

Data Link Layer

Goals:

- Principles behind data link layer services:
 - Error detection, correction
 - Sharing a broadcast channel: multiple access
 - Link layer addressing
 - Reliable data transfer, flow control: Done!
- Example link layer technology: Ethernet

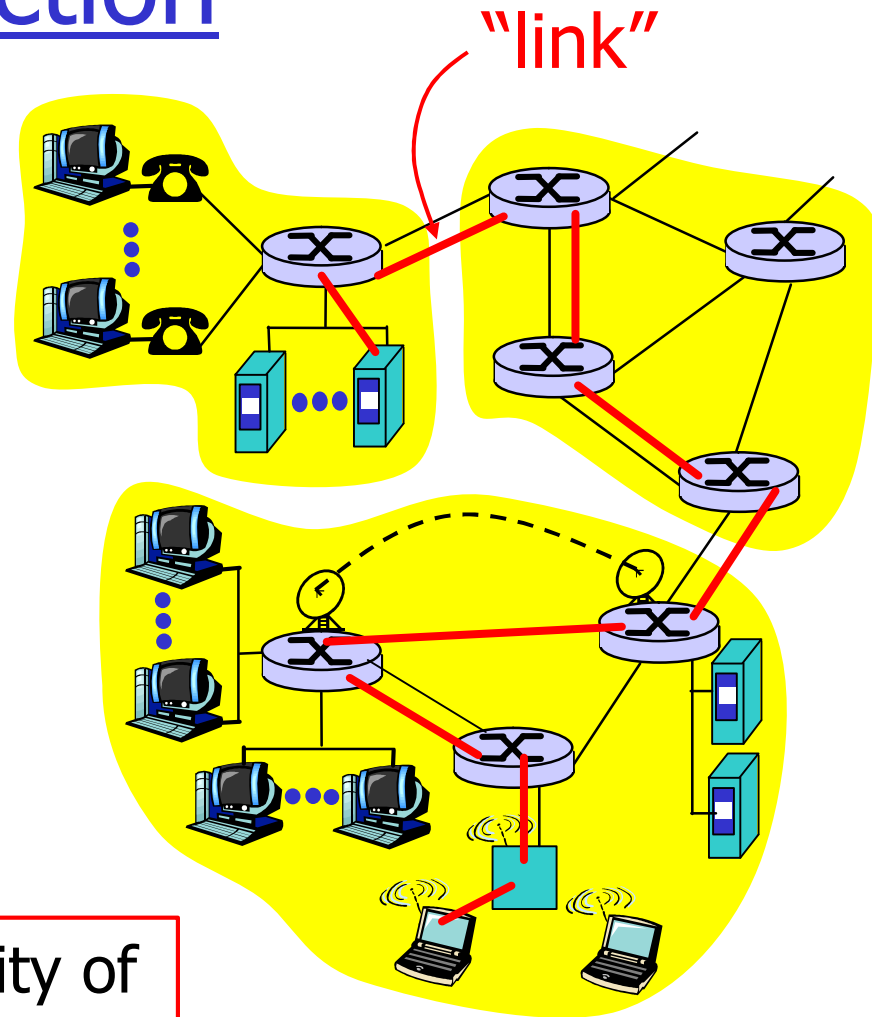
Data Link Layer

- ❑ Link layer services
- ❑ Link-Layer Addressing
- ❑ Ethernet
 - Basic idea
 - Hubs and switches

Link Layer: Introduction

Some terminology:

- ❑ Hosts and routers are **nodes**
- ❑ Communication channels that connect adjacent nodes along communication path are **links**
 - Wired links
 - Wireless links
 - LANs
- ❑ 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

Link Layer: Context

- ❑ Datagram transferred by different link protocols over different links:
 - e.g., Ethernet on first link, frame relay on intermediate links, 802.11 on last link
- ❑ Each link protocol provides different services
 - e.g., may or may not provide reliable data transport

Link Layer Services

Framing and link access

- Encapsulate datagram: frame adds header, trailer
- Channel access if shared medium
- Frame headers use 'physical addresses' = "MAC" to identify source and destination
 - Different from IP address!

Reliable delivery (between adjacent nodes)

- Seldom used on low bit error links (fiber optic, co-axial cable and some twisted pairs)
- Sometimes used on high error rate links (e.g., wireless links)

Link Layer Services (more)

Flow Control

- Pacing between sending and receiving nodes

Error Detection

- Errors are caused by signal attenuation and noise.
- Receiver detects presence of errors
signals sender for retrans. or drops frame

Error Correction

- Receiver identifies and **corrects** bit error(s) without resorting to retransmission

Half-duplex and full-duplex

- With half duplex, nodes at both ends of link can transmit, but not at same time

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Addresses

IP address (32-bit):

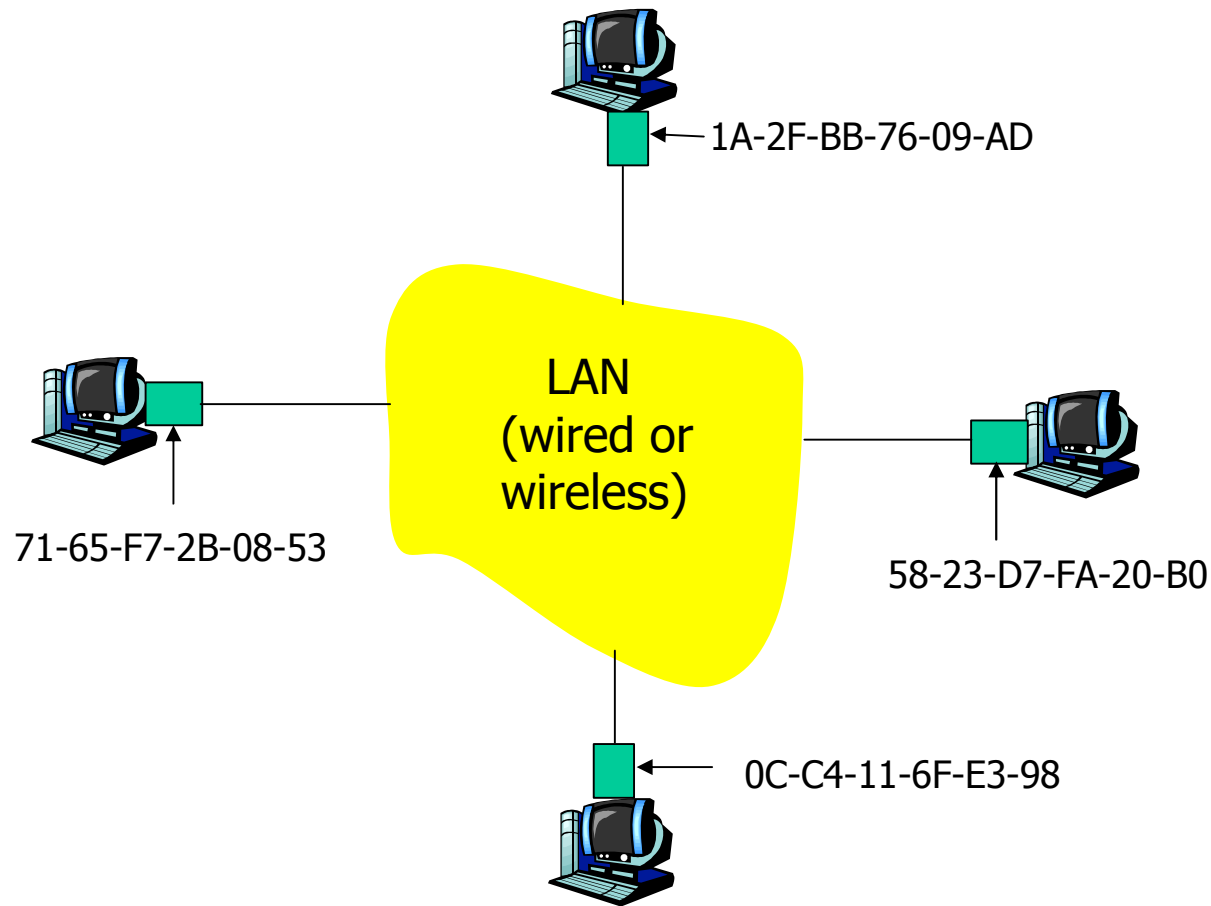
- ❑ Network-layer address
- ❑ Used to get datagram to destination network (recall IP network definition)

MAC (or LAN or physical or Ethernet) address:

- ❑ Data link-layer 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

Addresses (2.)

Each adapter on LAN has unique LAN address



Broadcast address =
FF-FF-FF-FF-FF-FF

■ = adapter

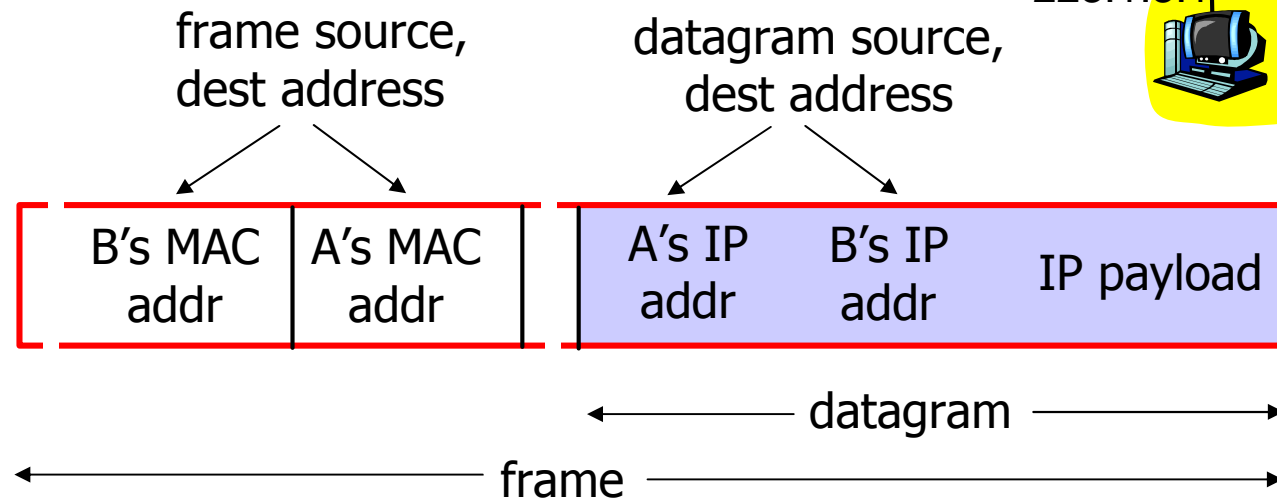
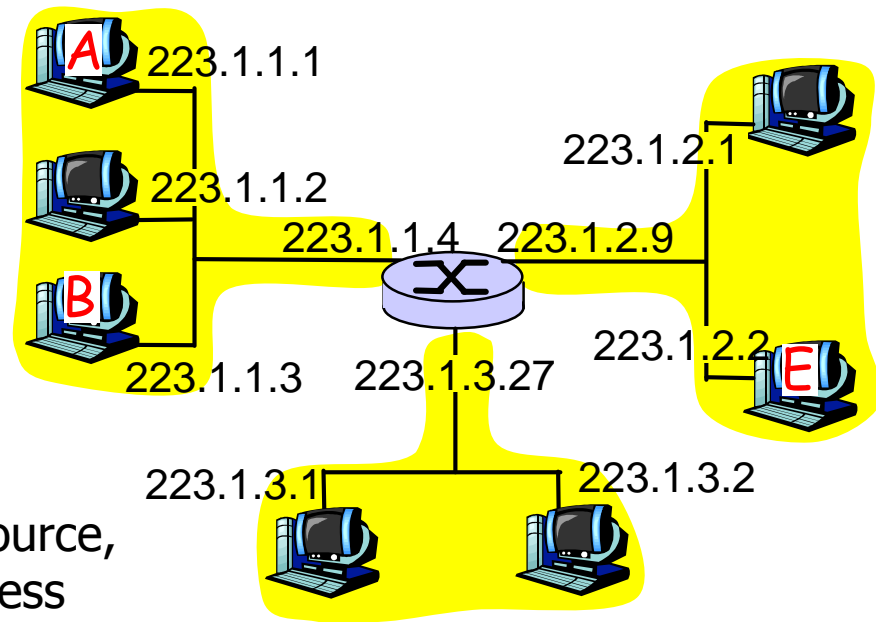
Addresses (3.)

- ❑ MAC address allocation administered by IEEE
- ❑ Manufacturer buys portion of MAC address space (to assure uniqueness)
- ❑ Analogy:
 - MAC address: like Social Security Number
 - 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 network to which one attaches

Example

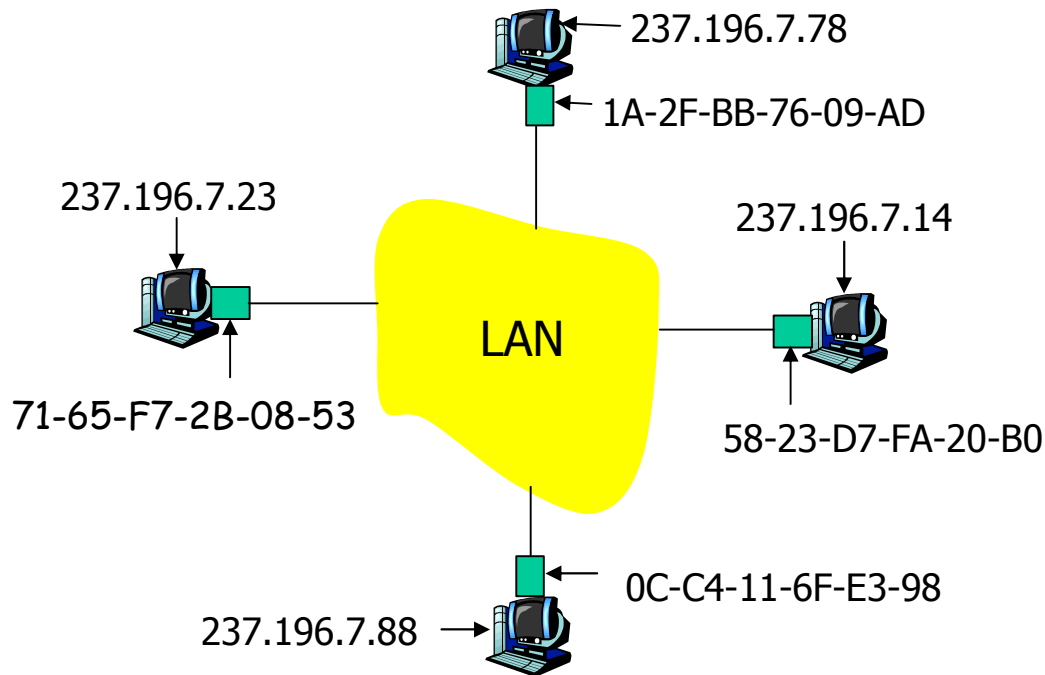
Starting at A, given IP datagram addressed to B:

- Look up net. address of B, find B on same net. as A
- Link layer send datagram to B inside link-layer frame



ARP: Address Resolution Protocol

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



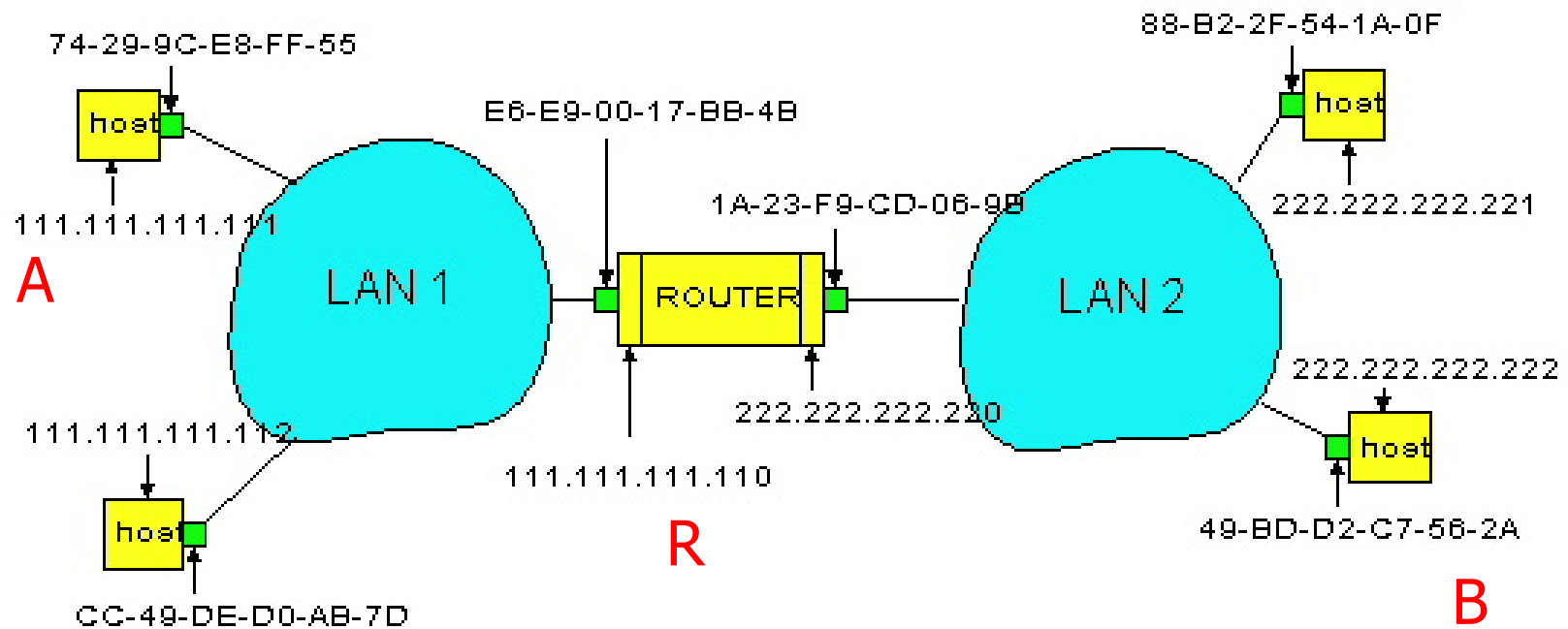
- ❑ Each IP node (Host, Router) on LAN has **ARP** table
- ❑ ARP Table: IP/MAC address mappings for some LAN nodes
<IP address; MAC address; TTL>
 - TTL (Time To Live): time after which address mapping will be forgotten (typically 20 min)

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

- Two ARP tables in router R, one for each LAN



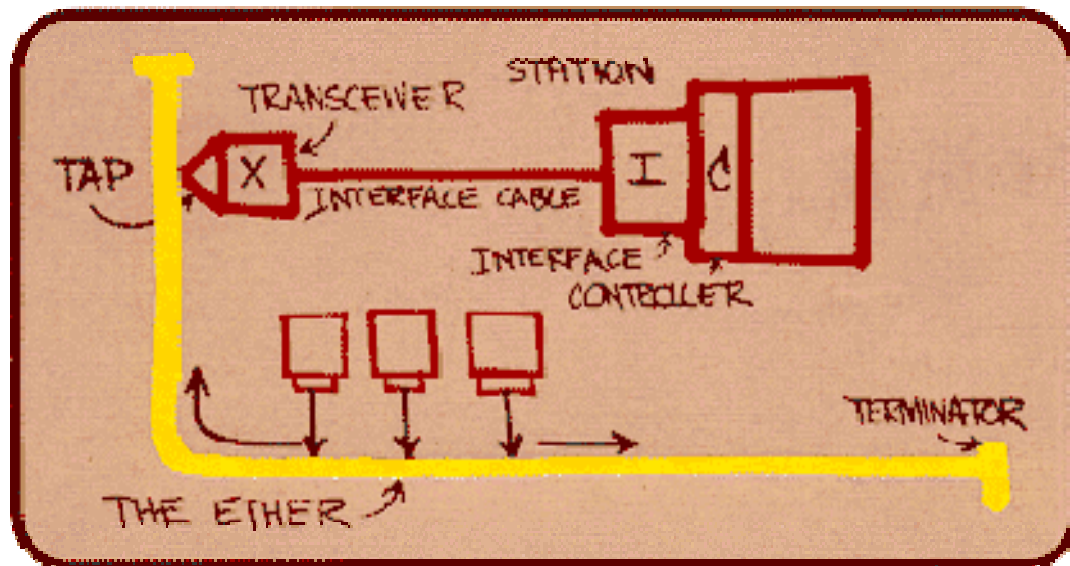
Data Link Layer

- ❑ Link layer services
- ❑ Multiple access protocols
- ❑ Link-Layer Addressing
- ❑ **Ethernet**, basic idea

Ethernet

“Dominant” LAN technology:

- ❑ Cheap \$20 for 100Mbps!
- ❑ First widely used LAN technology
- ❑ Simpler, cheaper than token LANs and ATM
- ❑ Kept up with speed race: 10 Mbps – 10 Gbps
- ❑ Shared medium



Metcalfe's Ethernet sketch

Unreliable, Connectionless Service

- ❑ **Connectionless:** No handshaking between sending and receiving adapter.
- ❑ **Unreliable:** Receiving adapter does not send ACKs or NACKs to sending adapter
 - Stream of datagrams passed to network layer can have gaps
 - Gaps will be filled if app is using TCP
 - Otherwise, app will see the gaps

Ethernet Uses CSMA/CD

- ❑ No slots
- ❑ Adapter does not transmit if it senses that some other adapter is transmitting, that is, **carrier sense**
- ❑ Transmitting adapter aborts when it senses that another adapter is transmitting, that is, **collision detection**
- ❑ Before attempting a retransmission, adapter waits a random time, that is, **random access**