Announcements

- Project #4 Due next week
- Reading
  - Chapter 4 (4.3)

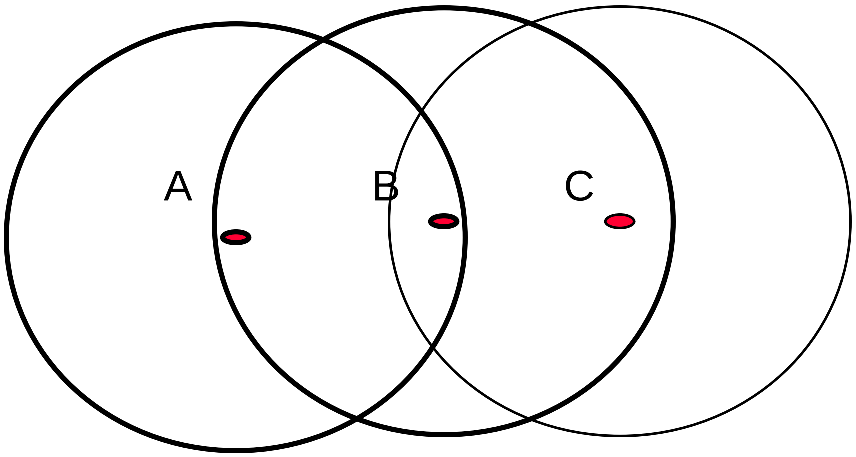
Collision Detection

- If a sender senses a collision
  - stop sending at once
  - apply random backoff
- “contention” period
  - after contention period, there will be no collision
  - send for for 2τ (max propagation delay)
    - need 2τ since might be a collision at far end at $\tau - \varepsilon$

Collision Free Protocols

- Use an allocation scheme
  – must be dynamic (based on load) or we are reduced to TDM
- Bit Map Reservation Protocol
  – round of allocation (contention period)
  – everyone who indicated a desire to send goes in turn
  – requires an overhead of one bit per **per station** per round
- Binary Countdown
  – reservation round send your host address
    - uses a “wired or” to compute winner
    - as soon as a station senses a 1 where it sent 0 it backs off
  – winner sends packet
  – gives higher priority to higher numbered hosts
    - can “rotate” station number after successful transmission

Wireless Shared Channels



- Every node may node be in range of every other node
  - a is in range to send to b, but not c
  - b can send to a or c
  - c can send to b
- Collisions
  - carrier sense will not work due to range
  - must avoid any host sending that is in rang of sender **or** receiver

Wireless Networks (MACA)

- Stations send data into the air
  - not all stations can “see” all other stations
- Need to avoid collisions between sender an receiver
  - possible for the sender to not be able to sense collision
- Use a two stage protocol
  - send a RTS (request to send)
  - receiver responds CLS (clear to send)
- Hosts that hear a RTS or CLS wait and don’t send
  - collisions still possible since two RTS frames may collide

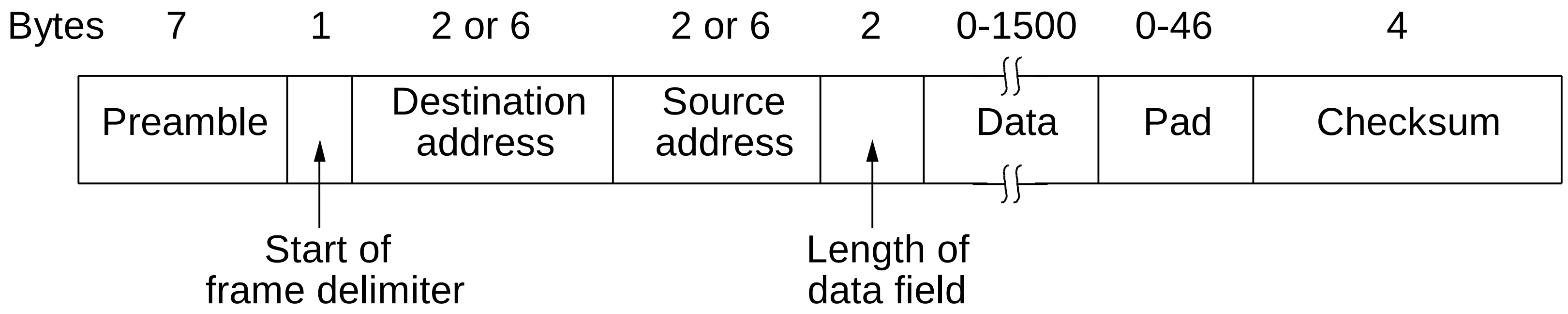
Ethernet Cable Options

- 10base5: Thicknet - first Ethernet
  - Thick cable, doesn’t bend well
  - vampire taps used to “tap” the network
  - max run is 500 meters
- 10Base2: Thin coax (cheaper net),
  - uses “T” connectors
  - max run is 200 meters
- 10baseT: twisted pair
  - uses a central hub
  - easier to find faults and problems
  - max run is 100 meters to hub

Manchester Encoding

- Problem: How to send zero/ones?
  - need to know timing information
  - when does on bit end?
- Answer: Force many transitions
  - every bit is half low and half high
  - 1 is high then low
  - 0 is low then high
  - but this doubles bandwidth
- Differential Manchester Encoding
  - better noise immunity
  - 0 is a transition at the start, 1 none
  - both transition during the middle

Ethernet Frame Format



From: *Computer Networks*, 3rd Ed. by Andrew S. Tanenbaum, (c)1996 Prentice Hall.

- Preamble used to sync clock
- Addresses
  - 48 bits
  - if it starts with a 0 it is globally unique (assigned by IEEE)
  - if it starts with a 1 it is locally unique
- Length
  - 0 to 1500 bytes
  - **min** length is 46 bytes
    - ensures frame reaches end of cable before end of frame is sent
- Checksum
  - 32 bit CRC to detect garbled data at link level

Collision Management

- Binary Exponential Backoff
  - after collision, divide into slot times
  - after first collision, wait either 0 or 1 slot times
  - after second collision, wait either 0, 1, 2, or 3 slot times
  - limited to 1023 slots
  - after 16 collisions, link layer gives up
- Performance
  - each station wants to transmit with probability p, then
    - $A = k\,[p^1(1-p)^{k-1}]$
    - A --> 1/*e* as k --> infinity
  - probability a contention interval has j slots is $A(1-A)^{j-1}$
  - mean number of slots per contention is:

$$\sum_{j=0}^{\infty} jA(1-A)^{j-1} = \frac{1}{A}$$

mean contention interval is then $2\tau/A$