Computer Networks
ICS 651

- Carrier Sense Multiple Access
- Frame Format
- Ethernet address
- Address Resolution Protocol
- Collision Detection and Random Binary Backoff
- Then and now: coaxial to hubs, 3Mb/s to Gigabit and 10G

Ethernet Concepts

- Ethernet is the quintessential Local Area Network (LAN) technology
- broadcast medium ("Ether") is a physical wire
- sender can monitor medium for other transmissions, hold off until there is silence
  - this is easier on a wire, where signal power is about as strong at the sender as at the receiver, than on the wireless medium, where signal power at the receiver is much weaker than at the sender
- after current transmission (if any) is over, sender can transmit
- sender can monitor its own transmission for errors (most likely due to collision)
- CRC in frame allows all receivers to detect collisions
- Ethernet is usually described as Carrier Sense Multiple Access (CSMA) with Collision Detection (CSMA/CD)
- collision detection depends on:
- finite speed of light
- maximum network diameter

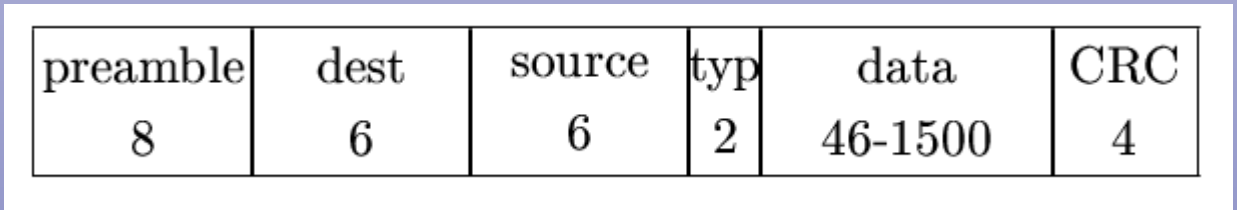
Ethernet Collision Detection

- if speed of light is c m/s
  - the speed of light on a wire is less than in a vacuum
- if minimum frame size is b bits
- if bandwidth is B b/s
- in-class exercise: what is the maximum network diameter (in meters -- find the formula) that still allows us to detect collisions?
- also compute for the specific case

  $c=2 * 10^8$ m/s, b = 256 bits, B = 100Mb/s

Ethernet Frame

- destination comes first: very little buffering/intelligence needed to discard a frame that is not for me
- address ff:ff:ff:ff:ff:ff is the broadcast address
- source address is generally ignored
- ethertype is 0x0800 for IP packets, 0x0806 for ARP packets, 0x86DD for IPv6 packets
- if ethertype is 1500 or less, it encodes the frame length, and other protocols (LLC/Logical Link Control) must be used to determine next higher layer



Ethernet Addresses

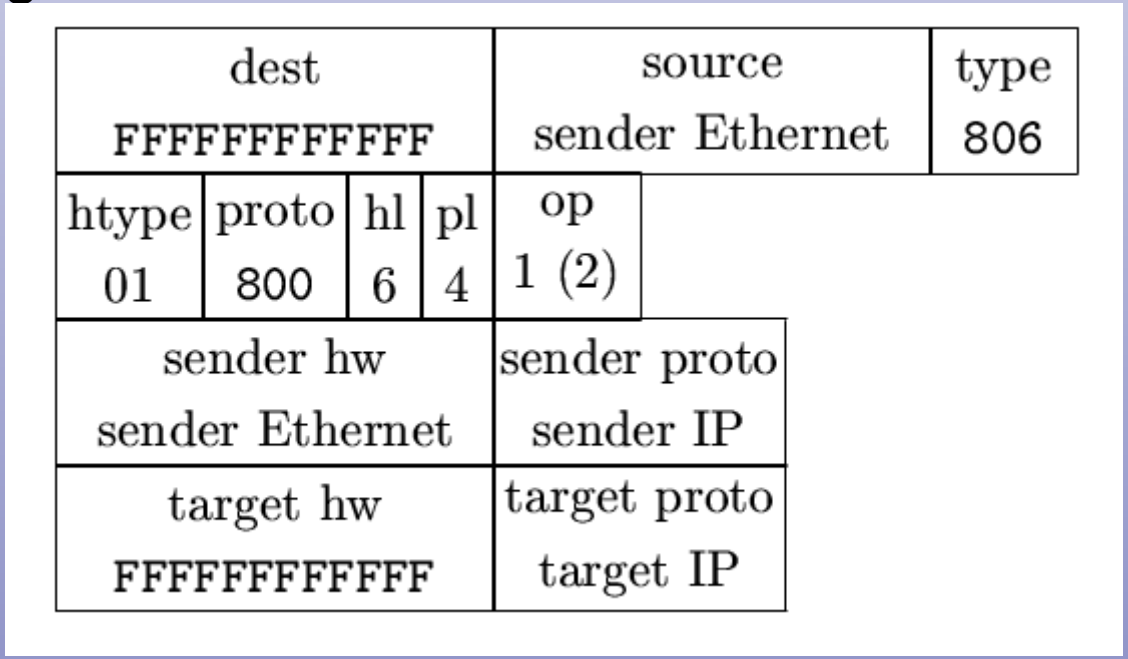
- every Ethernet interface must have a globally unique address
- unlike IP, this address is not used for routing, so does not need to have global significance (no need to be hierarchical)
- Ethernet addresses are sold in blocks of 2^{24} = 16,777,216 (value of the first three bytes belongs to each manufacturer)
- `arp -a` to see some addresses with which your computer is communicating
  - `ip -6 neigh` for the IPv6 equivalent on unix
  - `netsh int ipv6 show neigh` on windows
- other technologies, particularly WiFi, use Ethernet addresses
- because Ethernet does Medium Access Controll, Ethernet addresses are often called MAC addresses

Ethernet and IP

- use ethernet to carry IP packet
- IP host/router knows: IP address of next hop, interface on which to send it
- must fragment if header + data > 1500 bytes
- must pad packet if header + data < 46 bytes
- could broadcast packet, let all but one IP on the network discard it
- instead, broadcast a request, let the specific host reply:
  - Address Resolution Protocol, ARP, for IPv4
  - Neighbor Discovery Protocol, NDP, for IPv6

ARP

- request (op 1) is sent to broadcast address, reply (op 2) to sender hardware address
- only 28 bytes, padding needed to get to 46
- hardware and protocol lengths (hl, pl) make ARP flexible enough for lots of protocols
  - including IPv6, but IPv6 uses NDP



NDP

- Neighbor Discovery Protocol
- a collection of local-network functionality, largely replacing ARP and DHCP:
  - router solicitation and advertisement: find your default router, network number, and netmask, create your own address, get DNS servers
    - IPv4 uses DHCP, addresses are assigned rather than created
  - neighbor solicitation and advertisement: find the MAC address of your neighbor, verify that your IP address is not in use
    - IPv4 uses ARP
  - redirect: use this other router for the given destination
    - IPv4 uses ICMP

ARP Cache

- don't want to send a request for every IP packet
- when I get a reply, I cache the address
- IP is connectionless, so use a timer (15 minutes) to discard old entries
- if ARP cache fills, can do LRU discard
- if I get an ARP request from someone, I will assume:
  - they plan to send me a packet
  - I will eventually send them some reply
- so I add them to my cache

Ethernet Collision Algorithm

- If there is a collision, it will be detected in the first 512 bits (64 bytes) of the frame
  - 14-byte header, 46-byte minimum payload size, 4-byte CRC
- if a sender detects a collision, it must jam the wire
  - by putting a signal that is not a valid transmission
- receivers and other senders detect jamming, stop listening
- all senders must do binary exponential backoff
- randomization for backoff algorithm comes from my Ethernet address

Ethernet Evolution and Summary

- Xerox
- 3 Mb/s system with 2- or 6-byte addresses
- 10-Base 5: coaxial 10Mb/s with vampire taps
- 10-Base 2 (thinwire): coaxial 10Mb/s with point-to-point
- 10-Base T: CAT-5 to hubs, no actual shared medium
- 100- and 1000 Mb/s Ethernet(s) over twisted pair or fiber
- Gigabit and 10-Gigabit Ethernet
- Ethernet is usually classified as: Carrier Sense Multiple Access (CSMA) with Collision Detection: CSMA/CD