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
Data Link Layer

- Link layer services
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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

- 1A-2F-BB-76-09-AD
- 71-65-F7-2B-08-53
- 58-23-D7-FA-20-B0
- 0C-C4-11-6F-E3-98

LAN (wired or wireless)

= 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
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 100Mbs!
- First widely used LAN technology
- Simpler, cheaper than token LANs and ATM
- Kept up with speed race: 10 Mbps – 10 Gbps
- Shared medium
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