Chapter 15

Local Area Networks

Reading Materials

- **Data and Computer Communications**, William Stallings

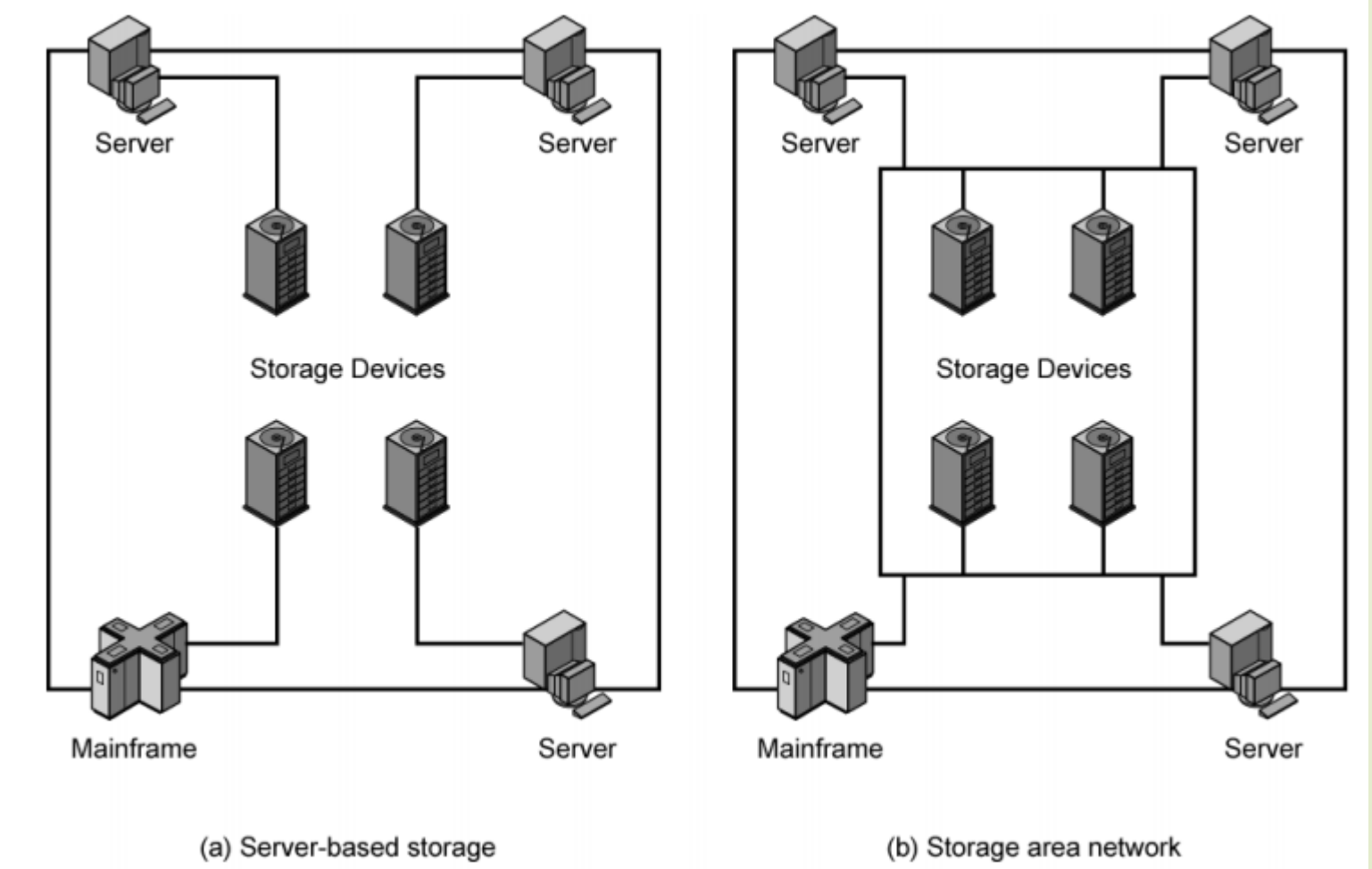
Contents

- Topologies
- Bridges & switches
- Ethernet
- Token ring
- CSMA/CD

LAN Applications

- Personal computer LANs
- Backend networks
- Storage Area Networks
- Backbone LANs

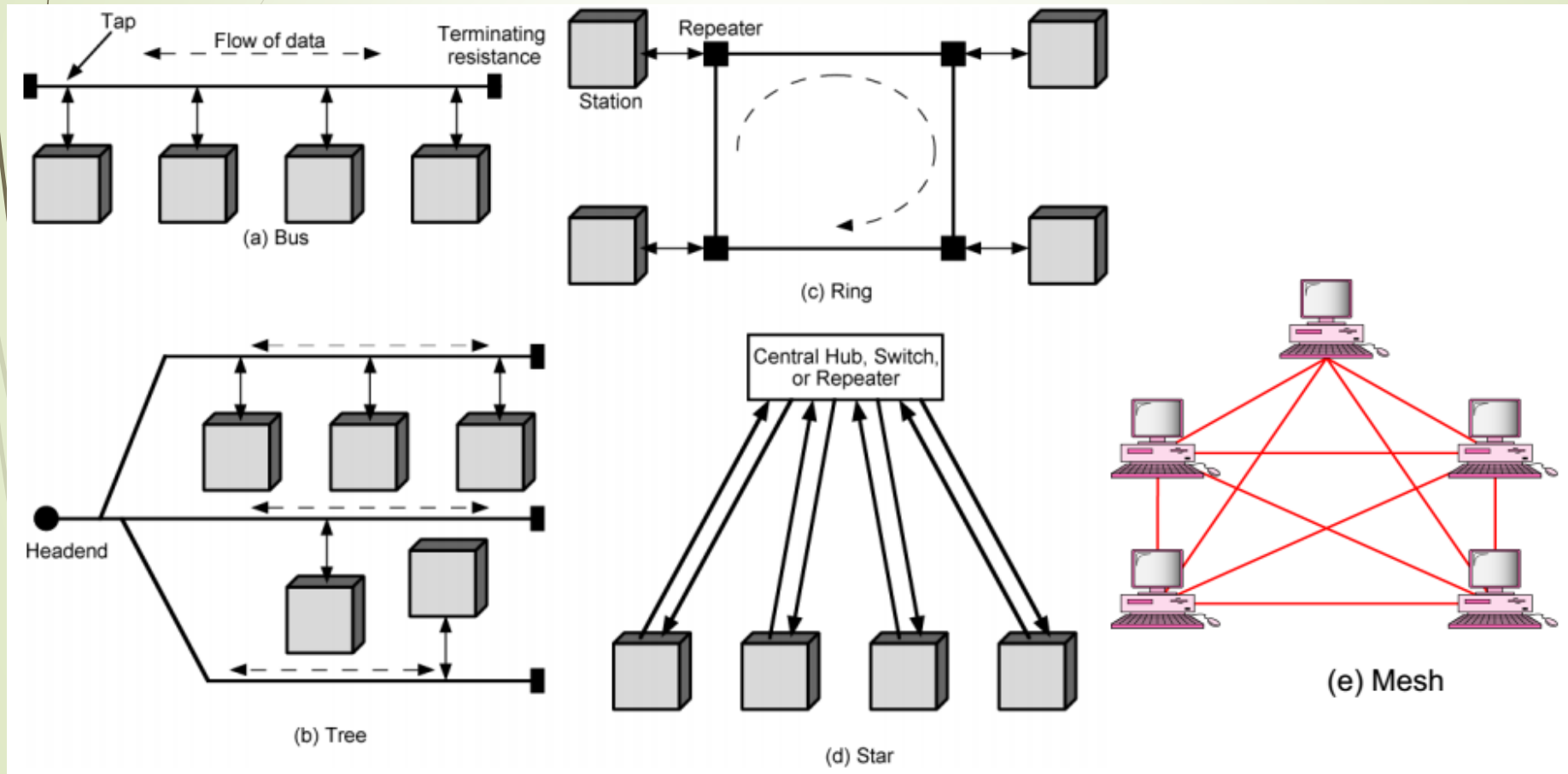
Storage Area Networks



Topologies

- Tree
- Bus
  - Special case of tree
    - One trunk, no branches
- Ring
- Star
- Mesh

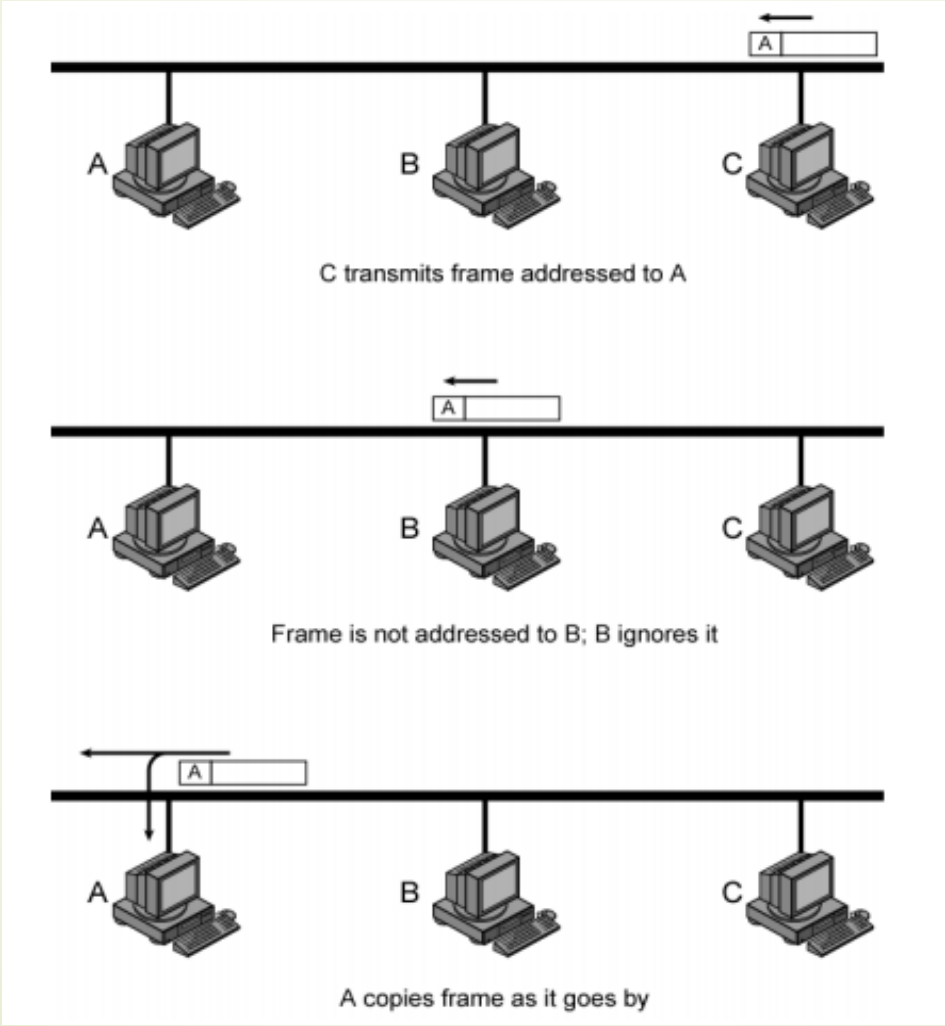
LAN Topologies



Bus and Tree

- Multipoint medium
- Transmission propagates throughout medium
- Heard by all stations
  - Need to identify target station
- Each station has unique address
- Full duplex connection between station and tap
  - Allows for transmission and reception
- Need to regulate transmission
  - To avoid collisions
- Terminator absorbs frames at end of medium

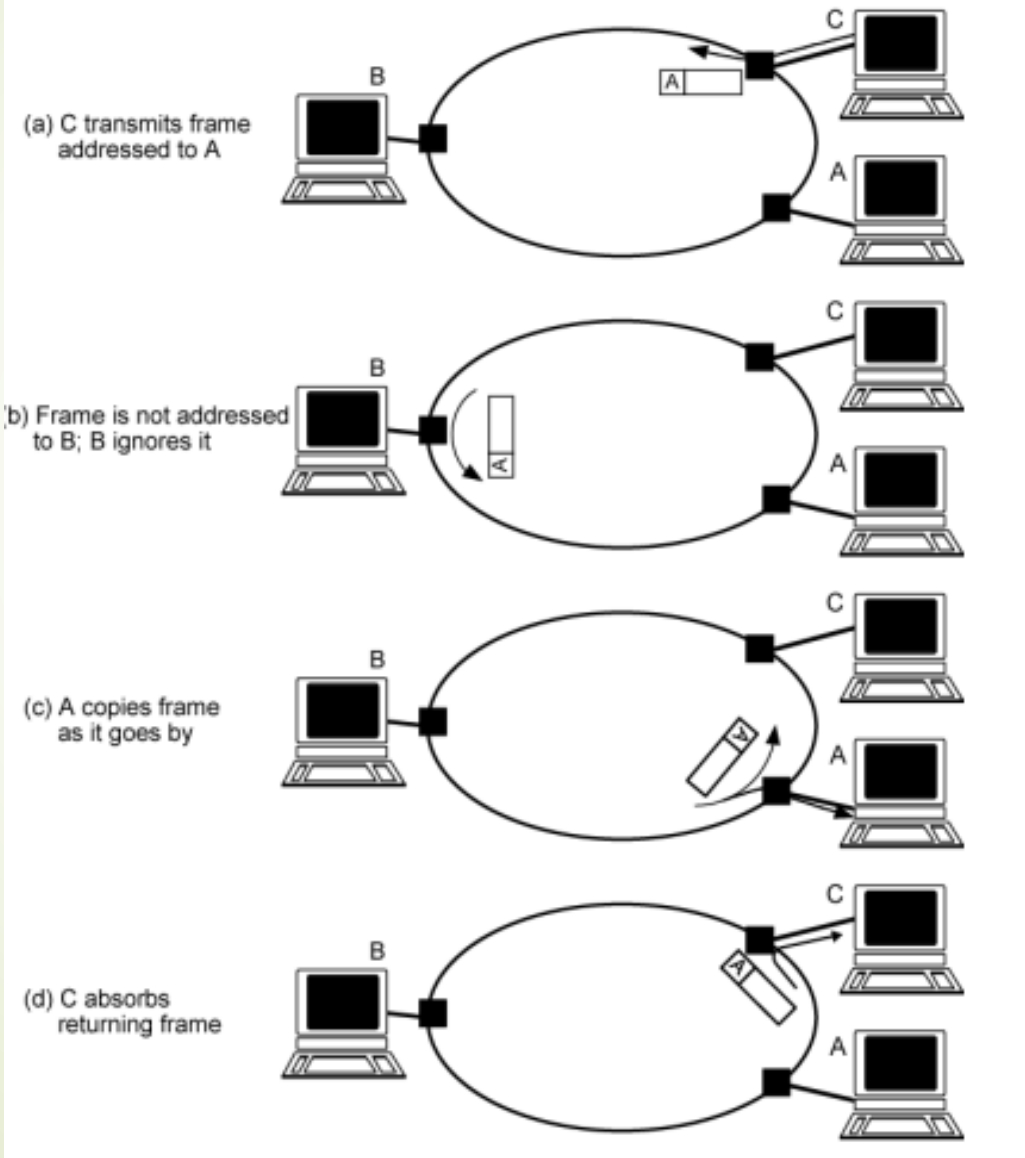
Frame Transmission on Bus LAN



Ring Topology

- Repeaters joined by point to point links in closed loop
  - Receive data on one link and retransmit on another
  - Links unidirectional
  - Stations attach to repeaters
- Data in frames
  - Circulate past all stations
  - Destination recognizes address and copies frame
  - Frame circulates back to source where it is removed
- Media access control determines when station can insert frame

Frame Transmission on Ring LAN



Star Topology

- Each station connected directly to central node
  - Usually via two point to point links
- Central node can broadcast
  - Physical star, logical bus
  - Only one station can transmit at a time
- Central node can act as frame switch

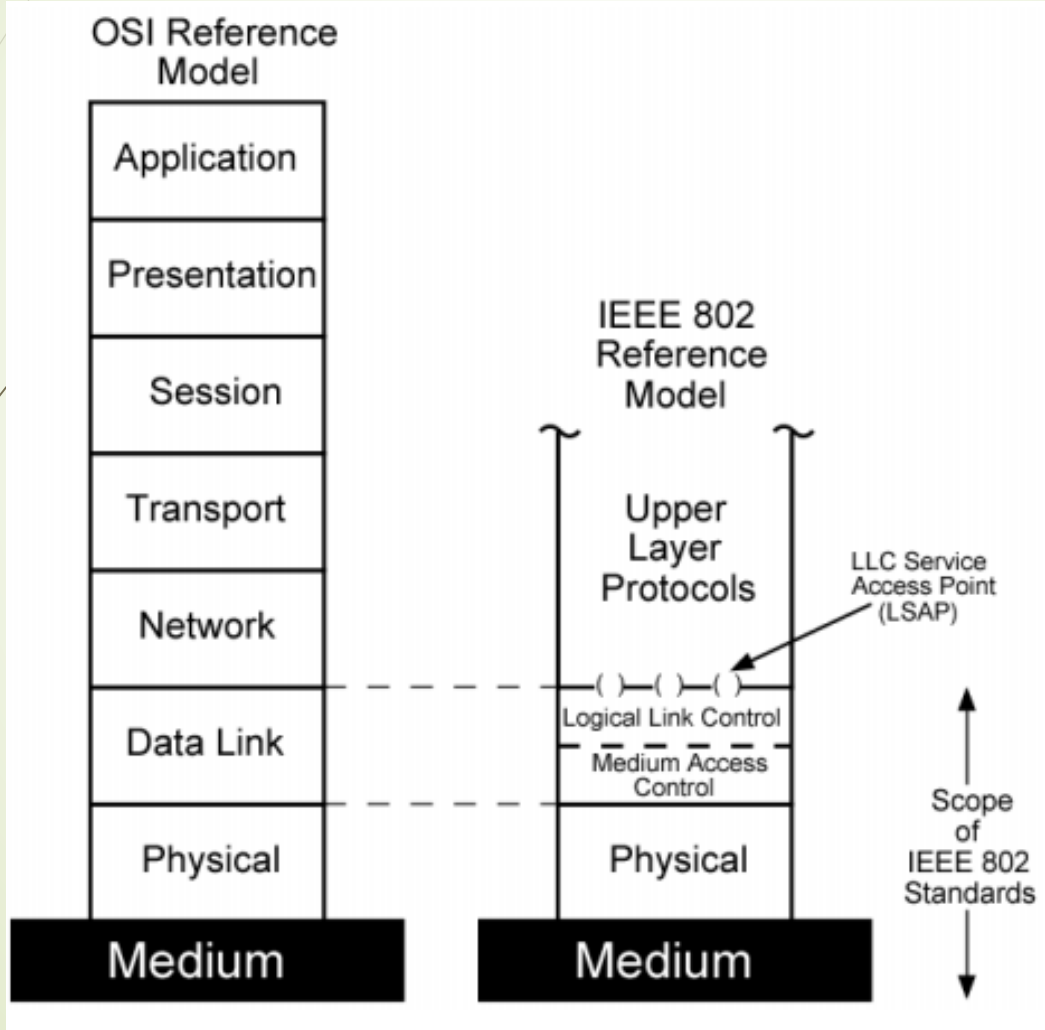
Choice of Topology

- Reliability
- Expandability
- Performance
- Needs considering in context of:
  - Medium
  - Wiring layout
  - Access control

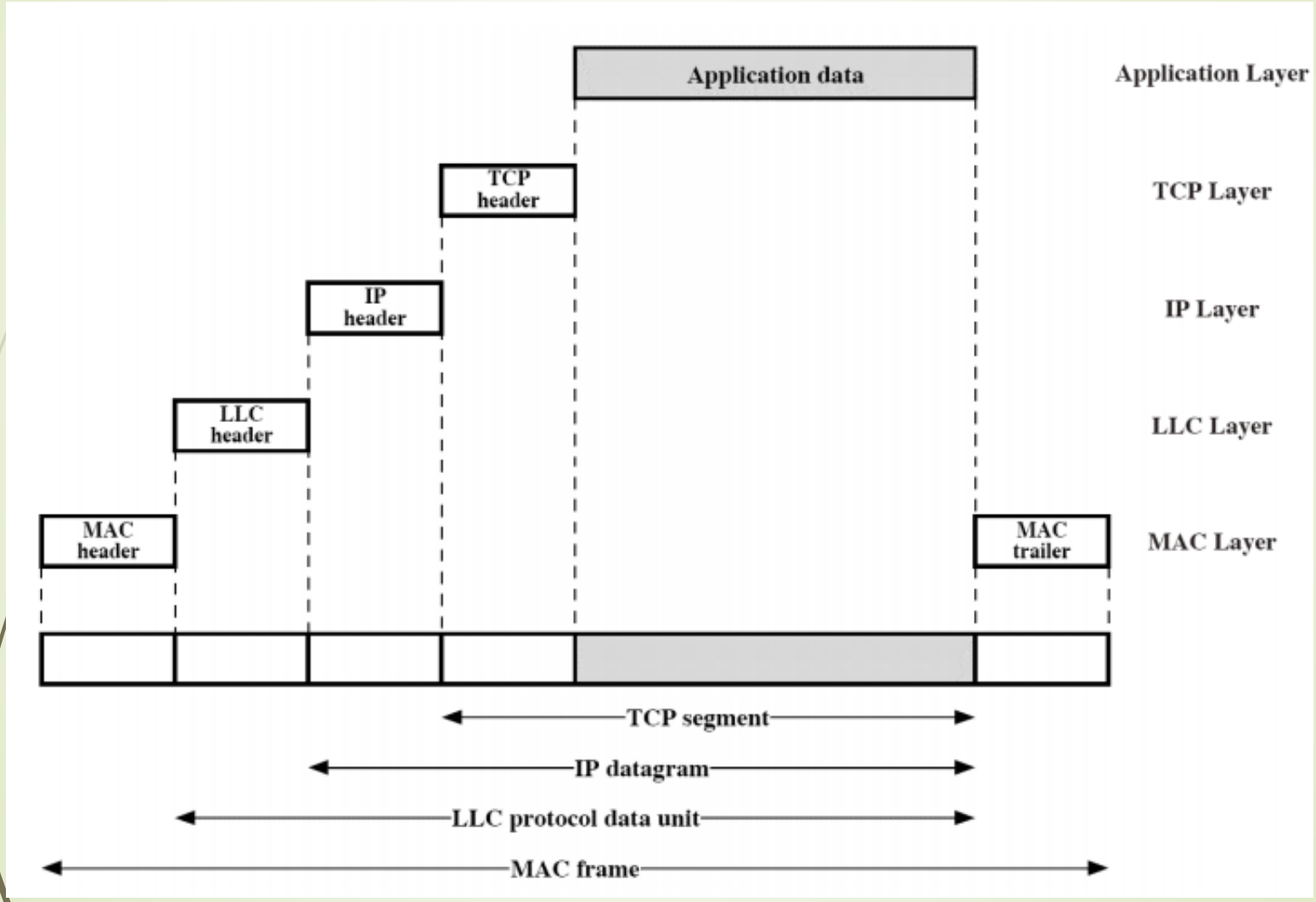
Protocol Architecture

- Lower layers of OSI model
- IEEE 802 reference model
  - Physical
  - Logical link control (LLC)
  - Media access control (MAC)

IEEE 802 versus OSI



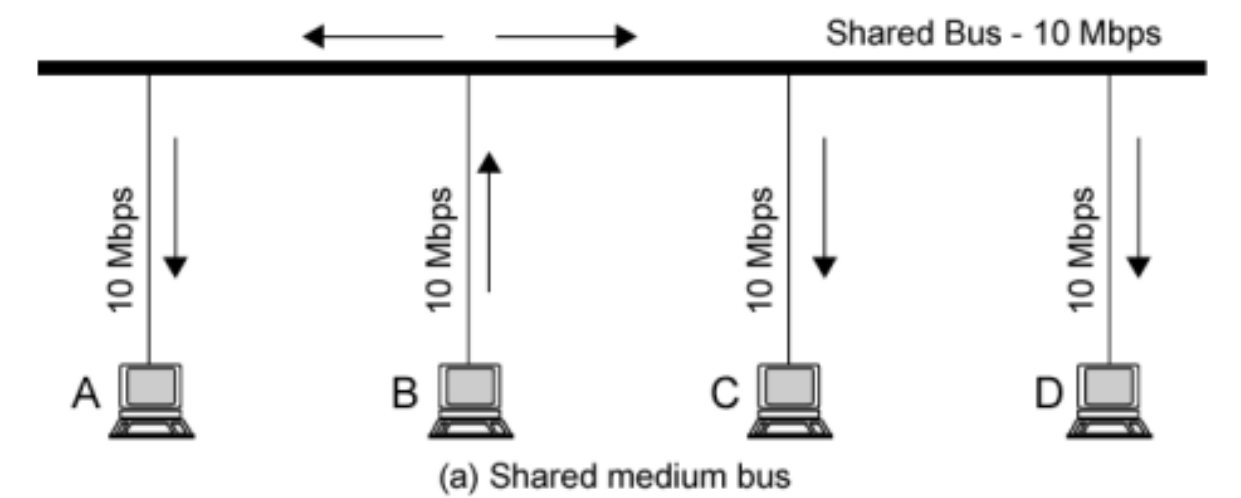
IEEE 802 Encapsulation



Hubs

- Active central element of star layout
- Each station connected to hub by two lines
  - Transmit and receive
- Hub acts as a repeater
- When single station transmits, hub repeats signal on outgoing line to each station
- Line consists of two unshielded twisted pairs
- Physically star, logically bus
- Transmission from any station received by all other stations
- If two stations transmit at the same time, collision

Shared Medium Bus and Hub



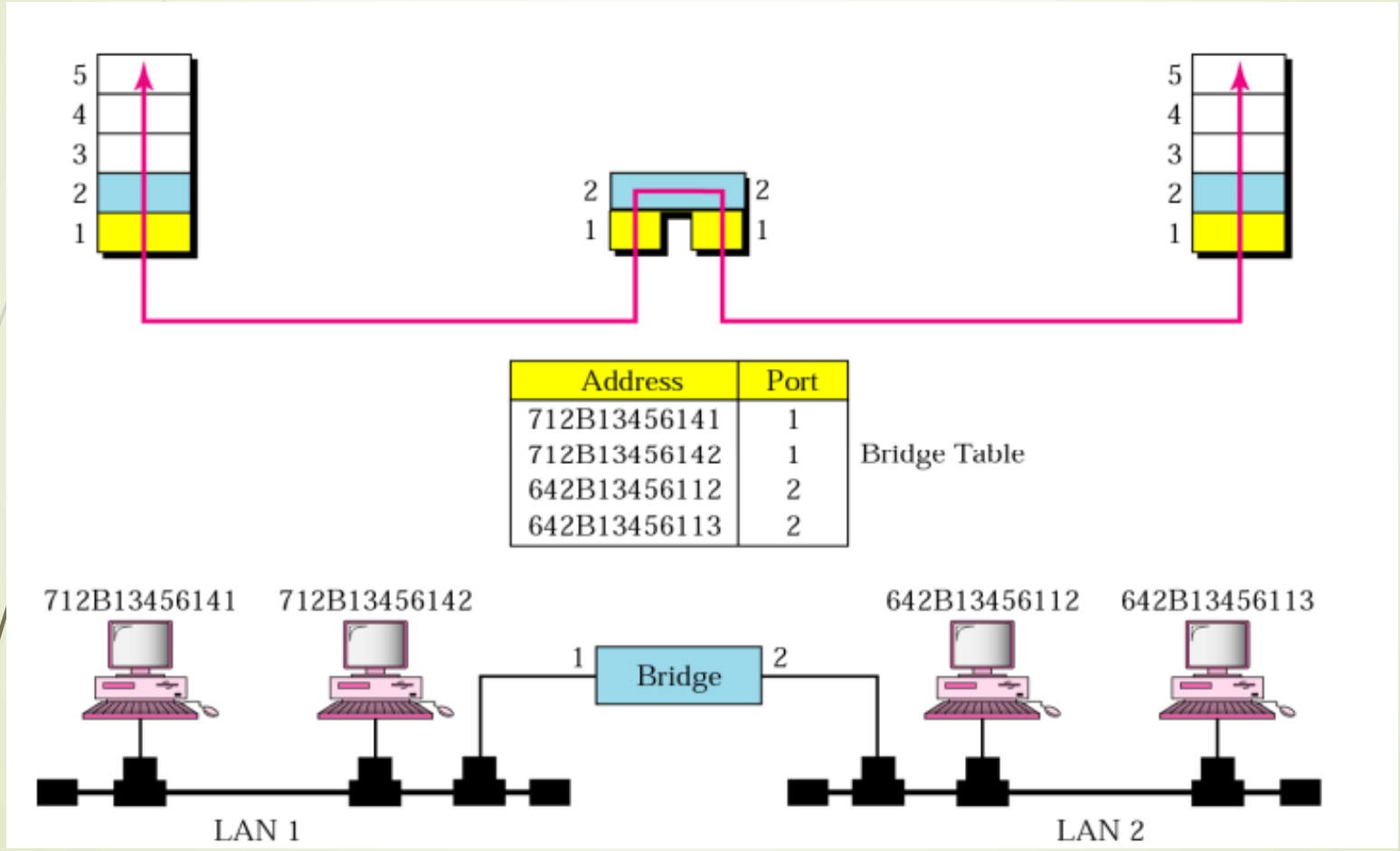
Bridges

- A bridge goes one step up on a hub in that it review the destination of the packet before sending. If the destination address is not on the other side of the bridge it will not transmit the data.
- A bridge only has one incoming and one outgoing port.
- Ability to expand beyond single LAN
- Provide interconnection to other LANs/WANs
- Bridge is simpler
  - Connects similar LANs
  - Identical protocols for physical and link layers
  - Minimal processing

Functions of a Bridge

- Read all frames transmitted on one LAN and accept those addressed to any station on the other LAN
- Using MAC protocol for second LAN, retransmit each frame
- Do the same the other way round

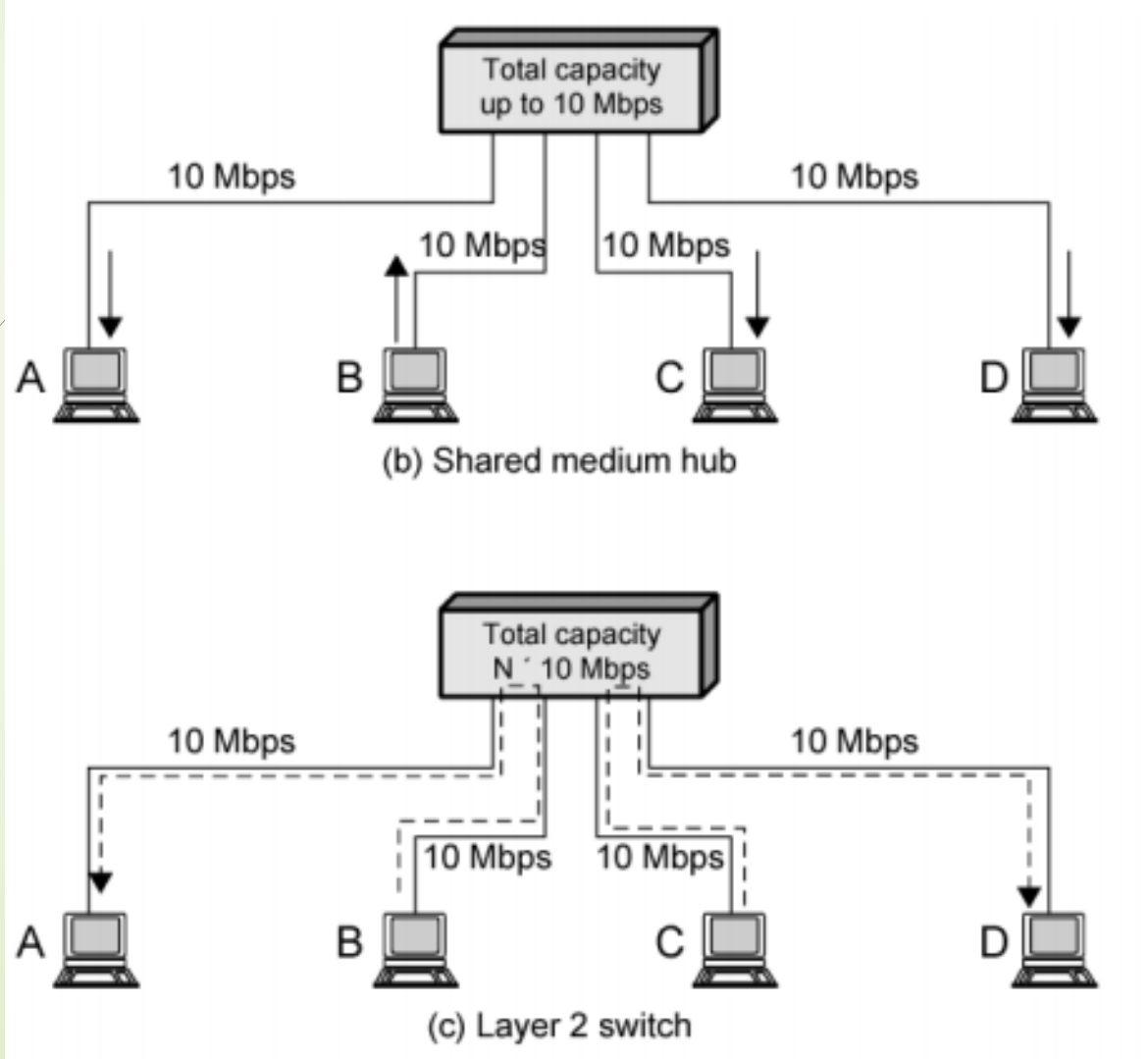
Bridge Operation



Layer 2 Switches

- A switch steps up on a bridge in that it has multiple ports. When a packet comes through a switch it is read to determine which computer to send the data to. I.E. one computer will be the sole receiver of the package.
- This leads to increased efficiency in that packets are not going to computers that do not require them
- Uses MAC address to identify stations.
- Incoming frame from particular station switched to appropriate output line
- Unused lines can switch other traffic
- More than one station transmitting at a time
- Multiplying capacity of LAN

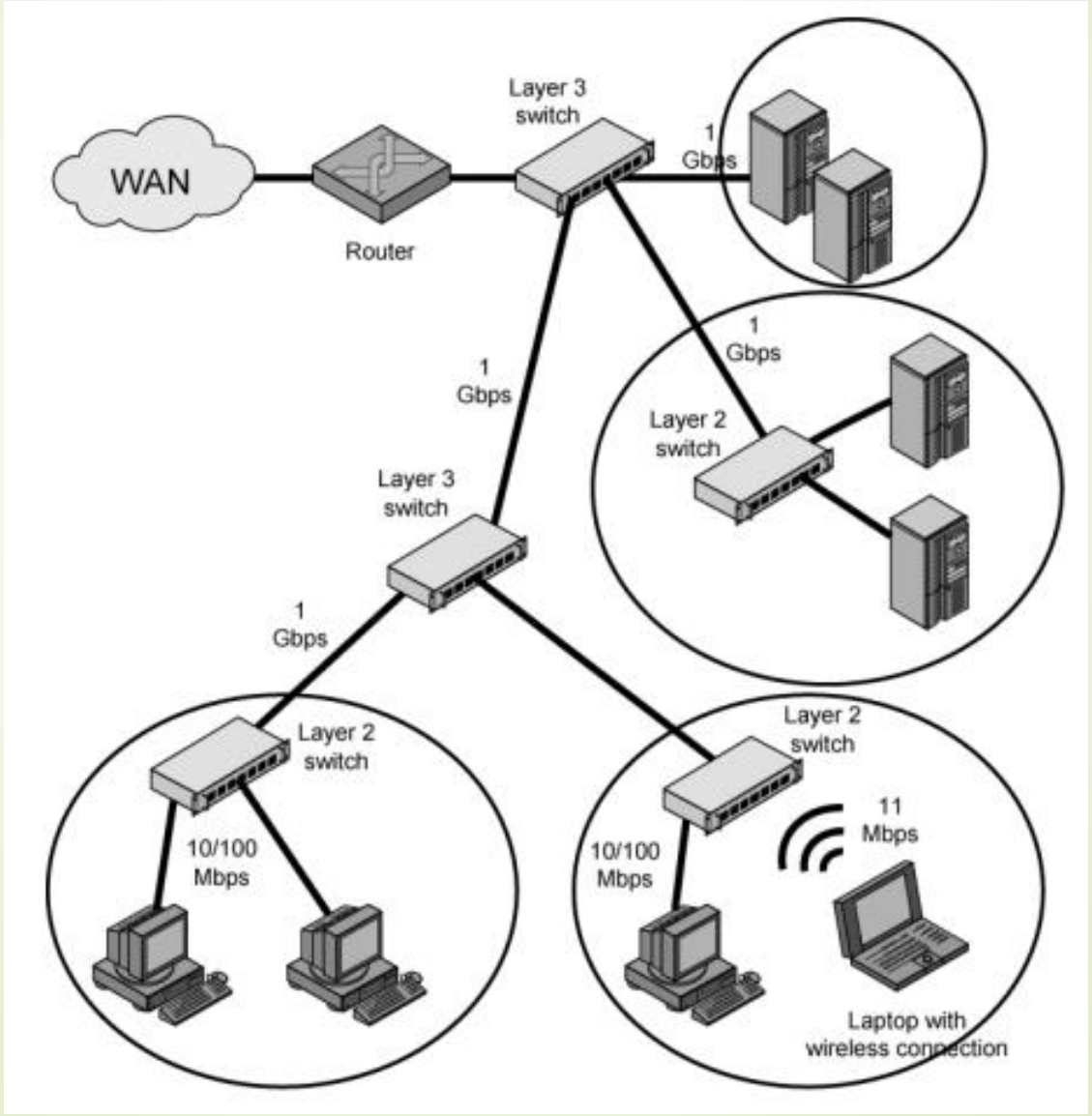
Shared Medium Hub and Layer 2 Switch



Layer 3 Switches

- A Layer 3 switch also does switching exactly like a Layer 2 switch.
- The Layer 3 means that it has an identity from the Layer 3 layer. Practically this means that a L3 switch is capable of having IP addresses and doing routing.
- For intra-VLAN communication, it uses the MAC address table. For extra-VLAN communication, it uses the IP routing table.

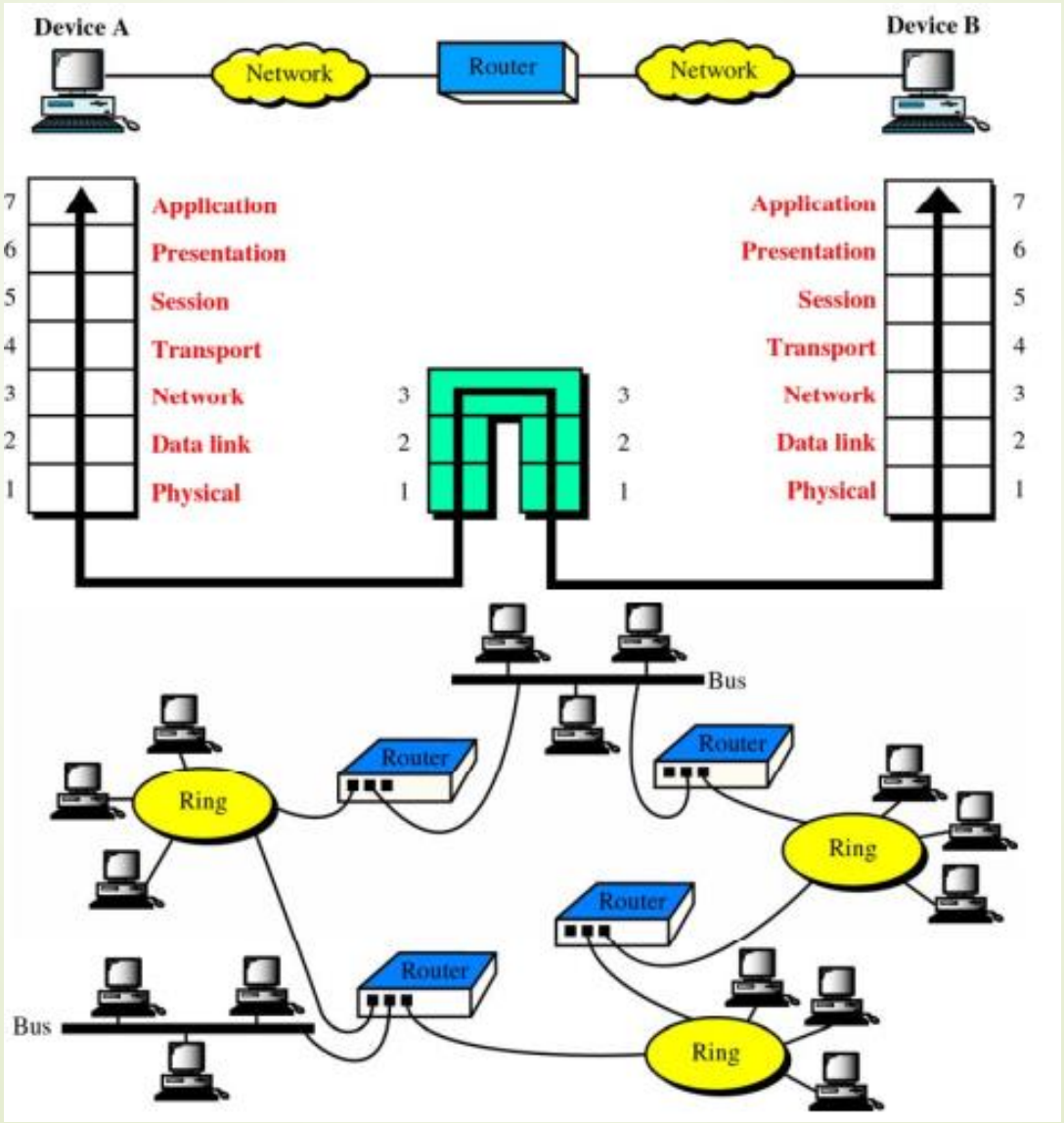
Typical Large LAN Organization Diagram



Routers

- A router is similar in a switch in that it forwards packets based on address. But, instead of the MAC address that a switch uses, a router can use the IP address.
- Before forwarding a packet the router will review the destination IP address. This allows the network to go across different protocols.
- The most common home use for routers is to share a broadband internet connection.
- The router has a public IP address and that address is shared with the network. When data comes through the router it is forwarded to the correct computer.

Routers


Device A
Network
Router
Network
Device B
7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data link
1 Physical
Application 7
Presentation 6
Session 5
Transport 4
Network 3
Data link 2
Physical 1
Bus
Router
Router
Ring
Ring
Router
Router
Bus
Ring

HIGH-SPEED LANS

- The IEEE 802.3 standard, known as Ethernet, now encompasses data rates of 10 Mbps, 100 Mbps, 1 Gbps, and 10 Gbps.
- For the lower data rates, the CSMA/CD MAC protocol is used.
- For the 1-Gbps and 10-Gbps options, a switched technique is used.

IEEE802.3 Medium Access Control

- The most widely used high-speed LANs today are based on Ethernet and were developed by the IEEE 802.3 standards committee.
- Random Access
  - Stations access medium randomly
- Contention
  - Stations content for time on medium

ALOHA

- Whenever a station has frame, it sends. No specific time.
- Then, it listens for max round trip time (twice the time it takes to send a frame between the two most widely separated stations) plus small increment
- If frame OK (FCS field i.e. CRC) and address matches receiver, send ACK
- If receiver gets back an ACK, fine. If not, sending station retransmits
- If no ACK after repeated transmissions, give up
- Low utilization, maximum 18%
- The frame may be invalid due to noise on the channel or because another station transmitted a frame at about the same time. In the latter case, the two frames may interfere with each other at the receiver so that neither gets through; this is known as a **collision**.

Slotted ALOHA

- Time in uniform slots equal to frame transmission time
- Need central clock (or other synchronization mechanism)
- Transmission begins at slot boundary
- Better utilization, 37%

Ethernet (CSMA/CD)

- Carriers Sense Multiple Access with Collision Detection
- Ethernet was originally developed by Xerox and then developed further by Xerox, DEC, and Intel.
- IEEE 802.3
- Ether: a medium that was once supposed to fill all space and to support the propagation of electromagnetic waves.

CSMA

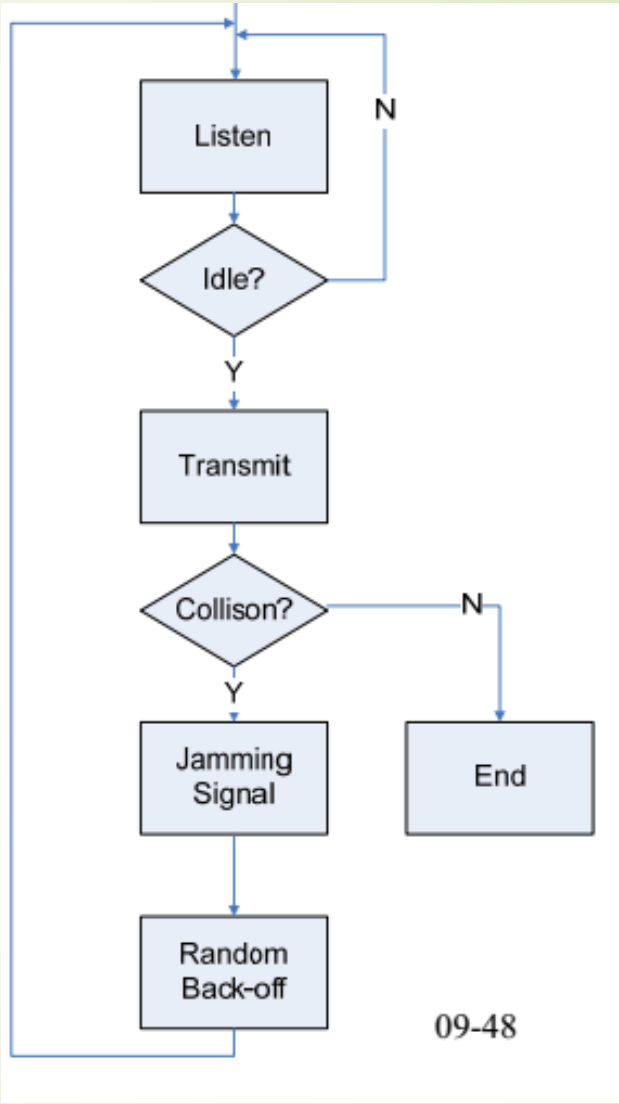
- For propagation time is much less than transmission time
- All stations know that a transmission has started almost immediately
- First listen for clear medium (carrier sense)
- If medium idle, transmit
- If two stations start at the same instant, collision
- Wait reasonable time (round trip plus ACK contention)
- No ACK then retransmit
- Max utilization depends on propagation time (medium length) and frame length
  - Longer frame and shorter propagation gives better utilization

CSMA

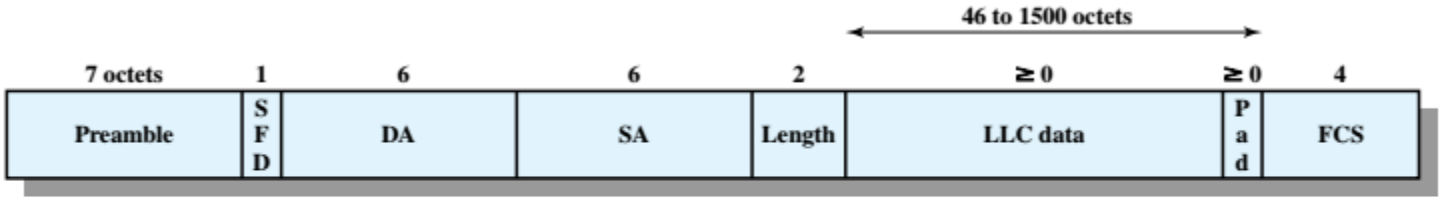
- Non-persistent CSMA
- 1-persistent CSMA
- p-persistent CSMA

CSMA/CD

- With CSMA, collision occupies medium for duration of transmission. CSMA/CD improves on that.
- Stations listen whilst transmitting
  - 1. If medium idle, transmit, otherwise, step 2
  - 2. If busy, listen for idle, then transmit
  - 3. If collision detected, jam then cease transmission
  - 4. After jam, wait random time then start from step 1



IEEE 802.3 Frame Format



SFD = Start of frame delimiter
DA = Destination address
SA = Source address
FCS = Frame check sequence

Figure 16.3 IEEE 802.3 Frame Format

- **Source Address (SA):** Specifies the station that sent the frame.
- **Length/Type:** Length of LLC data field in octets, or Ethernet Type field, depending on whether the frame conforms to the IEEE 802.3 standard or the earlier Ethernet specification. In either case, the maximum frame size, excluding the Preamble and SFD, is 1518 octets.
- **LLC Data:** Data unit supplied by LLC.
- **Pad:** Octets added to ensure that the frame is long enough for proper CD operation.
- **Frame Check Sequence (FCS):** A 32-bit cyclic redundancy check, based on all fields except preamble, SFD, and FCS.

Courtesy

- Professor Jiying Zhao, University of Ottawa