Announcements

- **Reading**
  - Today: 4.1 & 4.2 (skip 4.2.4 and 4.2.5)

- **Second Midterm:**
  - Tuesday April 15
  - covers material from chapters: 1-3, 5-6
    - emphasis on material since last midterm
Medium Access Layer

- **Broadcast Networks**
  - share a common resource for communication
    - bus, wire, air, etc.
  - need to coordination access to this resource

- **Limits of Static Channel Allocation**
  - suitable for constant rate traffic of similar speeds
  - however, bursty traffic results in poor channel utilization
  - consider one queue vs. separate queues for each person
    - $n$ queues with bursty arrival have mean delay $n$ times 1 queue

- **Dynamic Allocation**
  - only use channel when have something to send
  - need to control access to the channel
Shared Channel Model

- **Station model**
  - N independent stations
  - each wants to send $\lambda$ frames per second
  - a station may not send another frame until the first is sent

- **Single Channel Assumption**
  - all stations communicate over a single shared channel

- **Collisions: two stations attempt to send at once**
  - neither transmission succeeds

- **Time**
  - continuous time: frame transmissions can start anytime
  - discrete time: clock ensures all sends initiate at the start of a slot

- **Carrier Sense**
  - stations can tell if channel is in use before sending
  - stations must wait to know if channel was in use
Aloha

- **Stations**
  - ground based radio stations on islands

- **Pure Aloha**
  - send data at will, collisions will happen
  - on collision, wait a random amount of time & try again
  - use standard, fixed size packets
  - what is channel efficiency?
    - assume S new frames per frame time
    - assume G total frames trying to be sent per frame time
    - \( S = G P_0 \)
    - probability of k frames generated during a frame time
      - \( \Pr[k] = G^k e^{-G} / k! \)
    - \( P_o = e^{-2G}, \) so \( S = Ge^{-2G} \)
Performance of Aloha

Collides with the start of the shaded frame

Collides with the end of the shaded frame

\[ t_0 \]

\[ t_0 + t \]

\[ t_0 + 2t \]

\[ t_0 + 3t \]

Vulnerable

Time

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

Slotted ALOHA: \( S = Ge^{-G} \)

Pure ALOHA: \( S = Ge^{-2G} \)

\( S \) (throughput per frame time)

\( G \) (attempts per packet time)

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

● **Slotted Aloha**
  
  – Use a central clock
  – Each station only sends at the start of frame
  – Reduces collision window by 1/2
    * $S = Ge^{-G}$
Carrier Sense Multiple Access

- **look before you leap!**
  - don’t send if someone else is sending
- **collisions are still possible**
  - propagation delay induces uncertainty into sensing
  - possible two hosts both start sending at the same time
- **persistence: when to send after detecting channel in use**
  - 1-persistent
    - as soon as the channel is free, starting sending
  - nonpersistent CSMA
    - if channel is sensed busy, wait a random time and try again
  - p-persistent CSMA
    - if slot is idle send with probability p, else wait for next idle slot
Impact of Carrier Sense

From: Computer Networks, 3rd Ed. by Andrew S. Tanenbaum, (c)1996 Prentice Hall.
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 $2\tau$ (max propagation delay)
    - need $2\tau$ 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 not 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 range 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 and 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