

## 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

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## Data Link Layer

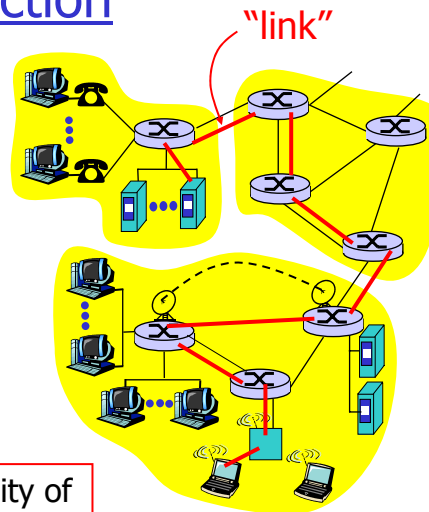
- ❑ **Link layer services**
- ❑ Link-Layer Addressing
- ❑ Ethernet
  - Basic idea
  - Hubs and switches

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## 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

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## 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

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## 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)

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## 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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## Data Link Layer

- ❑ Link layer services
- ❑ **Link-Layer Addressing**
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## Addresses

### *IP address (32-bit):*

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

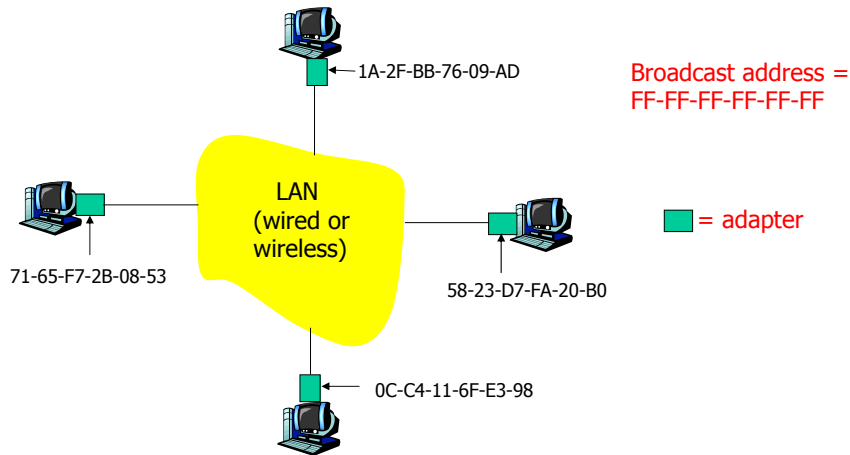
### **MAC (or LAN or physical or Ethernet) address:**

- ❑ 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

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## Addresses (2.)

Each adapter on LAN has unique LAN address



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## Addresses (3.)

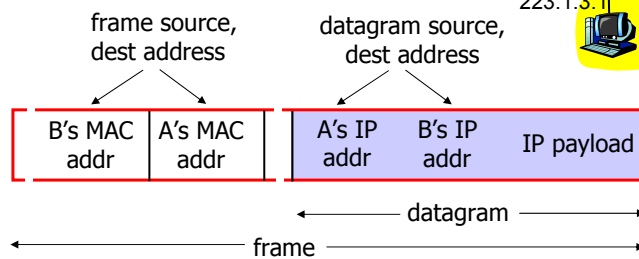
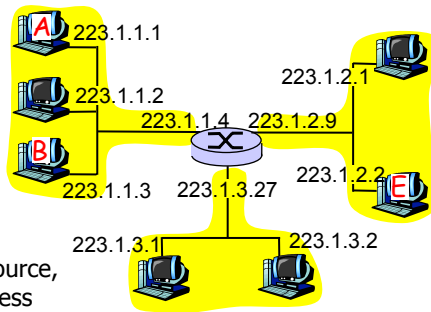
- MAC address allocation administered by IEEE
- Manufacturer buys portion of MAC address space (to assure uniqueness)
- Analogy:
  - MAC address: like Social Security Number
  - IP address: like postal address
- MAC flat address ⇔ portability
  - can move LAN card from one LAN to another
- IP hierarchical address NOT portable
  - depends on network to which one attaches

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## 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



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## ARP: Address Resolution Protocol

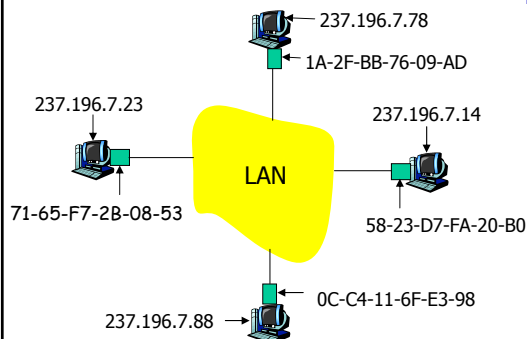
Question: how to determine MAC address of B knowing B's IP address?

- 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)



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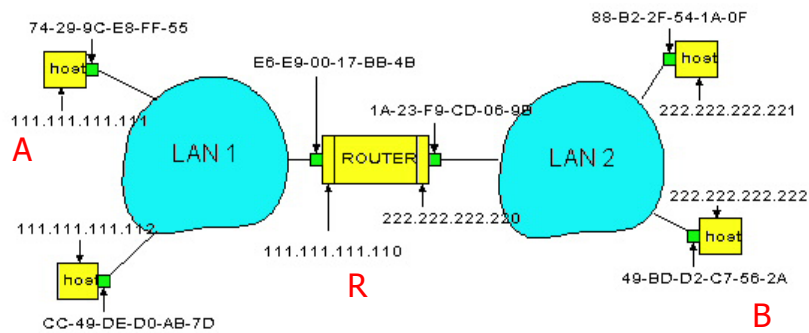
## ARP Protocol: Same LAN (Network)

- 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

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## Routing To Another LAN

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



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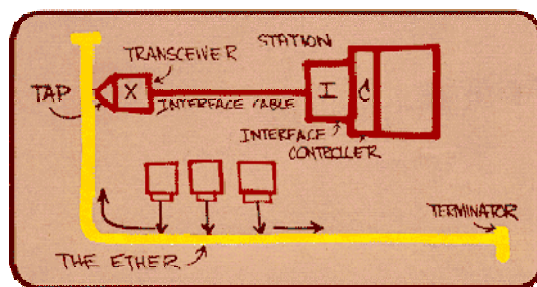
- Link layer services
- Multiple access protocols
- Link-Layer Addressing
- **Ethernet**, basic idea

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## 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

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## 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

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## 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**

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