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

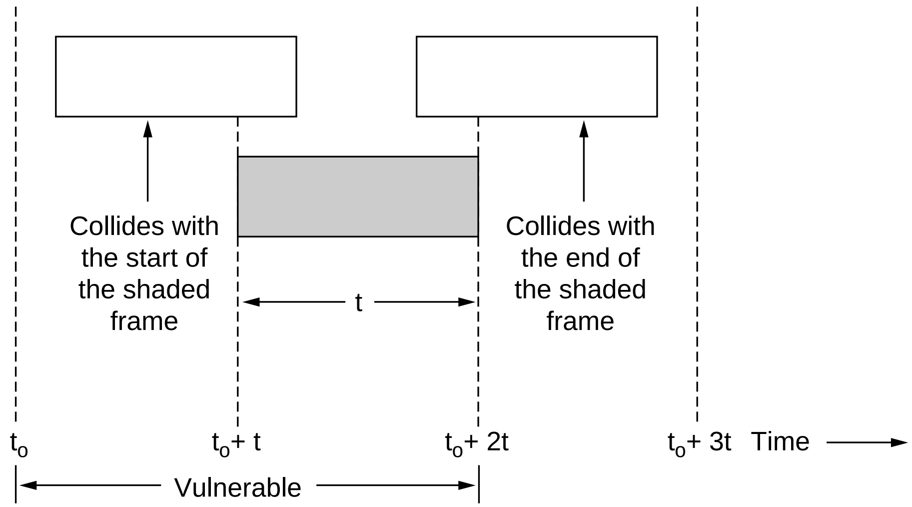
Shared Channel Model

- Station model
  - N independent stations
  - each wants to send λ 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 a 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 $S = G e^{-2G}$

Performance of Aloha



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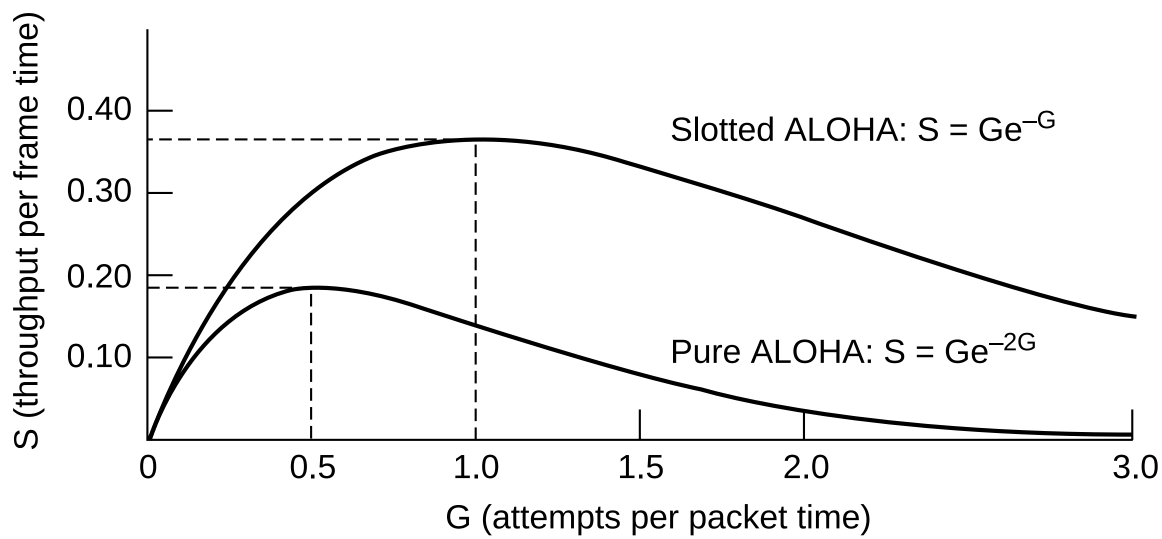

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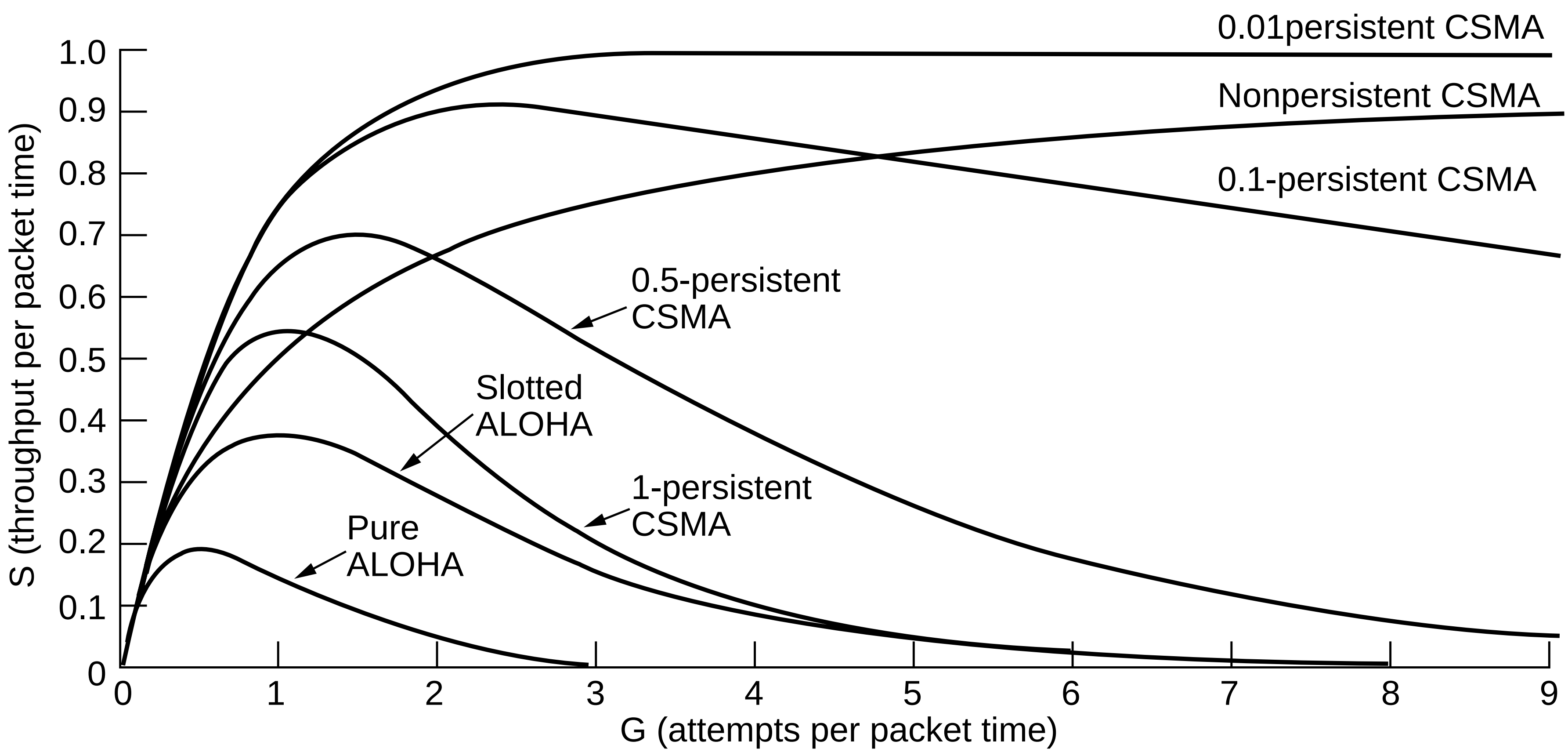
Aloha (cont.)

- Slotted Aloha
  - Use a central clock
  - Each station only sends at the start of frame
  - Reduces collision window by 1/2
    - $S = G\,e^{-G}$

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 detecing 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



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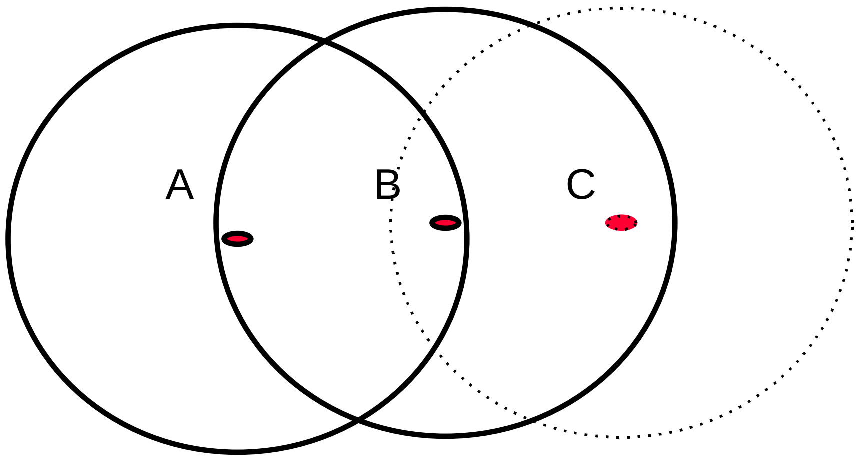
Collision Detection

- 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