Computer Networks
COL 334/672

Multiple Access Control Protocols

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Quiz on Moodle

Password: ethernet

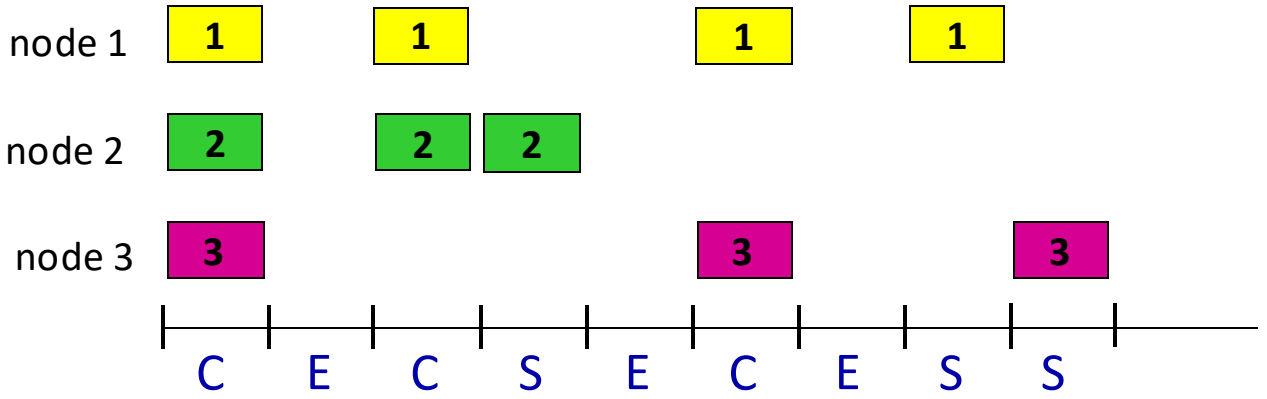
Link-layer services

- Encoding
- Framing
- Error detection
- **Addressing, Medium Access Control (MAC)**
  - algorithm that determines how nodes share channel, i.e., determine when node can transmit
  - Channel partitioning, Random access protocols

DESIGN GOALS

1. Efficiency
2. Fairness
3. Resilient
4. Simple

Slotted ALOHA



C: collision
S: success
E: empty

assumptions:

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

operation:

- when node obtains fresh frame, transmits in next slot
  - *if no collision:* node can send new frame in next slot
  - *if collision:* node retransmits frame in each subsequent slot with probability *p* until success

Slotted ALOHA: efficiency

efficiency: long-run fraction of successful slots
(many nodes, all with many frames to send)

- *suppose:* N nodes with many frames to send, each transmits in slot with probability p

$P_s = P(\text{any node transmits successfully}) = Np(1-p)^{N-1}$

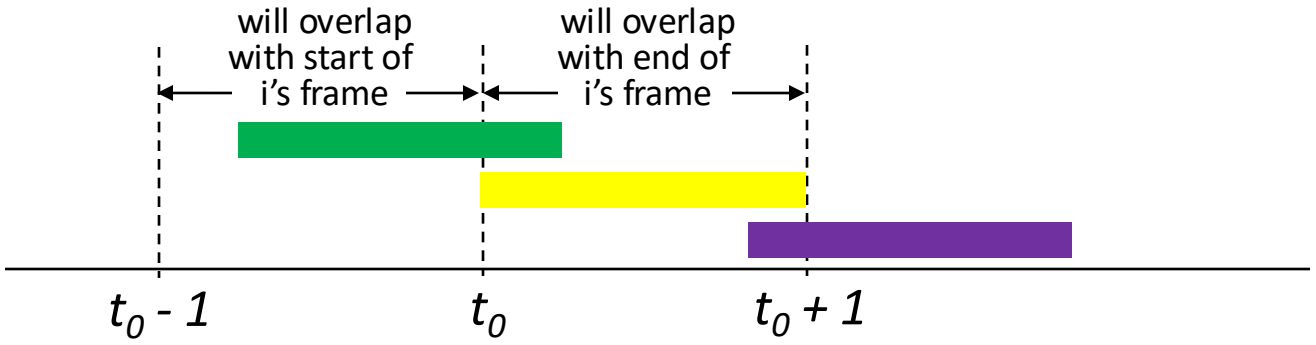
P_s maximized when $p = 1/N$ (Why? $\frac{dP_s}{dp} = 0$)

$$\lim_{N\to\infty} P_s = \lim_{N\to\infty} Np(1-p)^{N-1} = \lim_{N\to\infty} (1-p)^{N-1}$$

$$= 1/e \qquad \left[\lim_{x\to\infty} (1-1/x)^x = 1/e \right]$$

Pure ALOHA

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



- pure Aloha efficiency: 18% !

CSMA (carrier sense multiple access)

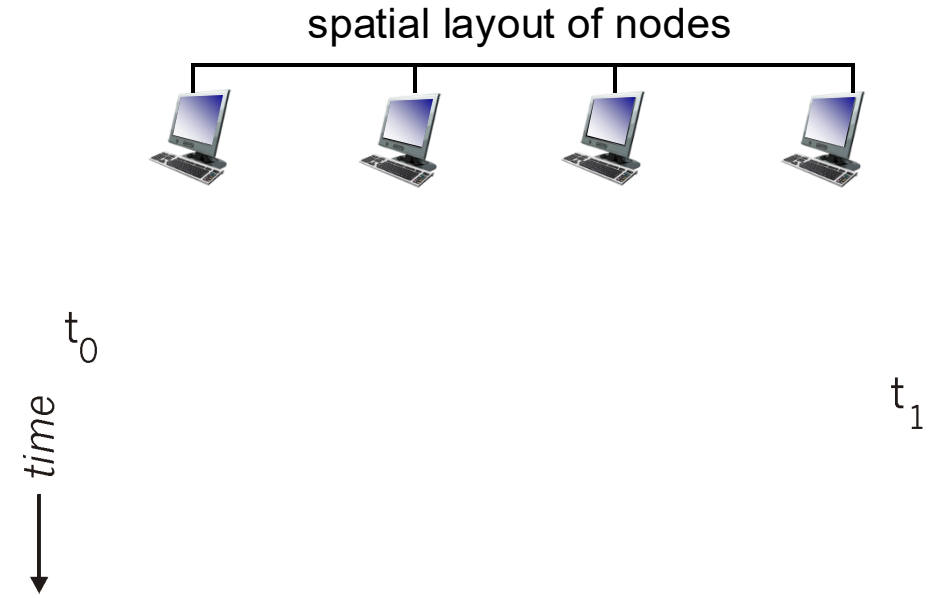
Simple CSMA: listen before transmit:

- if channel sensed idle: transmit entire frame
- if channel sensed busy: defer transmission

- Can collisions still occur on such a channel?

CSMA: collisions

- collisions can *still* occur with carrier sensing:
  - propagation delay means two nodes may not hear each other's just-started transmission
- collision: entire packet transmission time wasted



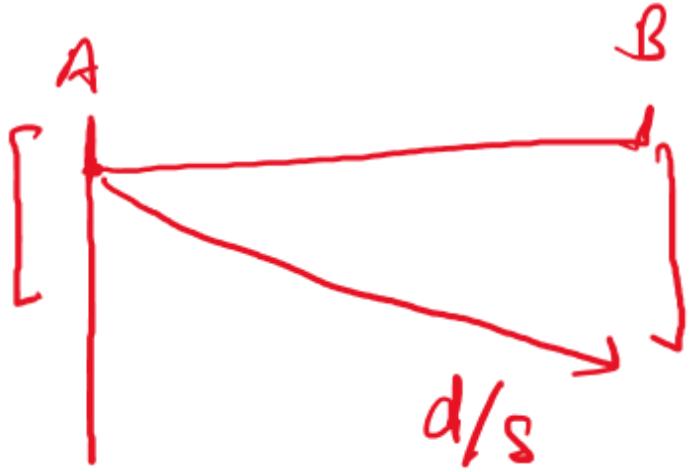
What to do in case of collision?

- T = time to detect collision

$\max(T) \leq d/s$

d = length of wire

s = speed of signal



CSMA with Collision Detection (CD)

- CSMA/CD reduces the amount of time wasted in collisions
  - Transmission aborted on collision detection
  - Send a jamming signal
- What happens after?
  - *Backoff:* Try after some random time!
- How to decide the backoff time?

→ intuition: wait longer if repeated collisions

Binary exponential backoff

For m^{th} attempt; pick a number $k: \{0, \ldots 2^m - 1\}$

wait = k x units

Ethernet MAC Protocol

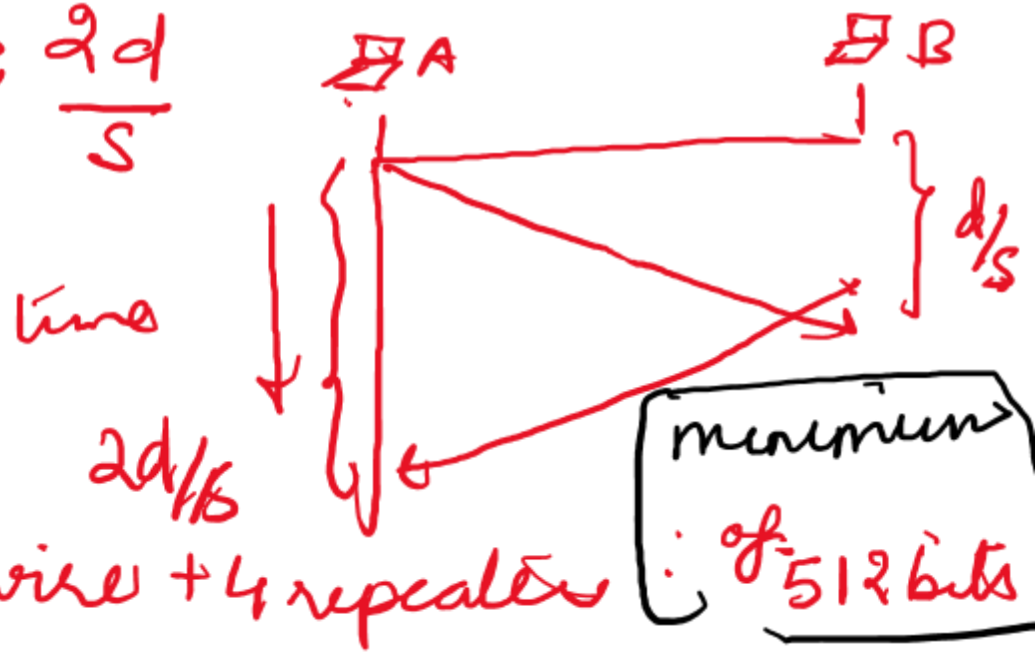
- Ethernet uses CSMA/CD
- Gap between two frames is **96-bit times** Why?
- Uses a minimum frame size (e.g. 64 bytes on 10 Mbps Ethernet) Why?
  - what if the frame is smaller?
  - zero-pad for smaller packets

Ethernet MAC Protocol

- Ethernet uses CSMA/CD
- Gap between two frames is **96-bit times** Why? gives time to the receiver to process the packet
- Uses a minimum frame size (e.g. 64 bytes on 10 Mbps Ethernet) Why?
  - What if the frame is smaller?
  - Zero-pad for smaller packets

↳ to make sure sender has enough time to detect collision

$\geq \frac{2d}{s}$



- Uses a maximum frame size Why?
  - Larger frames → higher probability of bit error
  - Others need to wait longer
  - Memory requirements on the network adapter

10 Mbps Ethernet: 2500 m wire + 4 repeaters