Lecture Today

- slotted vs unslotted ALOHA
- Carrier sensing multiple access
- Ethernet

Random Access Protocols

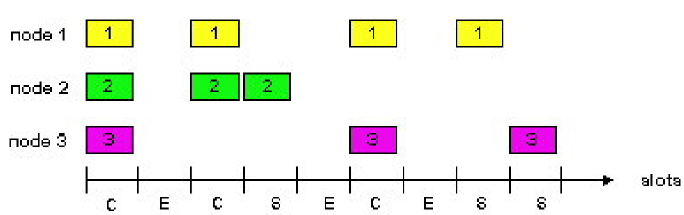
- When node has packet to send
  - transmit at full channel data rate R.
  - no *a priori* coordination among nodes
- two or more transmitting nodes ➔ "collision",
- random access MAC protocol specifies:
  - how to detect collisions
  - how to recover from collisions (e.g., via delayed retransmissions)
- Examples of random access MAC protocols:
  - slotted ALOHA
  - ALOHA
  - CSMA, CSMA/CD, CSMA/CA

Slotted ALOHA

Assumptions
- all frames same size
- time is divided into equal size slots, time to transmit 1 frame
- nodes start to transmit frames only at beginning of slots
- nodes are synchronized
- if 2 or more nodes transmit in slot, all nodes detect collision

Operation
- when node obtains fresh frame, it transmits in next slot
- no collision, node can send new frame in next slot
- if collision, node retransmits frame in each subsequent slot with prob. p until success

Slotted ALOHA



Pros
- single active node can continuously transmit at full rate of channel
- highly decentralized: only slots in nodes need to be in sync
- simple

Cons
- collisions, wasting slots
- idle slots
- nodes may be able to detect collision in less than time to transmit packet

Slotted Aloha efficiency

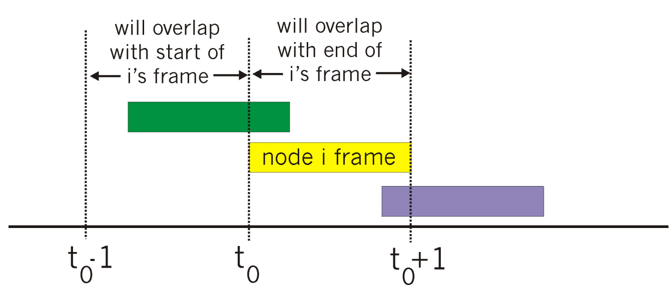
Efficiency is the long-run fraction of successful slots when there are many nodes, each with many frames to send

- N nodes with many frames to send, each transmits in slot with probability *q* (new arrival or re-Tx)
- prob that node 1 has success in a slot $= q(1-q)^{N-1}$
- Total expected utilization $= Nq(1-q)^{N-1}$
- For max efficiency with N nodes, find q* that maximizes $Nq(1-q)^{N-1}$
- For many nodes, take limit of $Nq^*(1-q^*)^{N-1}$ as N goes to infinity, gives 1/e = .37

At best: channel used for useful transmissions 37% of time!

Pure (unslotted) ALOHA

- unslotted Aloha: simpler, no synchronization
- when frame first arrives
  - transmit immediately
- collision probability increases:
  - frame sent at t_0 collides with other frames sent in $[t_0-1, t_0+1]$



Pure Aloha efficiency

P(success by given node) = P(node transmits at to) ·

P(no other node transmits in $[t_0-1,t_0]$) ·
P(no other node transmits in $[t_0,t_0+1]$)
$= q \cdot (1-q)^{N-1} \cdot (1-q)^{N-1}$
$= q \cdot (1-q)^{2(N-1)}$

… choosing optimum q and then letting N -> infty ...

Even worse ! $= 1/(2e) = .18$

CSMA (Carrier Sense Multiple Access)

CSMA: listen before transmit:

If channel sensed idle: transmit entire frame

- If channel sensed busy, defer transmission

- Human analogy: don't interrupt others!

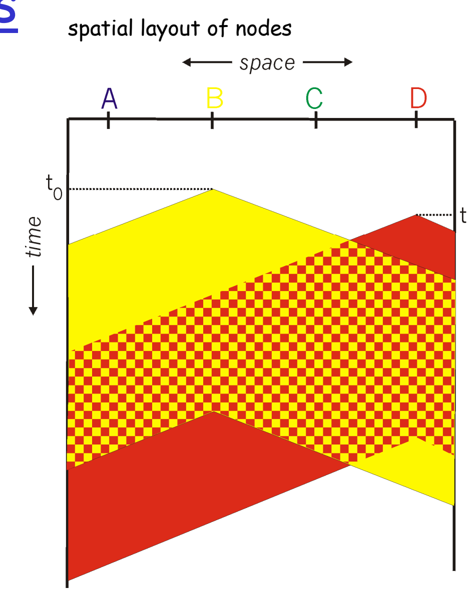
- Do we then get effective channel partitioning, with no collisions possible?

CSMA collisions

collisions *can* still occur:
propagation delay means two nodes may not hear each other's transmission

collision:
entire packet transmission time wasted

note:
role of propagation delay in determining collision probability



CSMA Efficiency

- Key parameters:
  - Propagation delay (in seconds): t_{prop}
  - packet transmission time t_{trans}
- Efficiency depends only on t_{prop}/t_{tran}, and decreases with this parameter.

CSMA Efficiency

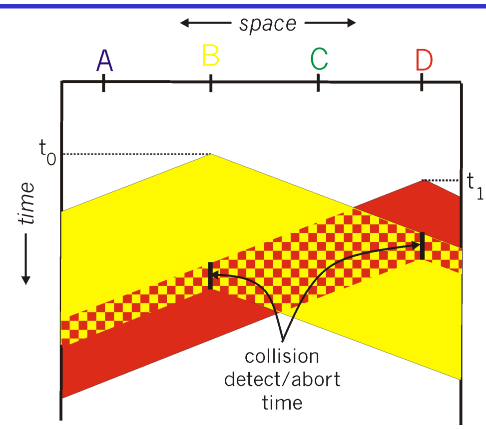
- Decreases with t_{prop}/t_{trans}
- Decreases with increasing distance between nodes.
- t_{trans} = R/L, where R is the link speed in bits/s and L is the frame length in bits.
- So efficiency decreases with increasing link speed R.

CSMA/CD (Collision Detection)

CSMA/CD: carrier sensing, deferral as in CSMA
- collisions *detected* within short time
- colliding transmissions aborted, reducing channel wastage

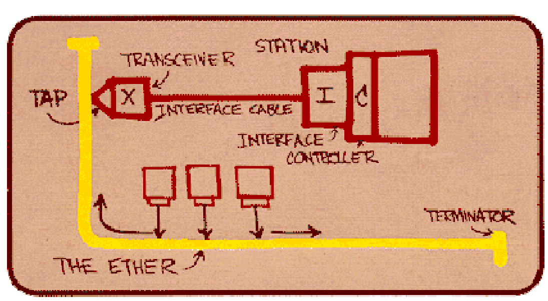
- collision detection:
  - easy in wired LANs: measure signal strengths, compare transmitted, received signals
  - difficult in wireless LANs: receiver shut off while transmitting
- human analogy: the polite conversationalist

CSMA/CD collision detection



Ethernet

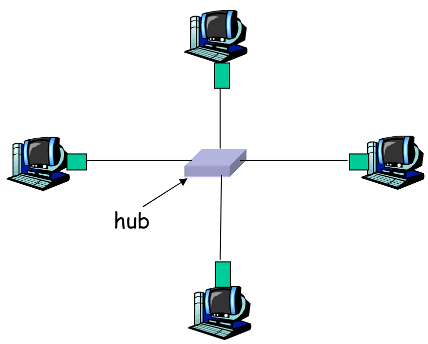
"dominant" wired LAN technology:
- cheap $20 for 100Mbs!
- first widely used LAN technology
- Simpler, cheaper than token LANs and ATM
- Kept up with speed race: 10 Mbps – 10 Gbps



Metcalfe's Ethernet sketch

Star topology

- Bus topology popular through mid 90s
- Now star topology prevails



Unreliable, connectionless service

- Connectionless: No handshaking between sending and receiving adapter.
- Unreliable: receiving adapter doesn't send acks or nacks to sending adapter
  - stream of datagrams passed to network layer can have gaps
  - gaps will be filled if app is using TCP
  - otherwise, app will see the gaps

Ethernet uses CSMA/CD

- No slots
- adapter doesn't transmit if it senses that some other adapter is transmitting, that is, carrier sense
- transmitting adapter aborts when it senses that another adapter is transmitting, that is, collision detection
- Before attempting a retransmission, adapter waits a random time, that is, random access

Ethernet CSMA/CD algorithm

1. Adaptor receives datagram from net layer & creates frame
2. If adapter senses channel idle, it starts to transmit frame. If it senses channel busy, waits until channel idle and then transmits
3. If adapter transmits entire frame without detecting another transmission, the adapter is done with frame !
4. If adapter detects another transmission while transmitting, aborts and sends jam signal
5. After aborting, adapter enters **exponential backoff**: after the mth collision, adapter chooses a K at random from $\{0,1,2,\ldots,2^m-1\}$. Adapter waits K·512 bit times and returns to Step 2