

# ICS 451: Today's plan

- Carrier Sense Multiple Access (CSMA)
  - with Collision Detection (CSMA/CD)
  - with Collision Avoidance (CSMA/CA)
- real-time properties of probabilistic MAC
- PPP
- Ethernet

# Ethernet Retransmission

- after a collision, wait 0 or 1 slot times
- after the same packet has collided again, wait 0, 1, 2, or 3 slot times, chosen at random
- double the maximum waiting time after each collision
  - up to 1,024 slot times
- transmission fails after 16 attempts
- Binary Exponential Backoff
  - also used in TCP

# 802.11 CSMA

- wireless medium, sender can't detect collision
- each frame acknowledged by receiver
  - separate ack frames
- sender listens before transmission
  - a short interval (SIFS) before sending an ack
  - before sending a data packet, either
    - a medium interval (DIFS) if there was no collision
    - a longer interval (EIFS) if collision was detected

# 802.11 CSMA/CA

- sender can reserve channel:
  - Request to Send, RTS frame
  - receiver replies with Clear to Send, CTS frame
- anyone in range of RTS or CTS avoids sending
- RTS/CTS are optional in 802.11
  - more useful for larger packets

# Summary

- ALOHA is simple: transmit when ready
  - retransmit if necessary
  - still used, e.g. in satellite networks
  - sometimes used to reserve voice channels, so efficiency of the aloha part is not paramount
- Carrier sense allows higher efficiencies
  - best on a wire: quick collision detection and retransmission
  - CA similar, but slower overall, more overhead

# Predictable Performance: real-time traffic

- probabilistic MAC is simple and very successful
- probabilistic MAC offers no guarantees about *when* a packet will be transmitted, if at all
  - it might take  $7 * 1,024$  slot times
  - before the packet is dropped!
- this is bad for real-time traffic
  - only very lightly loaded networks can be used for high-quality voice or video

# Predictable Performance: solutions

- use deterministic MAC
  - e.g. token ring
  - transmit delay is bounded for any station
- give real-time traffic higher priority, and have a centralized system allocate traffic
  - 802.11 Point Coordination Function (PCF)
  - Wireless Access Point grants access to PCF-capable stations, which can send without contention
  - after PCF, Distributed Coordination Function (DCF) allows all stations to contend

# Data Link Layer Protocols

- SLIP
- Point-to-Point Protocol (PPP)
- Ethernet (802.3)
- WiFi (802.11)
  - and many more



# PPP

- Point-to-Point Protocol
- for use over serial lines or telephone modems
- framing uses 01111110 as frame start and end
  - can use bit-stuffing or byte-stuffing
- supports multiple protocols, not just IP
- supports authentication (login)
  - password authentication protocol, PAP
  - extensible authentication protocol, EAP
- supports per-protocol options, e.g. assignment of IP addresses

# Ethernet

- minimum payload size 46 bytes
  - + 14-byte header, 60 bytes
  - + 4-byte CRC, 64 bytes
- maximum payload size 1500 bytes
  - 1514 (1518) byte frame size
- globally unique 6-byte (48-bit) MAC addresses
  - ff:ff:ff:ff:ff:ff is broadcast address
  - LSB of first byte set to 1: multicast address
  - 24-bit blocks (OUIs) sold to manufacturers
    - Organization Unique Identifier

# Ethernet Frame format

- preamble, 8 bytes, used for clock synchronization
- destination address, 6 bytes
- source address, 6 bytes
- ethernet type, 2 bytes, used as protocol ID
  - 0x800 for IPv4, 0x806 for ARP, 0x86DD for IPv6
- payload, 46-1500 bytes
- CRC, 4 bytes

# Ethernet optimizations

- destination address at beginning, and hardware-specific MAC address, allow early discard of frame
- CRC at end allows CRC computation as the frame is being sent or received

# Ethernet design problems

- header size is not a multiple of 4 bytes
  - hard to process in software
- no payload length field
  - protocols sending less than 46 bytes need to record the length of the header
  - an additional protocol, Logical Link Control or LLC, allows definition of length
    - but rarely used in practice

# Ethernet service

- connectionless
- packets very likely to be delivered
  - as long as there is physical connectivity
- packets delivered to the entire network
  - or not delivered to anyone
- every host sees same packets in same order
- packets delivered or collision detected

# Ethernet Physical Layers

- 10Base5: 10Mb/s over thick coaxial cable
  - vampire tap
- 10Base2: 10Mb/s over thin coaxial cable
  - BNC connectors
- 10BaseT, 100BaseT: twisted pair (RJ45)
  - point-to-point connections only, star topology
  - hubs connect all the hosts
- fiber
- Gb/s, 10Gb/s

# Ethernet Hubs

- physical-layer (bit-level) forwarding
  - with signal regeneration
  - generates or propagates jamming signal
- topology cannot have any loops
- entire network is one collision domain
  - only one packet live at a time
  - limits size of the network