# BLG 337E- Principles of Computer Communications

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## 16/10/ 2018

## -Medium Access Layer-

References:

*Data and Computer Communications*, William Stallings, Pearson-Prentice Hall, 9th Edition, 2010.

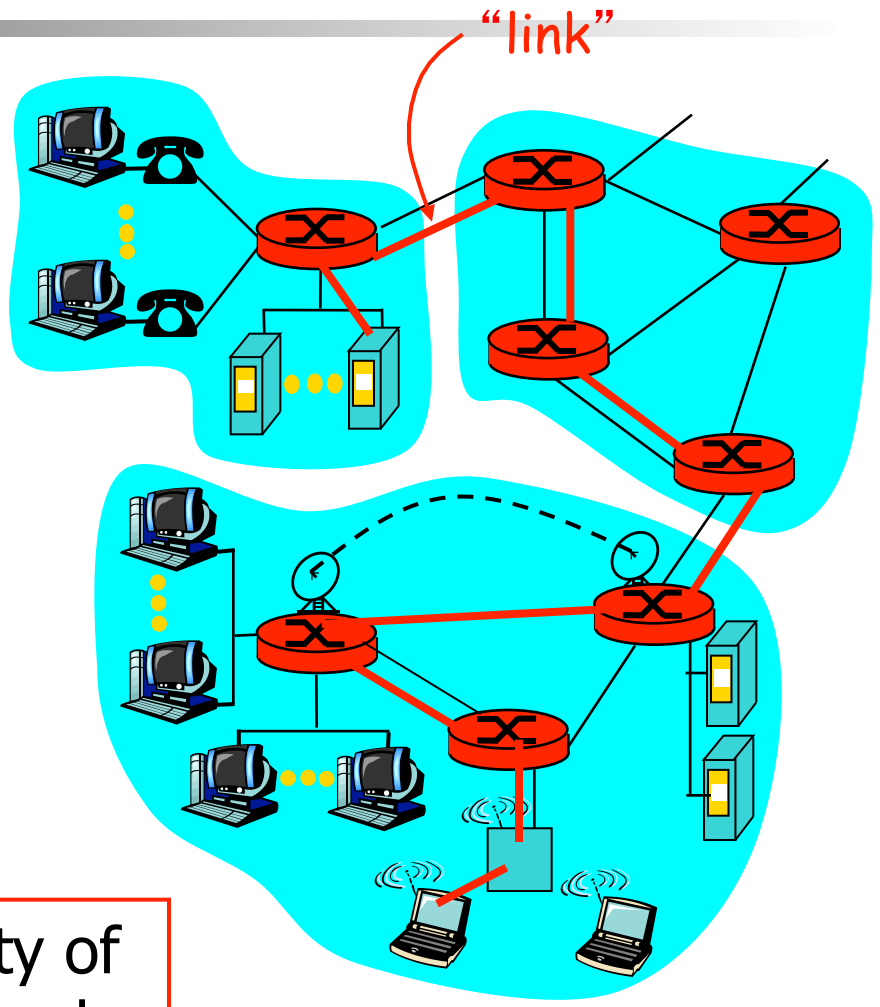
-*Computer Networking, A Top-Down Approach Featuring the Internet*, James F.Kurose, Keith W.Ross, Pearson-Addison Wesley, 6th Edition, 2012.

-Google!

# Data Link Layer

Some terminology:

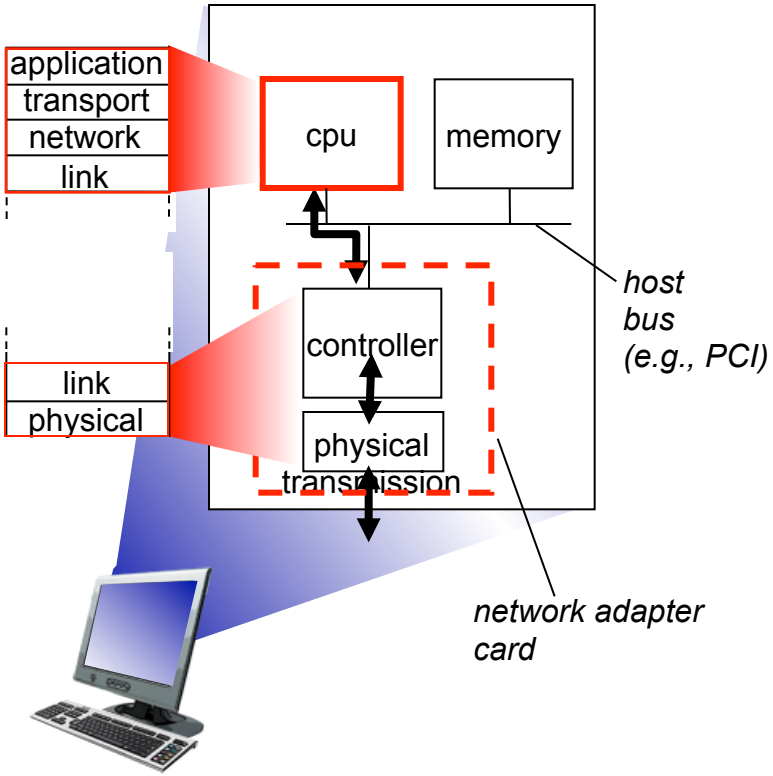
- hosts and routers are **nodes**
- communication channels that connect adjacent nodes along communication path are **links**
  - wired links
  - wireless links
- layer-2 packet is a **frame**, encapsulates datagram



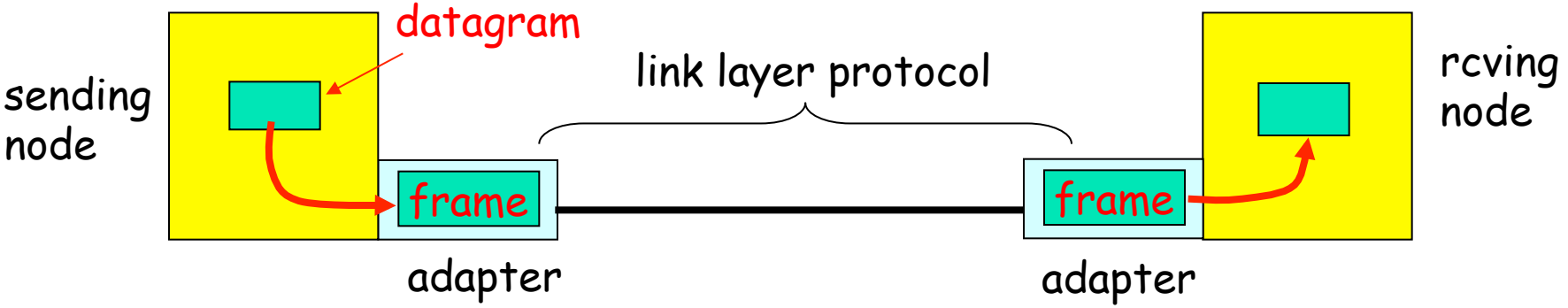

**Data link layer** has responsibility of transferring datagram from one node to adjacent node over a link

# Where is the link layer implemented?

- in each and every host
- link layer implemented in "adaptor" (aka *network interface card* NIC) or on a chip
  - Ethernet card, 802.11 card; Ethernet chipset
  - implements link, physical layer
- attaches into host's system buses
- combination of hardware, software, firmware



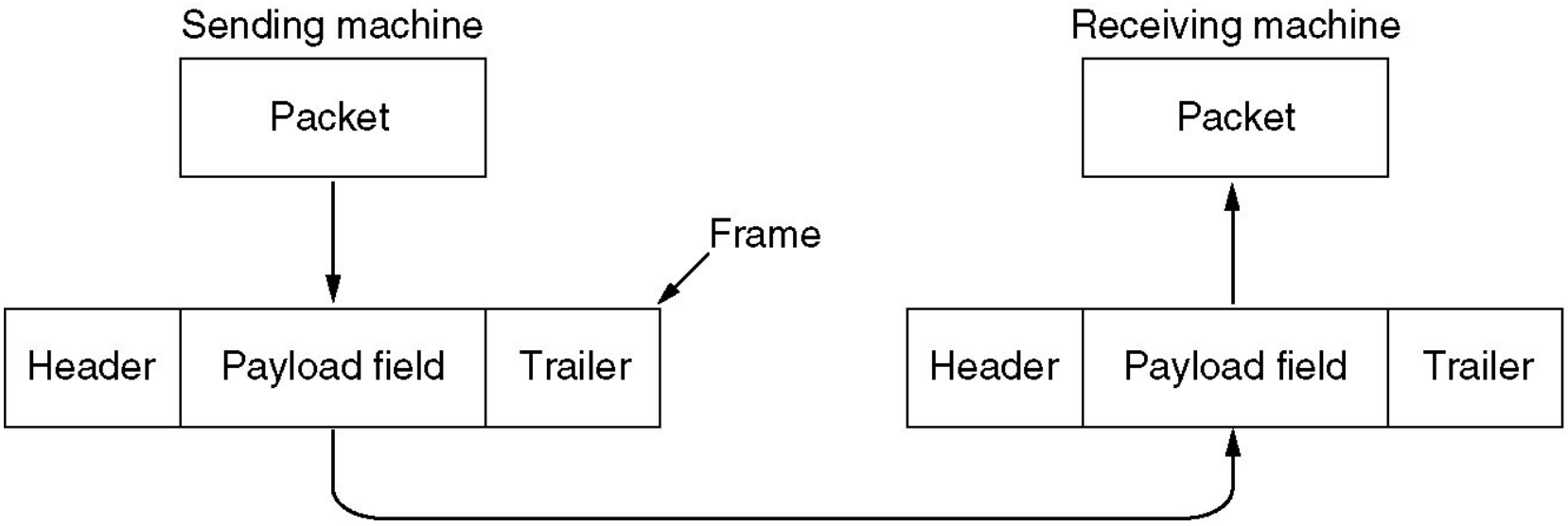
# Adaptors Communicating




- link layer implemented in "adaptor" (NIC)
  - Ethernet card, PCMCI card, 802.11 card
- sending side:
  - encapsulates datagram in a frame
  - adds error checking bits, flow control, etc.
- receiving side
  - looks for errors, flow control, etc
  - extracts datagram, passes to rcving node
- adapter is semi-autonomous
- link & physical layers

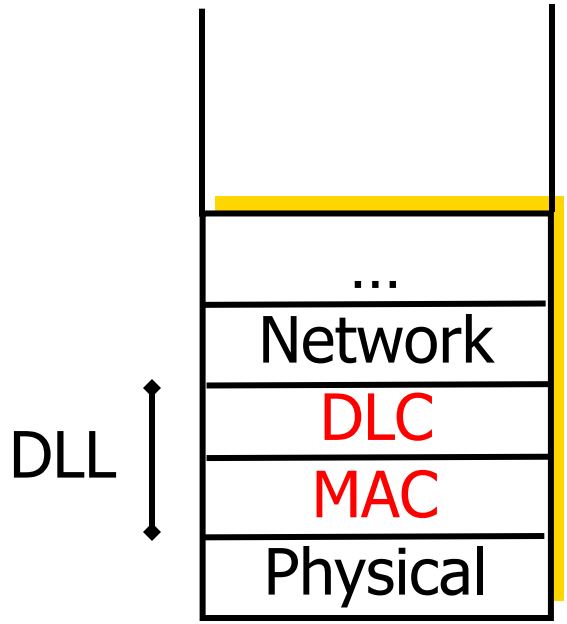
# Functions of Data Link Layer

Relationship between packets and frames.



# Data Link Layer

- Services Provided to the Network Layer
  - Medium Access Control
  - Framing
  - Error Control: Dealing with transmission errors
  - Flow Control: Slow receivers not swamped by fast senders




DLL: Data Link Layer
DLC: Data Link Control
MAC: Medium Access Control

# Link Layer Services

- Framing, link access:
  - encapsulate datagram into frame, adding header, trailer
  - channel access if shared medium
  - "MAC" addresses used in frame headers to identify source, dest
    - different from IP address!
- Reliable delivery between adjacent nodes
  - seldom used on low bit error link (fiber, some twisted pair)
  - wireless links: high error rates
- Error Detection:
  - errors caused by signal attenuation, noise.
  - receiver detects presence of errors:
    - signals sender for retransmission or drops frame
- Error Correction:
  - receiver identifies *and corrects* bit error(s) without resorting to retransmission
- Flow Control:
  - pacing between adjacent sending and receiving nodes

# MAC Addresses and ARP

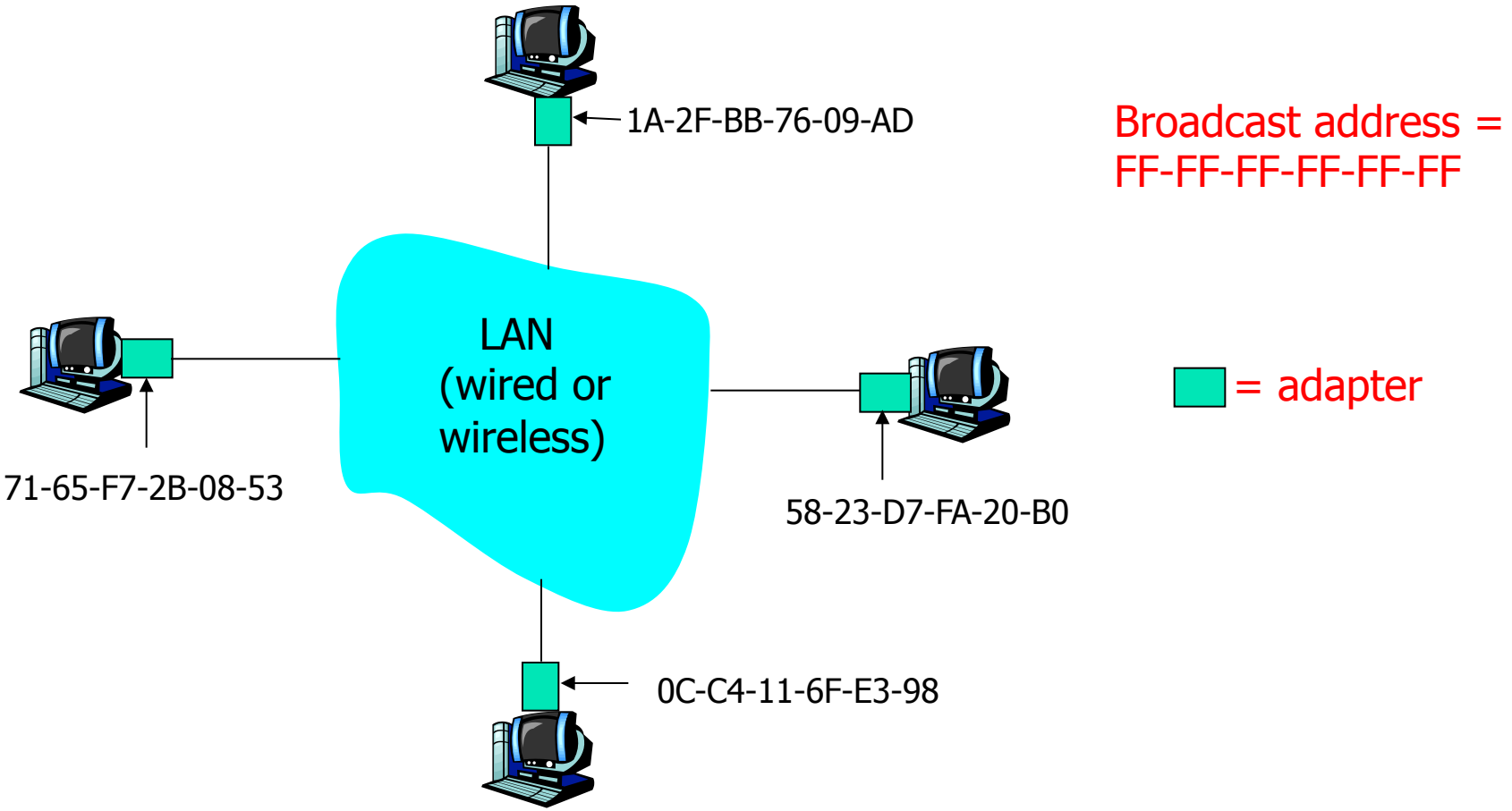
- 32-bit IP address:
  - network-layer address
  - used to get datagram to destination IP subnet
- MAC (or LAN or physical or Ethernet) address:
  - used to get datagram from one interface to another physically-connected interface (same network)
  - *48 bit MAC address (for most LANs) burned in the adapter ROM*
  - *MAC address allocation administered by IEEE*
- Analogy:

  (a) MAC address: like Social Security Number

  (b) IP address: like postal address
- MAC flat address ➜ portability
  - can move LAN card from one LAN to another
- IP hierarchical address NOT portable
  - depends on IP subnet to which node is attached

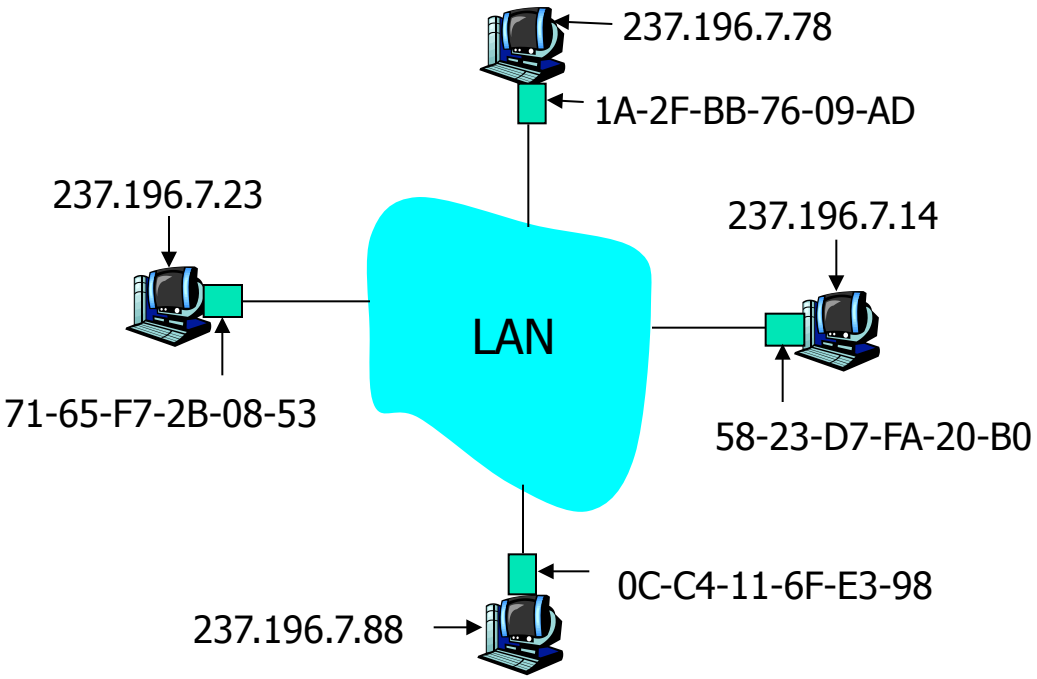
# LAN Addresses and ARP

Each adapter on LAN has unique LAN address



# ARP: Address Resolution Protocol

Question: how to determine MAC address of B knowing B's IP address?




- Each IP node (Host, Router) on LAN has ARP table
- ARP Table: IP/MAC address mappings for some LAN nodes

  < IP address; MAC address; TTL>

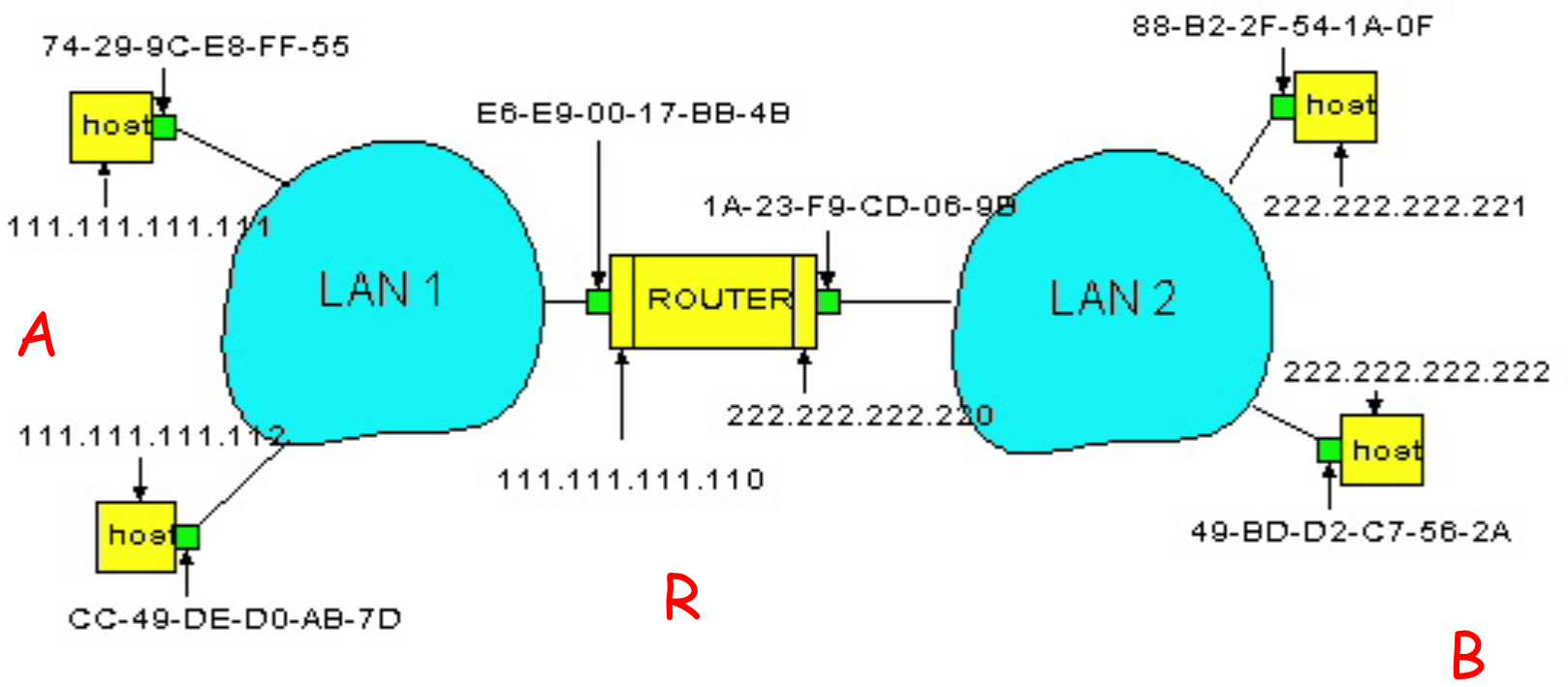
  - TTL (Time To Live): time after which address mapping will be forgotten (typically 20 min)

# ARP protocol: Same LAN (network)

- A wants to send datagram to B, and B's MAC address not in A's ARP table.
- A broadcasts ARP query packet, containing B's IP address
  - Dest MAC address = FF-FF-FF-FF-FF-FF
  - all machines on LAN receive ARP query
- B receives ARP packet, replies to A with its (B's) MAC address
  - frame sent to A's MAC address (unicast)
- A caches (saves) IP-to-MAC address pair in its ARP table until information becomes old (times out)
  - soft state: information that times out (goes away) unless refreshed
- ARP is "plug-and-play":
  - nodes create their ARP tables without intervention from net administrator

# Routing to another LAN

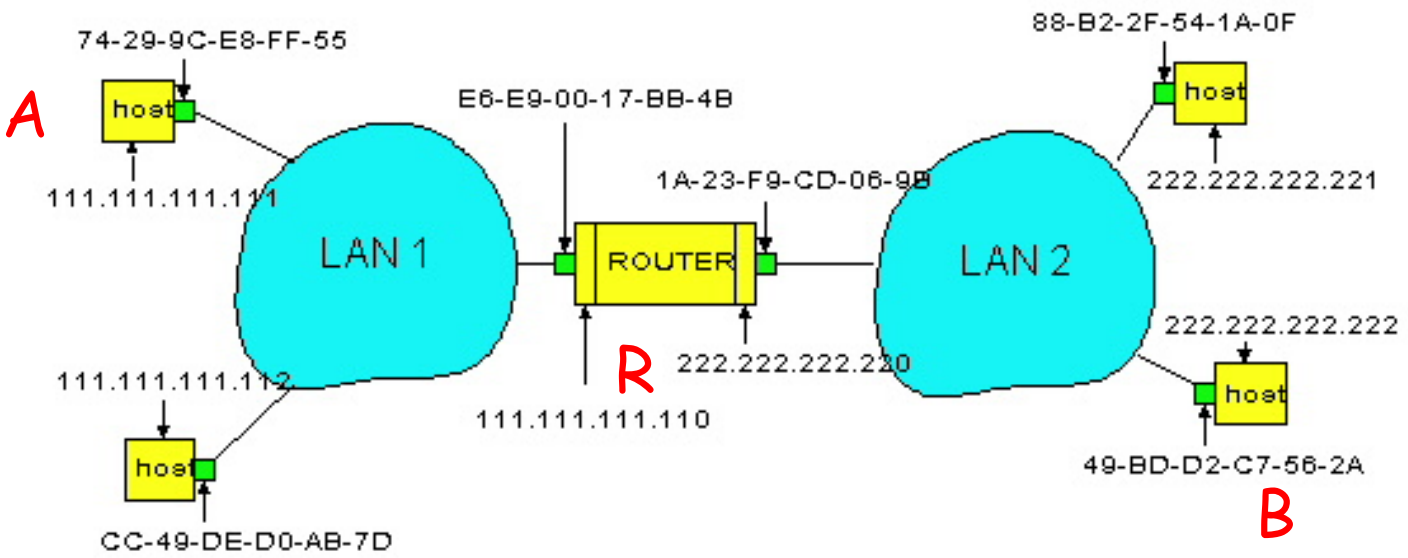
walkthrough: send datagram from A to B via R  assume  A knows B's IP address



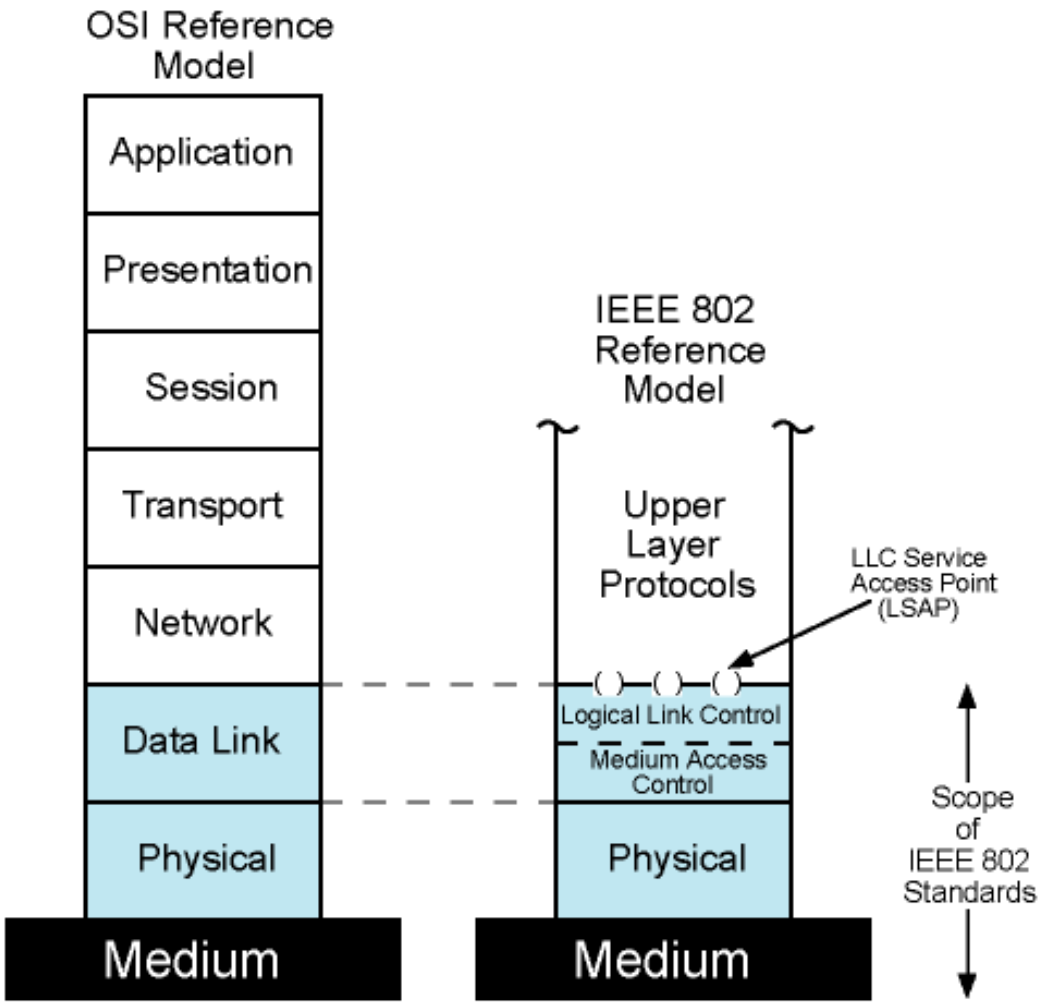

- Two ARP tables in  router R, one for each IP network (LAN)
- In routing table at source Host, find router 111.111.111.110
- If exists in ARP table at source, find MAC address E6-E9-00-17-BB-4B
- A creates datagram with source A, destination B

# Routing to another LAN

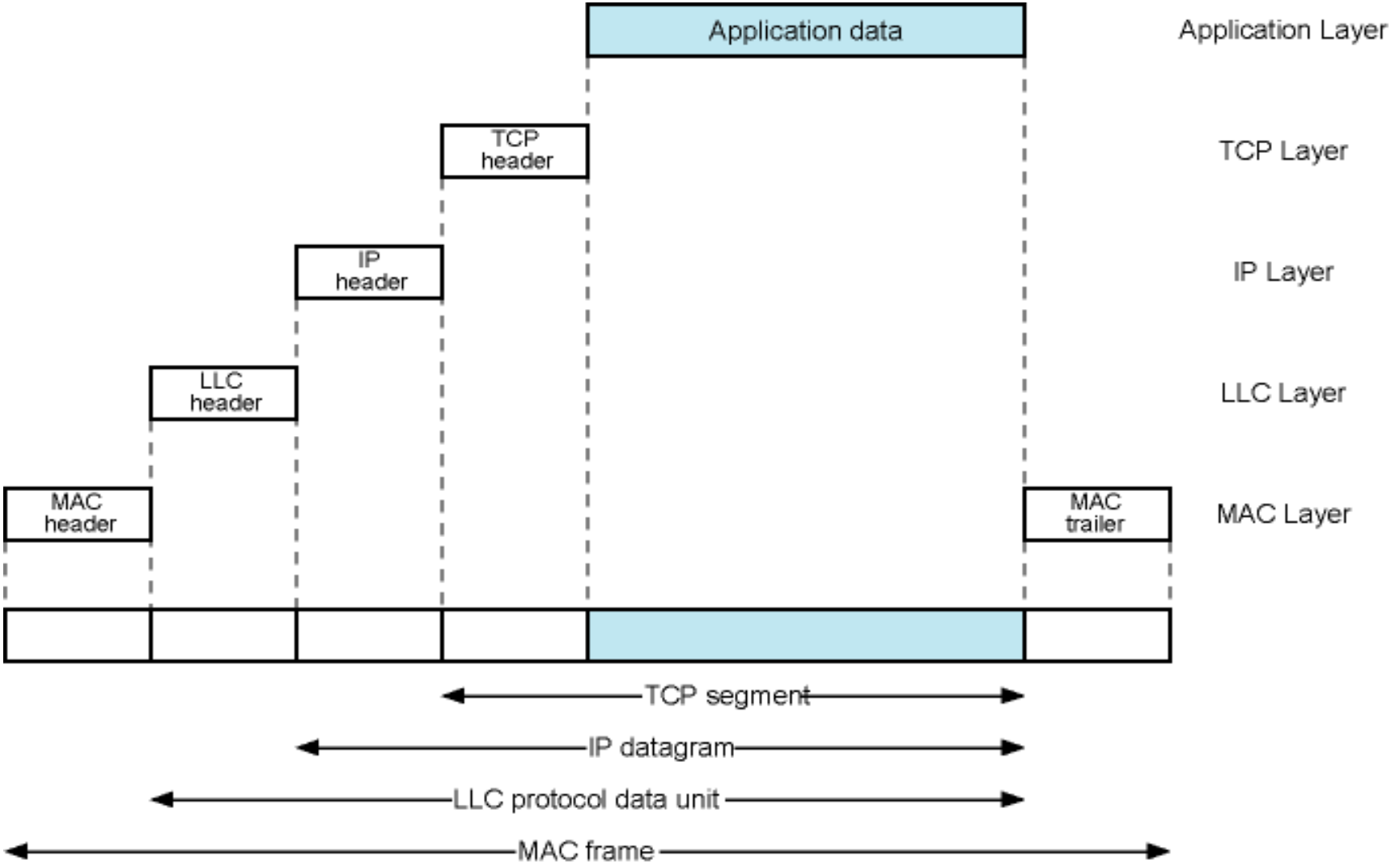
- A uses ARP to get R's MAC address for 111.111.111.110
- A creates link-layer frame with R's MAC address as dest, frame contains A-to-B IP datagram
- A's adapter sends frame
- R's adapter receives frame
- R removes IP datagram from Ethernet frame, sees its destined to B
- R uses ARP to get B's MAC address
- R creates frame containing A-to-B IP datagram sends to B



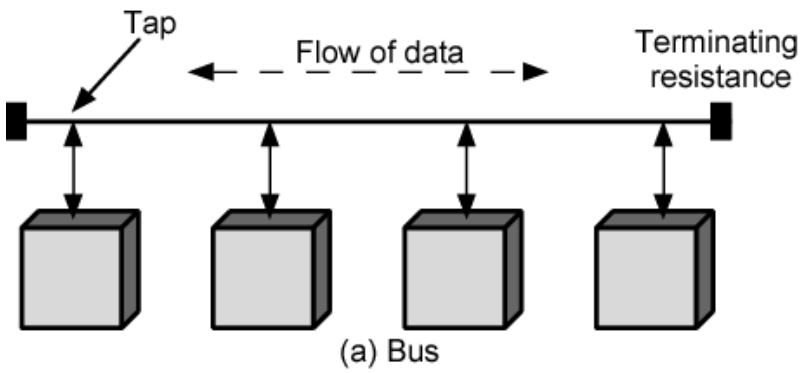
# IEEE 802 Protocol Layers Compared to OSI Model



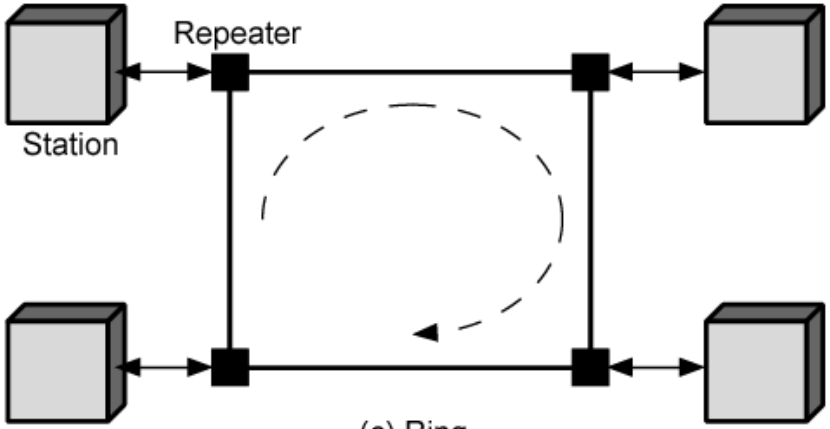
# LAN Protocols in Context



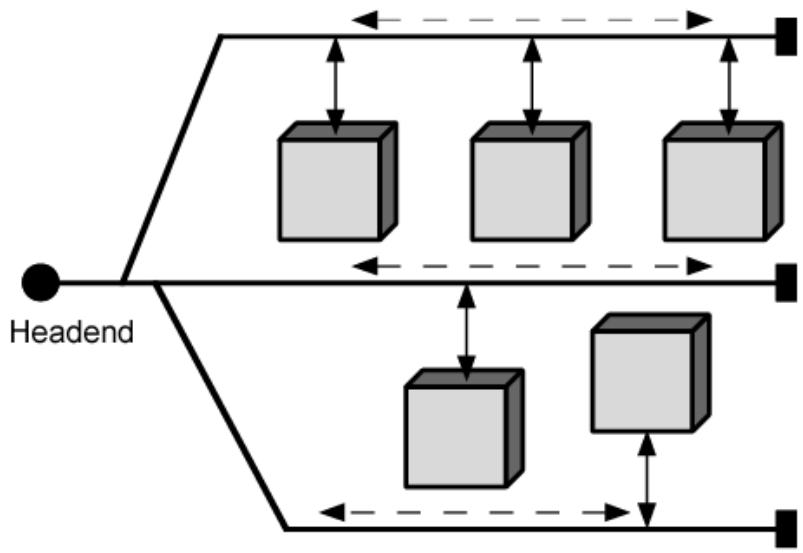
# LAN Topologies



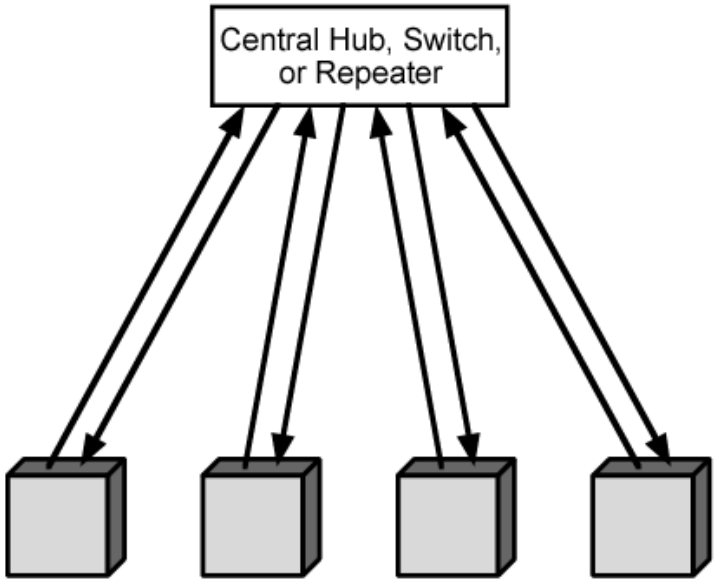

(a) Bus




(c) Ring



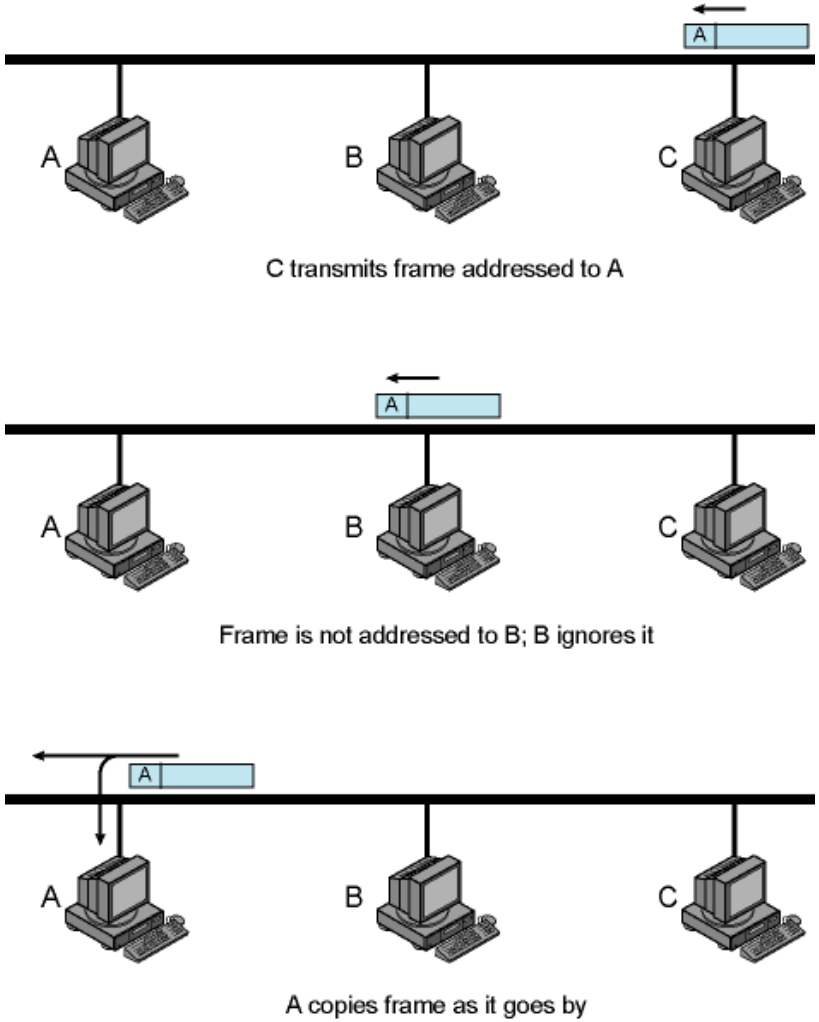

(b) Tree



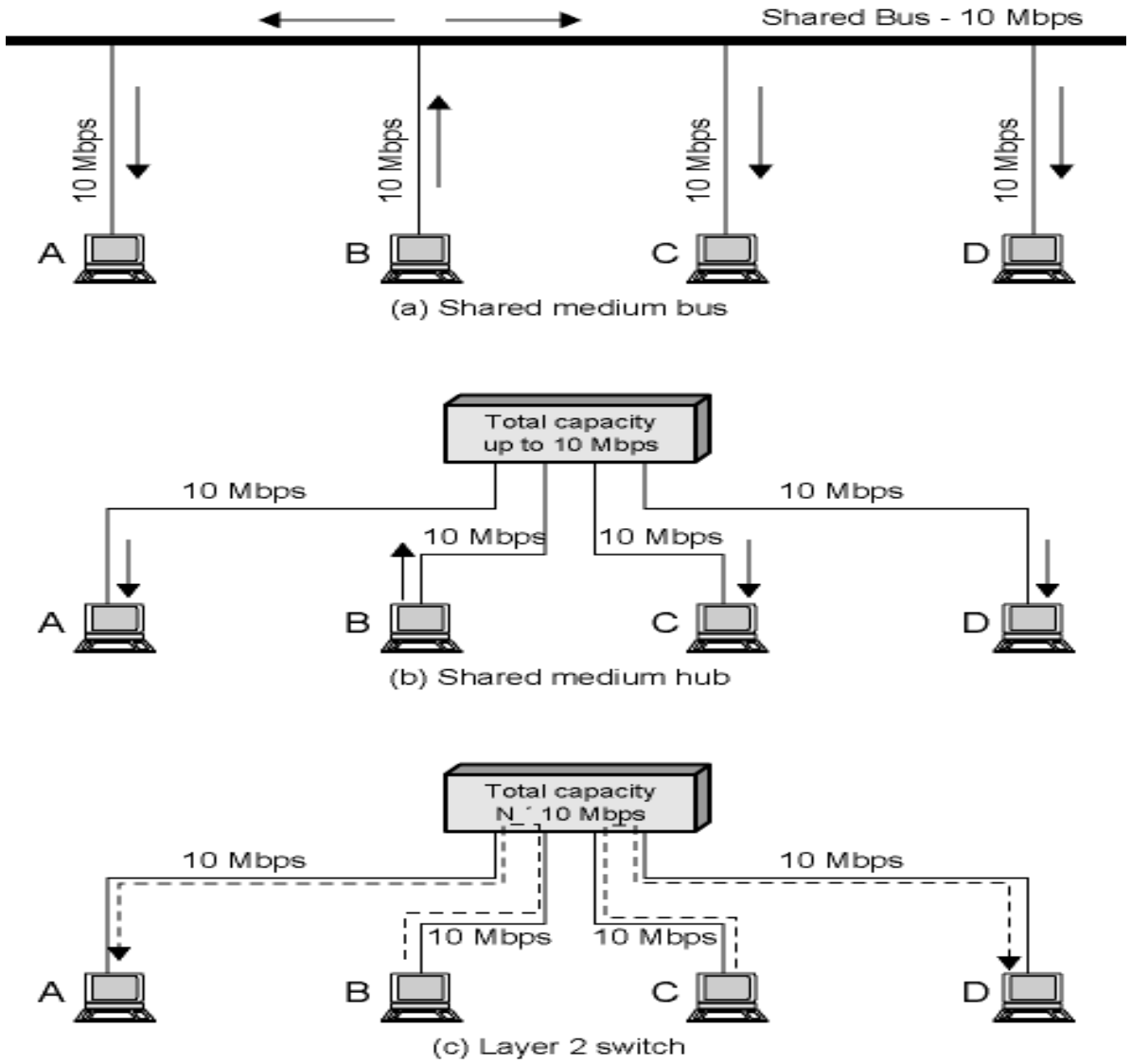

(d) Star

# Bus Topology

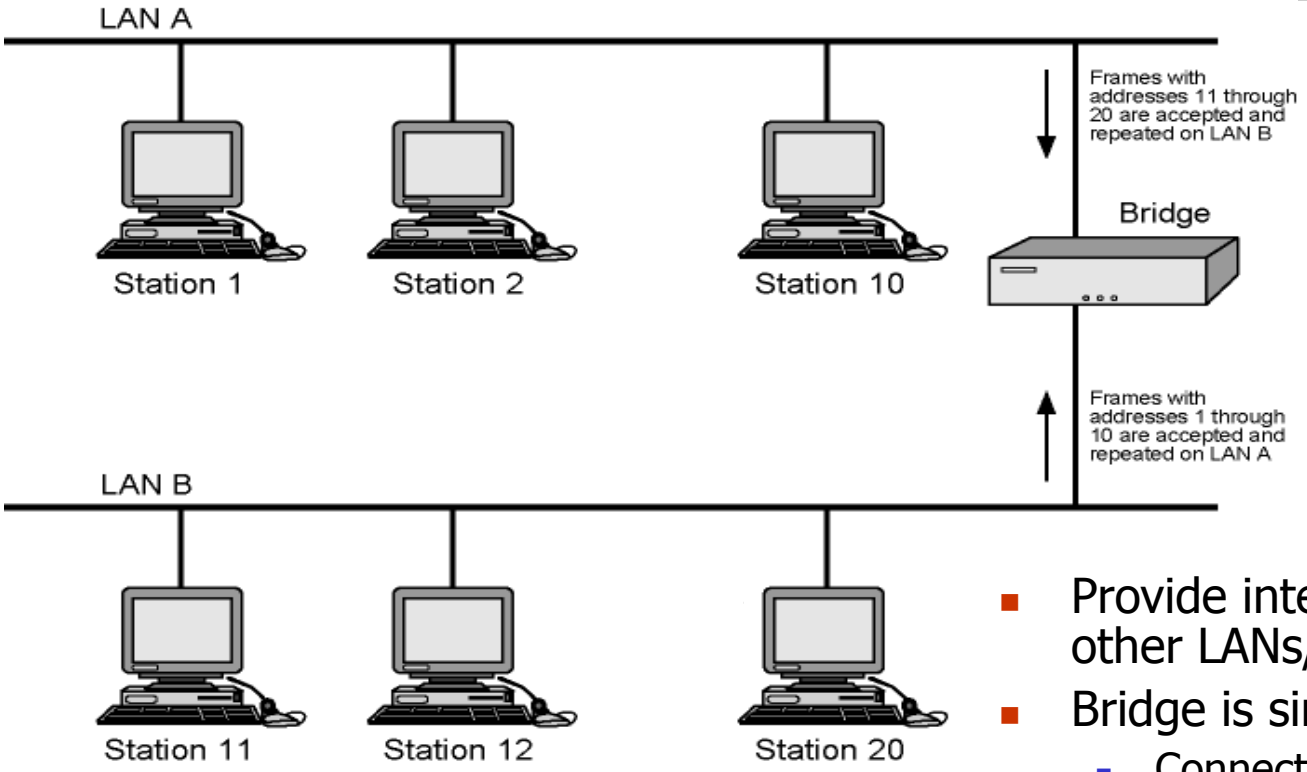
- Stations attach to linear transmission medium (bus)
  - Via a tap
- Full-duplex between station and tap
- Transmission propagates length of medium in both directions
- Received by all other stations
- Ends of bus terminated
  - Absorbs signal
- Transmit data in small blocks (frames)
- Each station assigned unique address
  - Destination address included in frame header



# LAN Bus, Hubs and Switches



# Bridge Operation




- Provide interconnection to other LANs/WANs
- Bridge is simpler
  - Connects similar LANs
  - Identical protocols for physical and link layers
  - Minimal processing
- Router more general purpose
  - Interconnect various LANs and WANs