. A bridge connecting two LANs

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CONNECTING DEVICES (continue…)

- Bridges (continue…)
- Transparent bridges
- A bridge in which the stations are completely unaware of the bridge's existence. Three criteria for a transparent bridge:-

1. Frames must forward from one station to another
2. The forwarding table is automatically made by learning frame movements in the network
3. Loops in the system must be prevented.

- Forwarding: A transparent bridge must correctly forward the frames
- Learning:
- The earliest bridges had forwarding tables that were static. The systems administrator would manually enter each table entry during bridge setup. Although the process was simple, it was not practical. If a station was added or deleted, the table had to be modified manually.
- A better solution to the static table is a dynamic table that maps addresses to ports automatically.
- To make a table dynamic, we need a bridge that gradually learns from the frame movements. To do this, the bridge inspects both the destination and the source addresses. The destination address is used for the forwarding decision; the source address is used for adding entries to the table and for updating purposes, as shown in figure 7.

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CONNECTING DEVICES (continue…)

- Bridges (continue…)
- Transparent bridges (continue…)

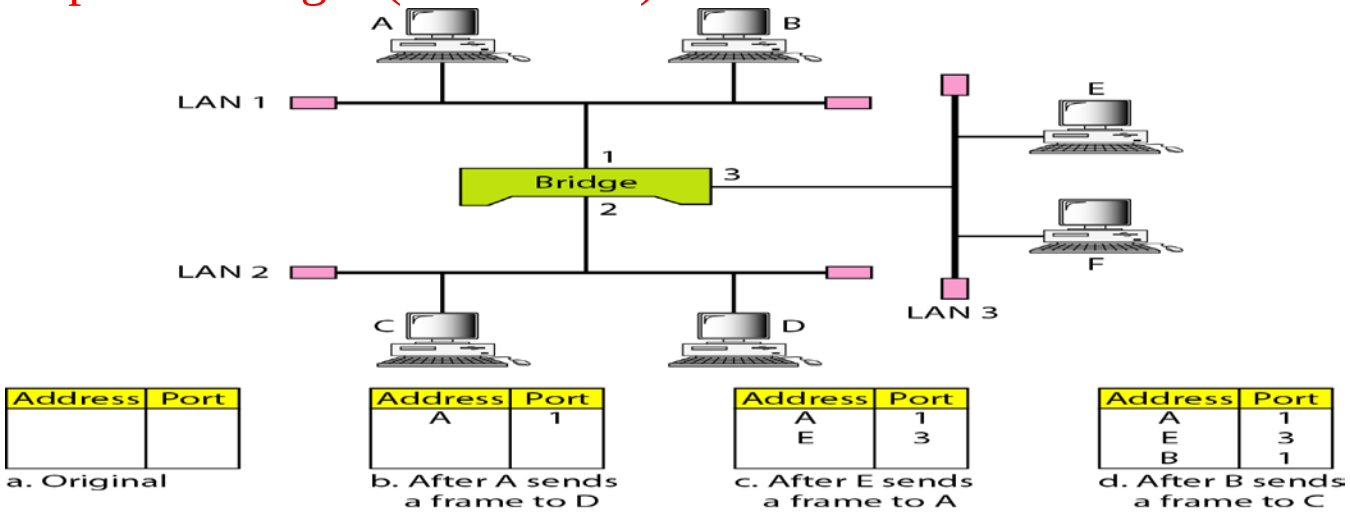

Figure 7. A learning bridge and the process of learning

- Loop Problem: Transparent bridges work fine as long as there are no redundant bridges in the system. Systems administrators, however, like to have redundant bridges (more than one bridge between a pair of LANs) to make the system more reliable. If a bridge fails, another bridge takes over until the failed one is repaired or replaced, as shown in figure 8.
- Redundancy can create loops in the system, which is very undesirable.

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CONNECTING DEVICES (continue…)

- Bridges (continue…)
- Transparent bridges (continue…)

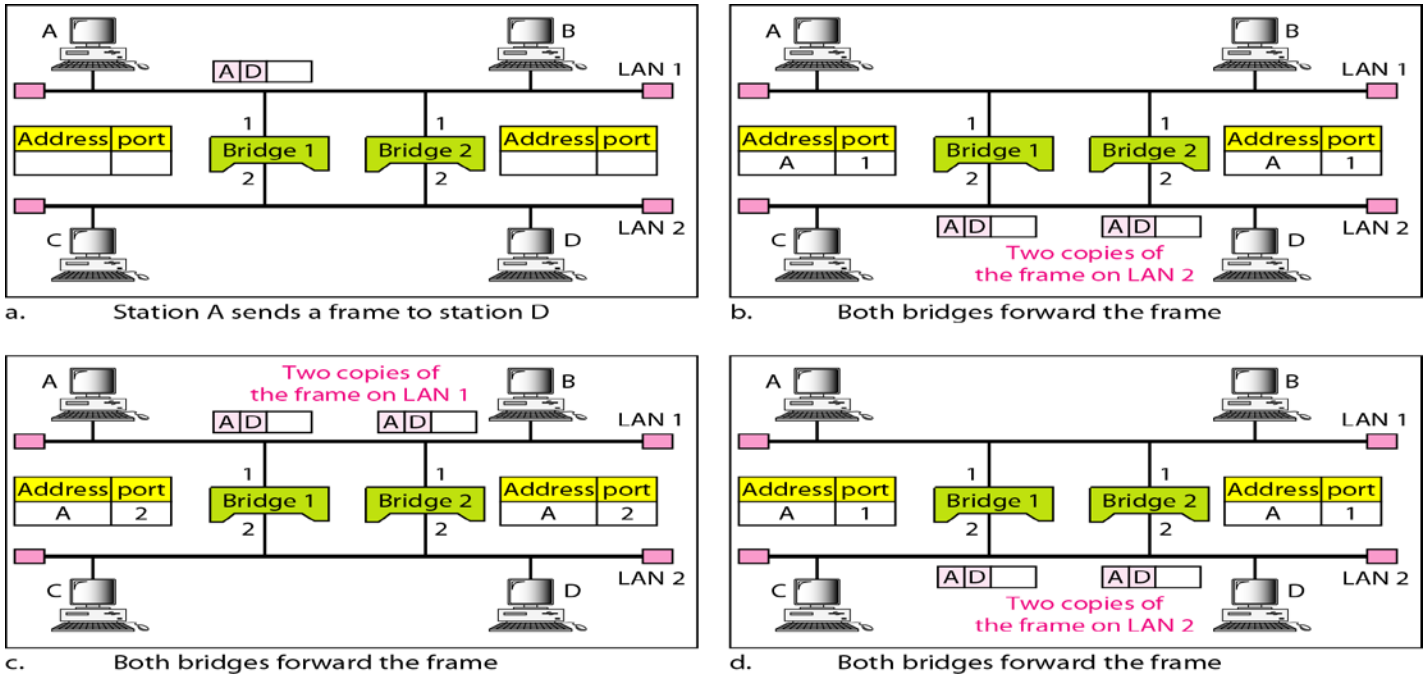

Figure 8. Loop problem in a learning bridge

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CONNECTING DEVICES (continue…)

- Bridges (continue…)
- Spanning tree
- To solve the looping problem, IEEE specification requires that bridges use the spanning tree algorithm.
- Spanning tree is a graph in which there is no loop.
- In figure 9, we have shown both LANs and bridges as nodes. The connecting arcs show the connection of a LAN to a bridge and vice versa.
- To find the spanning tree, we need to assign a cost (metric) to each arc. The interpretation of the cost is left up to the systems administrator. It may be the path with minimum hops (nodes), the path with minimum delay, or the path with maximum bandwidth.
- If two ports have the same shortest value, the systems administrator just chooses one. We have chosen the minimum hops. However, the hop count is normally 1 from a bridge to the LAN and 0 in the reverse direction.
- The process to find the spanning tree involves three steps:
- 1. Every bridge has a built-in ID (normally the serial number, which is unique). Each bridge broadcasts this ID so that all bridges know which one has the smallest ID. The bridge with the smallest ID is selected as the root bridge (root of the tree).

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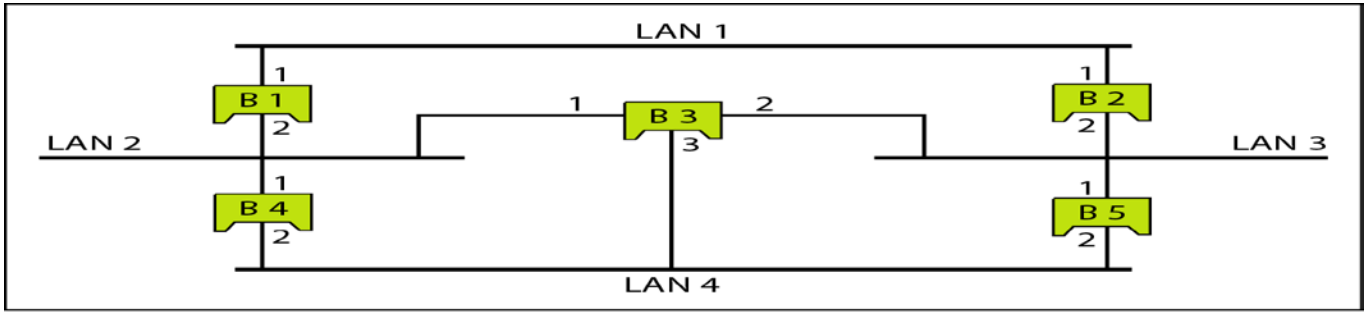
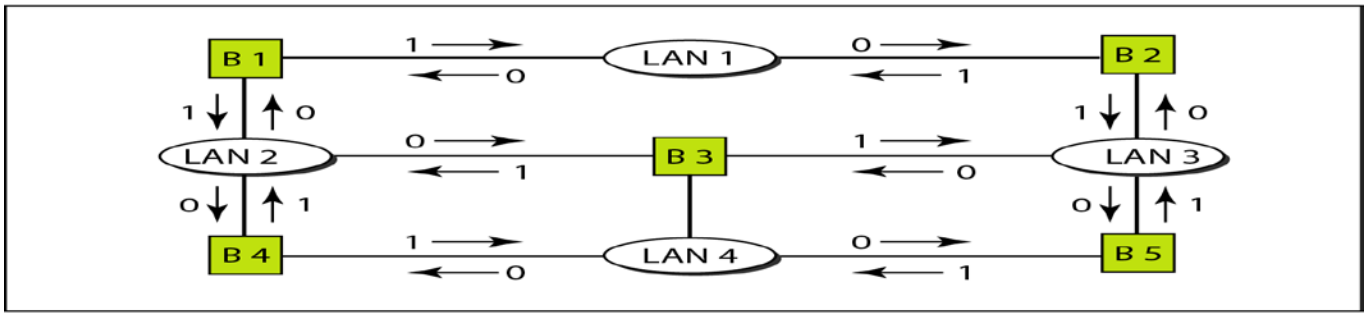
CONNECTING DEVICES (continue…)

- Bridges (continue…)
- Spanning tree (continue…)



a. Actual system



b. Graph representation with cost assigned to each arc

Figure 9. A system of connected LANs and its graph representation

- 2. The algorithm tries to find the shortest path (a path with the shortest cost) from the root bridge to every other bridge or LAN. The shortest path can be found by examining the total cost from the root bridge to the destination
- 3. The combination of the shortest paths creates the shortest tree, as shown in figure 10.

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CONNECTING DEVICES (continue…)

- Bridges (continue…)
- Spanning tree (continue…)

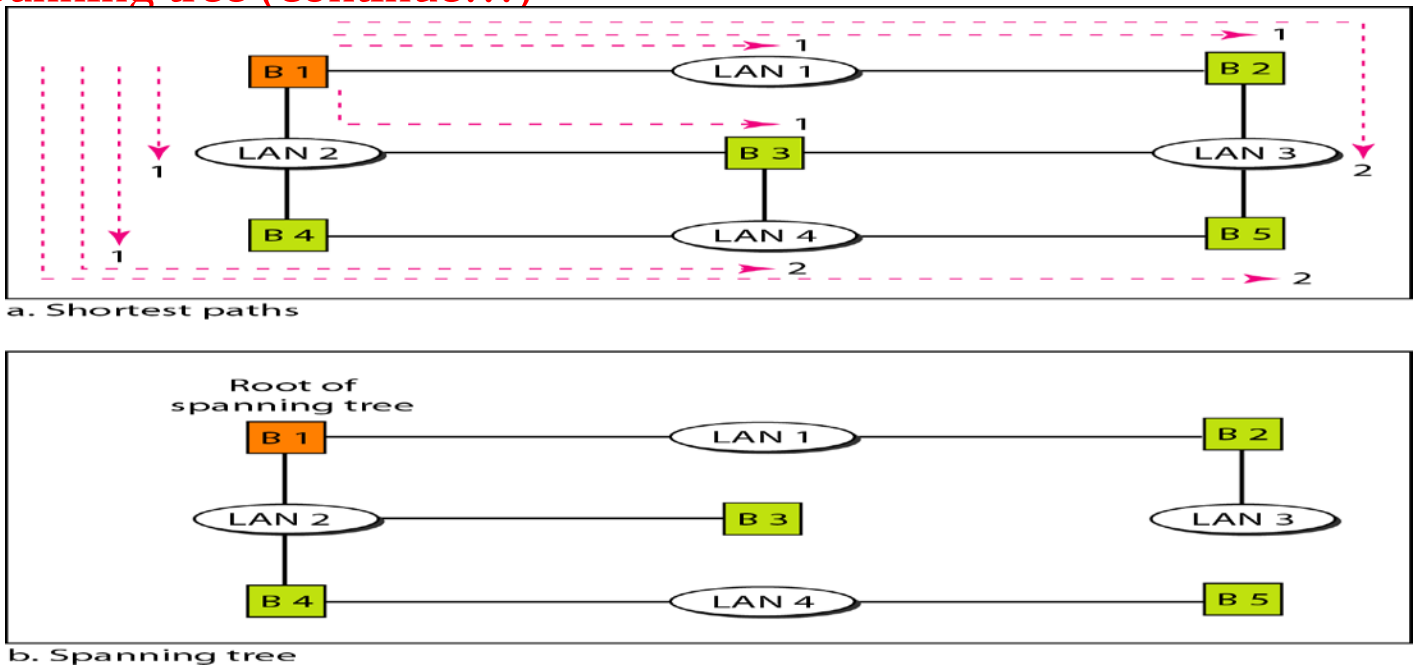

Figure 10. Finding the shortest paths and the spanning tree in a system of bridges

- 4. Based on the spanning tree, we mark the ports that are part of the spanning tree, the forwarding ports, which forward a frame that the bridge receives. We also mark those ports that are not part of the spanning tree, the blocking ports, which block the frames received by the bridge, as shown in figure 11.
- Note that there is only one single path from any LAN to any other LAN in the spanning tree system. This means there is only one single path from one LAN to any other LAN.

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CONNECTING DEVICES (continue…)

- Bridges (continue…)
- Spanning tree (continue…)

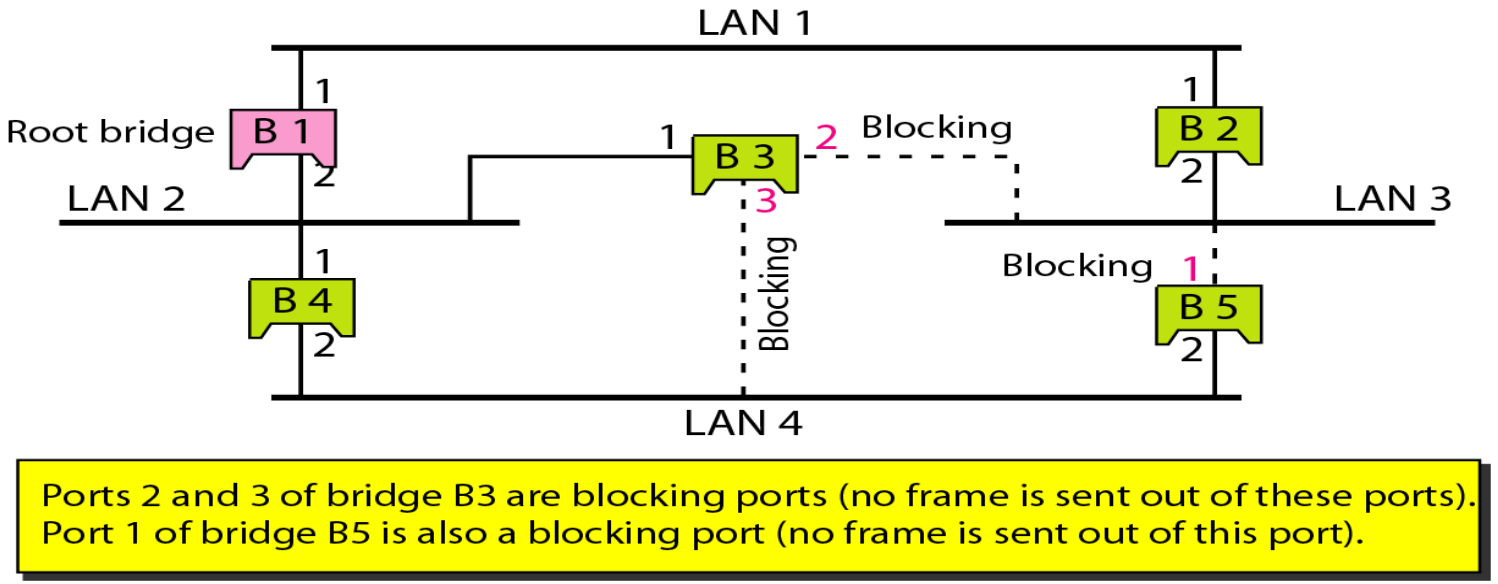

Figure 11. Forwarding and blocking ports after using spanning tree algorithm

- Source routing bridges
- A sending station defines the bridges that the frame must visit. The addresses of these bridges are included in the frame. In other words, the frame contains not only the source and destination addresses, but also the addresses of all bridges to be visited.
- Not very common today
- It can prevent loops in a system with redundant bridges.

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CONNECTING DEVICES (continue…)

- Bridges (continue…)
- Bridges Connecting Different LANs
- Many technical issues to connect LANs using different protocols at the data link layer. there are many issues to be considered:
- Frame format. Each LAN type has its own frame format.
- Maximum data size. If an incoming frame's size is too large for the destination LAN, the data must be fragmented into several frames. The data then need to be reassembled at the destination. However, no protocol at the data link layer allows the fragmentation and reassembly of frames. The bridge must therefore discard any frames too large for its system.
- Data rate. Each LAN type has its own data rate. The bridge must buffer the frame to compensate for this difference.
- Bit order. Each LAN type has its own strategy in the sending of bits. Some send the most significant bit in a byte first; others send the least significant bit first.
- Security. Some LANs, such as wireless LANs, implement security measures in the data link layer. Other LANs, such as Ethernet, do not.
- Multimedia support. Some LANs support multimedia and the quality of services (QoS) needed for this type of communication; others do not.

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CONNECTING DEVICES (continue…)

- Two layer switch
- The two-layer switch performs at the physical and data link layers.
- A two-layer switch is a bridge with many ports and a design that allows better performance, as shown in figure 12. A bridge with many ports may be able to allocate a unique port to each station, with each station on its own independent entity. This means no competing traffic (no collision).
- Filtering based on the MAC address of the frame it received.
- Two-layer switch can be more sophisticated.
- It can have a buffer to hold the frames for processing.
- It can have a switching factor that forwards the frames faster.
- Builds switching table by "learning" host addresses from source addresses of incoming packets.
- Unknown destination addresses are flooded out other ports
- Broadcast frames are flooded out other ports

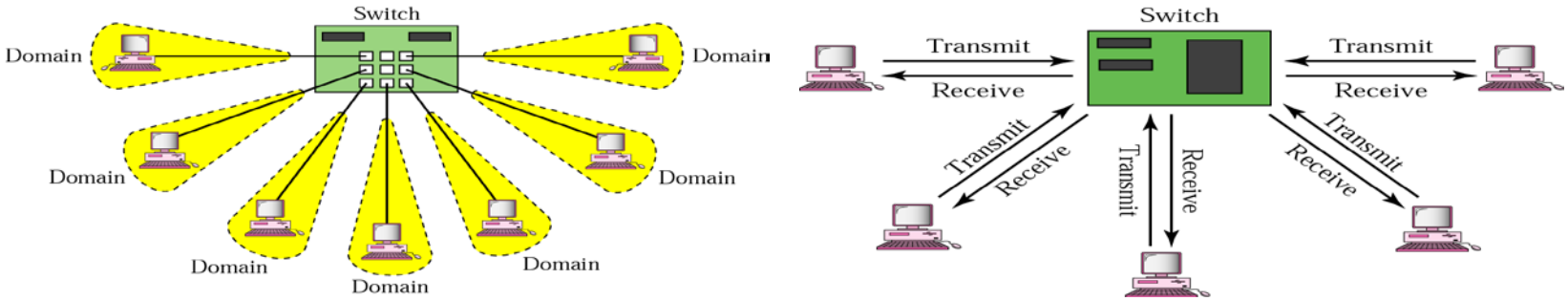

Figure 12. Two-layer switch at the physical and data link layers

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CONNECTING DEVICES (continue…)

Router

- Three-layer device that routes packets based on their logical (network layer) address.
- A router connects LANs and WANs in the Internet and Builds routing table by neighbor routers using routing protocols, as shown in figure 13.
- Unknown IP packets are discarded
- Broadcast frames are discarded.

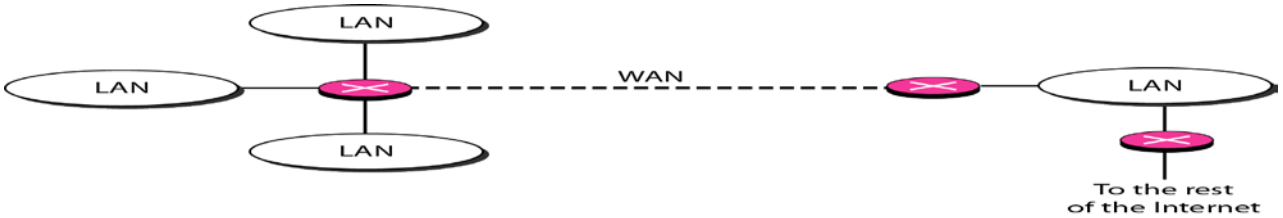

Figure 13. Routers connecting independent LANs and WANs

Three-Layer Switches

- Three-Layer Switch : a router, but a faster and more sophisticated
- Router and three-layer switch interchangeably.

gateway

- A gateway is normally a computer that operates in all five layers of the Internet or seven layers of OSI model. A gateway takes an application message, reads it, and interprets it. This means that it can be used as a connecting device between two internetworks that use different models. Gateways can provide security.

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CONNECTING DEVICES (continue…)

Bridging and switching are both used for segmentation

- Results in multiple collision domains
- Still a single broadcast domain
- Stations can get dedicated bandwidth

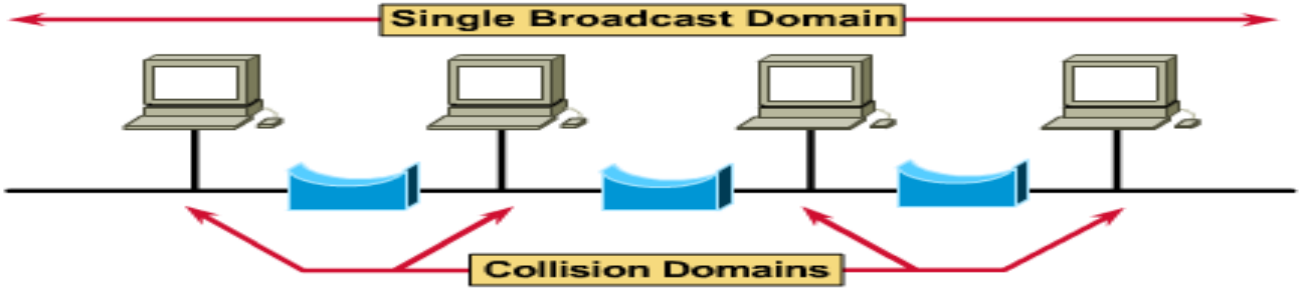
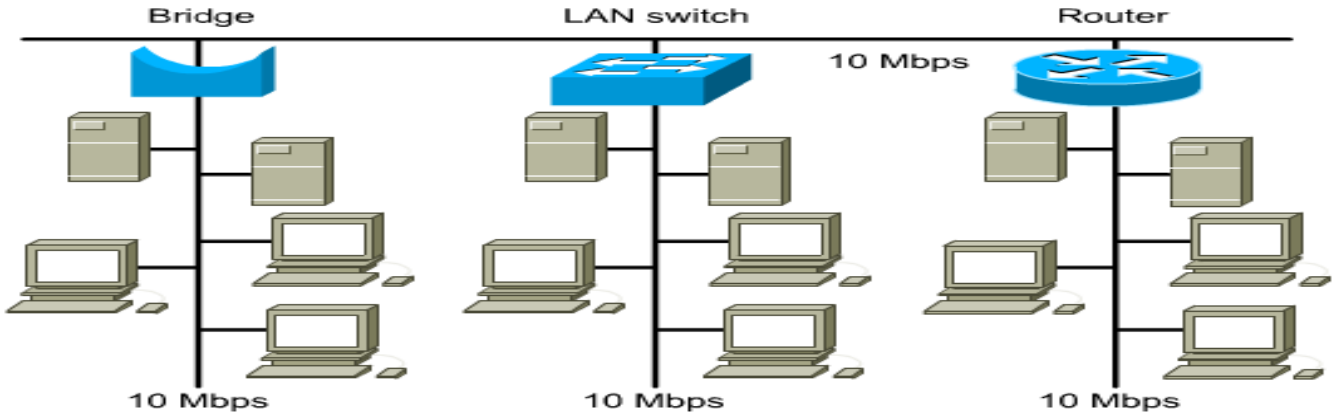


Figure 14. Broadcast and Collision Domains



- Isolates traffic between segments
- Achieve more bandwidth per user by creating smaller collision domains

Figure 15. LAN Segmentation

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BACKBONE NETWORKS

- A backbone network allows several LANs to be connected. In a backbone network, no station is directly connected to the backbone; the stations are part of a LAN, and the backbone connects the LANs.

➢ Bus Backbone

- In a bus backbone, the topology of the backbone is a bus. The backbone itself can use one of the protocols that support a bus topology such as l0Base5 or l0Base2.
- Bus backbones are used as a distribution backbone to connect different buildings in an organization.
- Each building can comprise either a single LAN or another backbone (a star backbone). A good example of a bus backbone is one that connects single- or multiple-floor buildings on a campus. Each single-floor building has a single LAN. Each multiple-floor building has a backbone (usually a star) that connects each LAN on a floor. A bus backbone can interconnect these LANs and backbones.

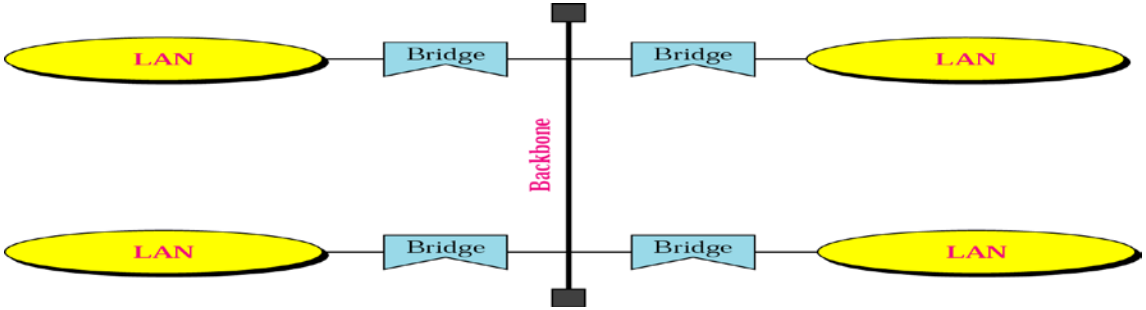

Figure 16. Bus backbone

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BACKBONE NETWORKS (continue…)

➢ Star Backbone

- In a star backbone, sometimes called a collapsed or switched backbone, the topology of the backbone is a star, as shown in figure 17.
- In this configuration, the backbone is just one switch that connects the LANs.
- Mostly used as a distribution backbone inside a building.

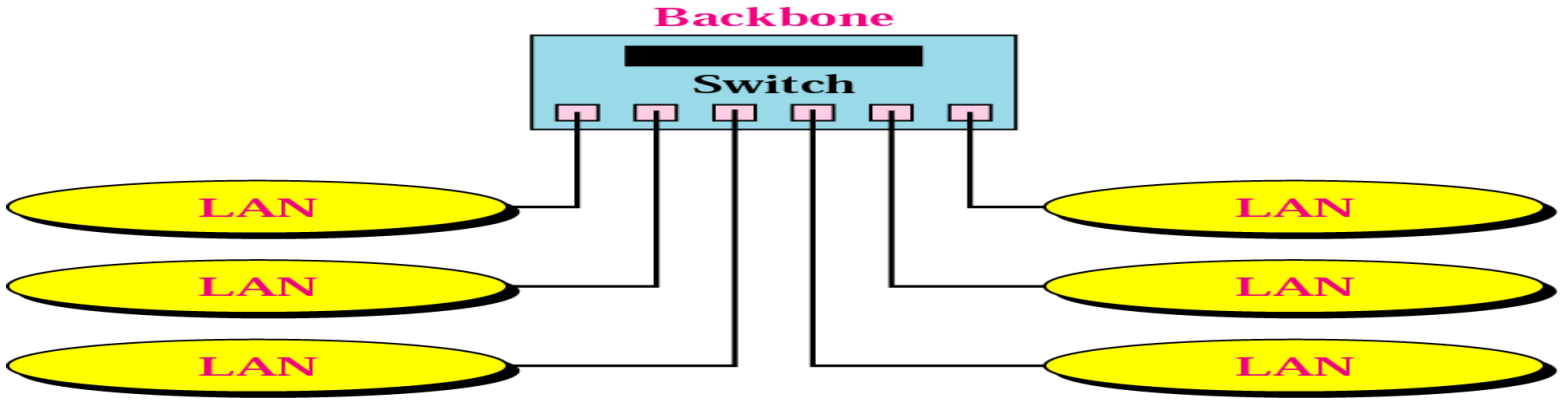

Figure 17. Star backbone

- In a multifloor building, we usually find one LAN that serves each particular floor. A star backbone connects these LANs. The backbone network, which is just a switch, can be installed in basement or the first floor, and separate cables can run from the switch to each LAN. If individual LANs have a physical star topology, either hubs (or switches) can be installed in a closet on the corresponding floor, or all can be installed close to switch. We often find a rack or chassis in basement where backbone switch and all hubs or switches are installed.

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BACKBONE NETWORKS (continue…)

➢ Connecting Remote LANs

- This type of backbone network is useful when a company has several offices with LANs
- The connection can be done through bridges, called remote bridges
- A point-to-point link acts as a LAN in a remote backbone connected by remote bridges

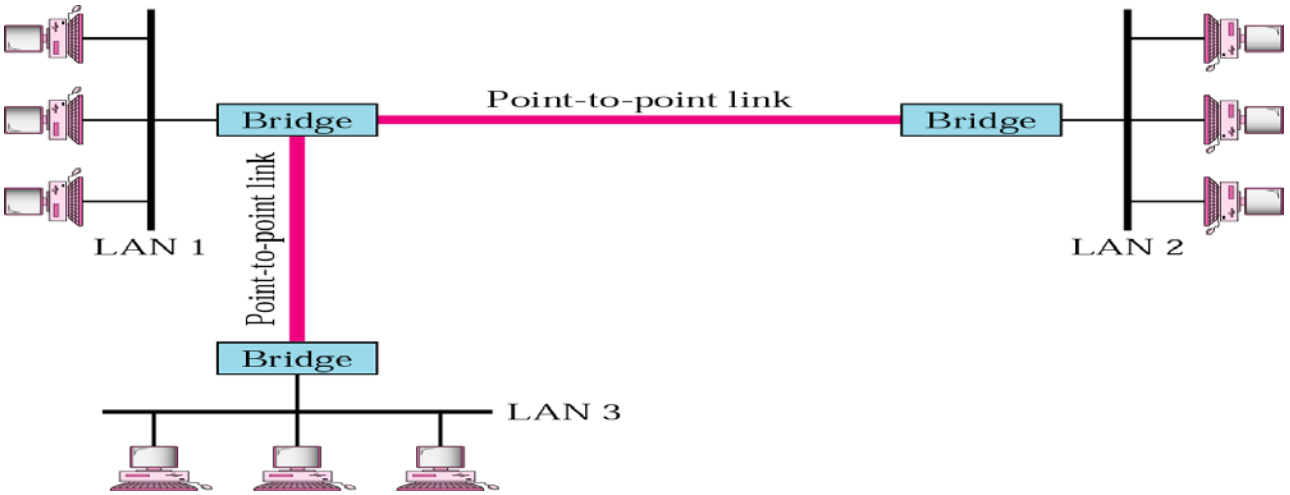

Figure 18. Connecting remote IANs with bridges

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VIRTUAL LANs

- Virtual local area network (VLAN) as a local area network configured by software, not by physical wiring.

- Example, if we have switched LAN in an engineering firm in which 10 stations are grouped into three LANs that are connected by a switch. The first four engineers work together as the first group, the next three engineers work together as the second group, and the last three engineers work together as the third group. The LAN is configured to allow this arrangement, as shown in figure 19. What would happen if the administrators needed to move two engineers from the first group to the third group, to speed up the project being done by the third group?
- The LAN configuration would need to be changed. The network technician must rewire.

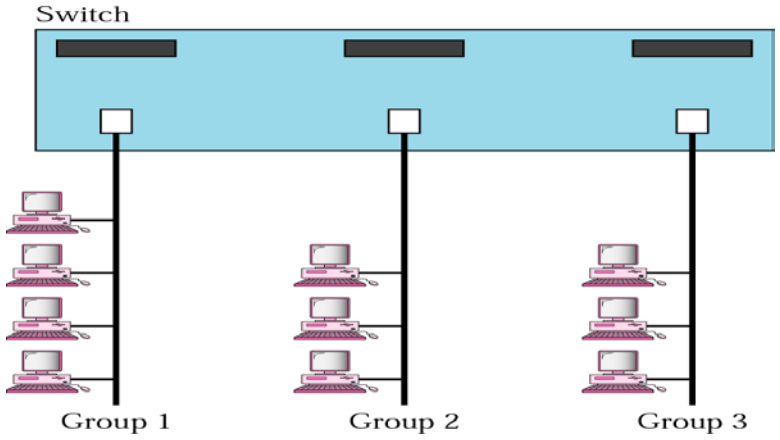

Figure 19. A switch connecting three LANs

VIRTUAL LANs (continue…)

- In the figure 20. we shows the same switched LAN divided into VLANs. The whole idea of VLAN technology is to divide a LAN into logical, instead of physical, segments. A LAN can be divided into several logical LANs called VLANs. Each VLAN is a work group in the organization. If a person moves from one group to another, there is no need to change the physical configuration.
- Any station can be logically moved to another VLAN. All members belonging to a VLAN can receive broadcast messages sent to that particular VLAN.

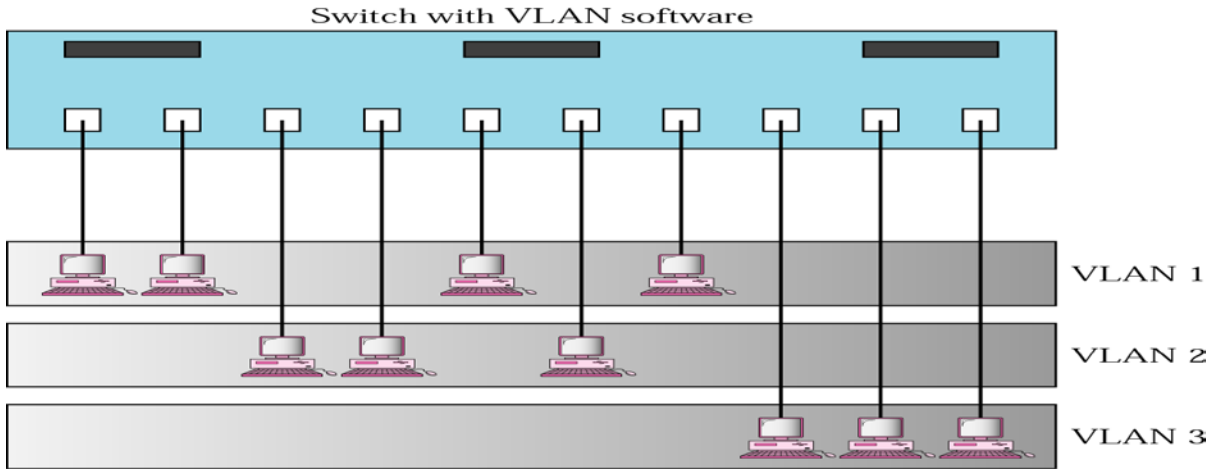

Figure 20. A switch using VLAN software

- When a station moves from VLAN 1 to VLAN 2, it receives broadcast messages sent to VLAN 2, but no longer receives broadcast messages sent to VLAN 1.
-

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VIRTUAL LANs (continue…)

- VLAN technology even allows the grouping of stations connected to different switches in a VLAN. Figure 21. shows a backbone local area network with two switches and three VLANs. Stations from switches A and B belong to each VLAN.
- This is a good configuration for a company with two separate buildings. Each building can have its own switched LAN connected by a backbone. People in the first building and people in the second building can be in the same work group even though they are connected to different physical LANs.
- VLANs create broadcast domains.

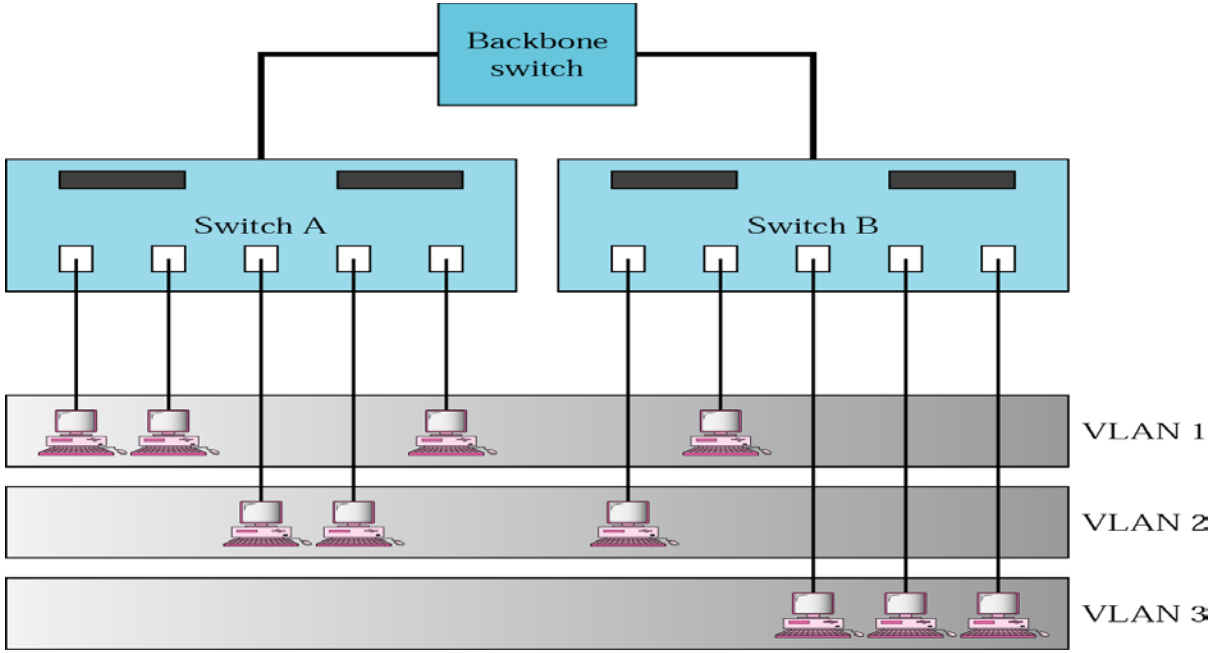

Figure 21. Two switches in a backbone using VLAN software

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VIRTUAL LANs (continue…)

- Membership
- Membership is characterized by port numbers, MAC addresses, IP addresses, Multicast IP addresses, or a combination of the above.

- Configuration
- VLAN can be configured in one of three ways: manual, semiautomatic, and automatic.

- Communication between switches
- Each switch must know not only which station belongs to which VLAN, but also the membership of stations connected to other switches
- Three methods are devised: table maintenance, frame tagging, and TDM.

- Advantages of VLAN
- Cost and time reduction
- Creating virtual workgroups
- Security.

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Summary

- A repeater is a connecting device that operates in the physical layer of the Internet model. A repeater regenerates a signal, connects segments of a LAN, and has no filtering capability.
- A bridge is a connecting device that operates in the physical and data link layers of the Internet model.
- A transparent bridge can forward and filter frames and automatically build its forwarding table.
- A bridge can use the spanning tree algorithm to create a loopless topology.
- A backbone LAN allows several LANs to be connected.
- A backbone is usually a bus or a star.
- A virtual local area network (VLAN) is configured by software, not by physical wiring.
- Membership in a VLAN can be based on port numbers, MAC addresses, IP addresses, IP multicast addresses, or a combination of these features.
- VLANs are cost- and time-efficient, can reduce network traffic, and provide an extra measure of security.

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