University of Glasgow

School of Computing Science

60 YEARS OF COMPUTING AT GLASGOW

Media Access Control

Networked Systems (H)

Lecture 5

Lecture Outline

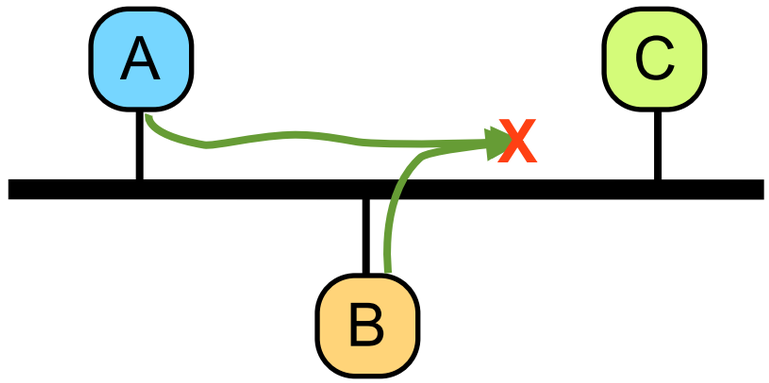
- Controlling access to the channel
- Link contention
- Media access control protocols
  - Contention-based protocols – CSMA/CD
  - Token ring
  - Slotted – TDMA

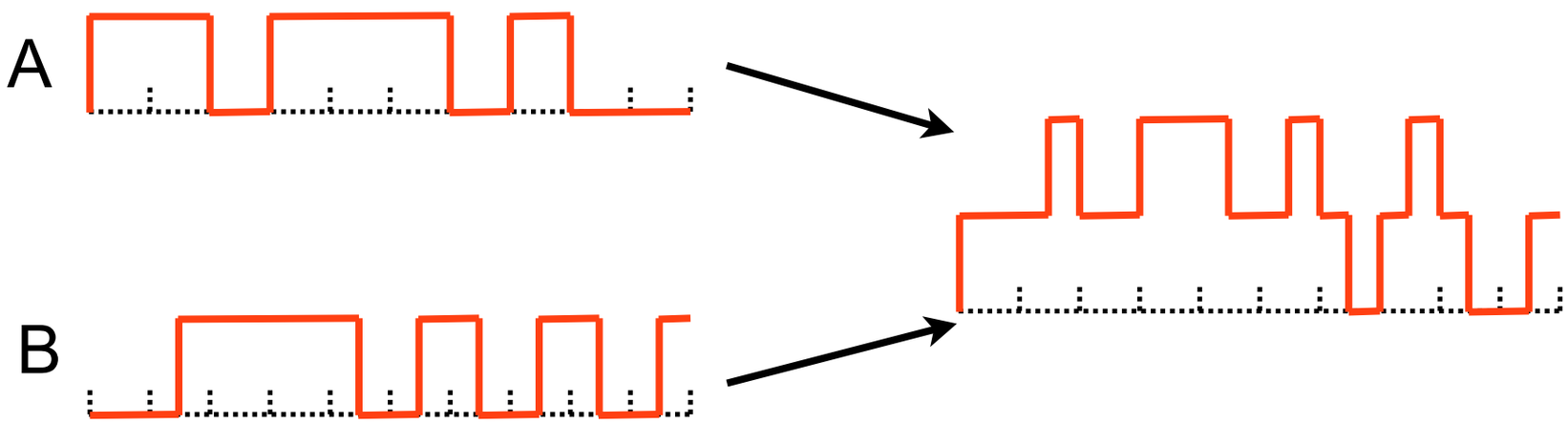
Controlling Access to the Channel

- Links may be point-to-point or multi-access
- How to arbitrate access to the link?
  - Point-to-point links typically two unidirectional links
    - Separate physical cables for each direction
    - Need framing in each direction, but there is no contention for the link
    - ARQ with stop-and-wait or sliding-window for flow control
  - Multi-access links typically share a bidirectional link
    - A single physical cable – nodes contend for access to the link
    - A single radio frequency

Link Contention

- A *collision* occurs if two hosts transmit simultaneously
- Signals overlap: only garbage received





Media Access Control (MAC) Protocols

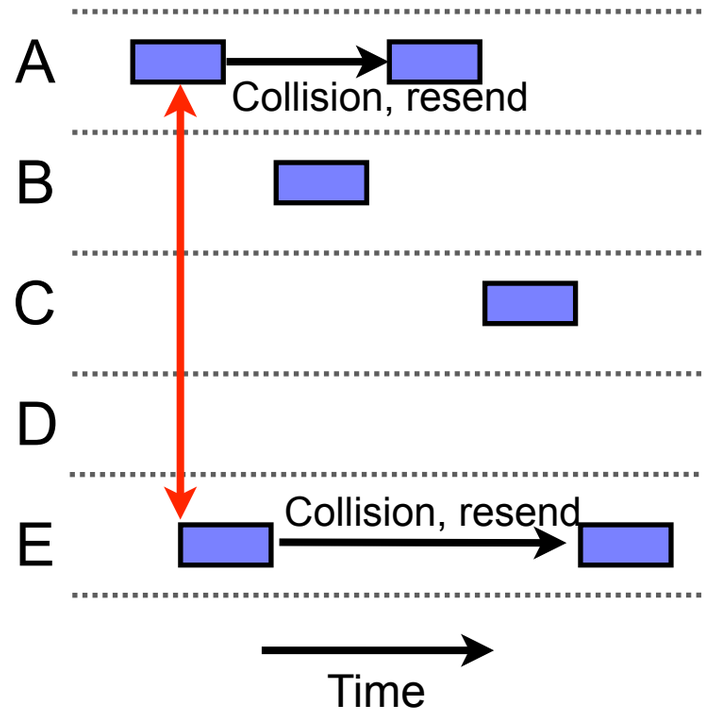
- Manage/avoid collisions with *media access control* protocol
  - Contention based (ALOHA, CSMA/CD, etc.)
  - Token based (Token ring)
  - Slotted (TDMA)
- Different degrees of fairness, access policies, etc.

Contention-based MAC

- Multiple hosts share channel in a way that can lead to collisions: system is *contention-based*
- Two-stage access to channel:
  - Detect that a collision is occurring/will occur
    - By listening to the channel while/before sending
  - Send if no collision, or back-off and/or retransmit data according to some algorithm to avoid/resolve collision
    - Back-off delay randomised and increasing to prevent repeated collisions
    - Can be arranged to give priority to certain hosts/users/traffic classes
- Probabilistic, variable latency, access to channel

The ALOHA Network

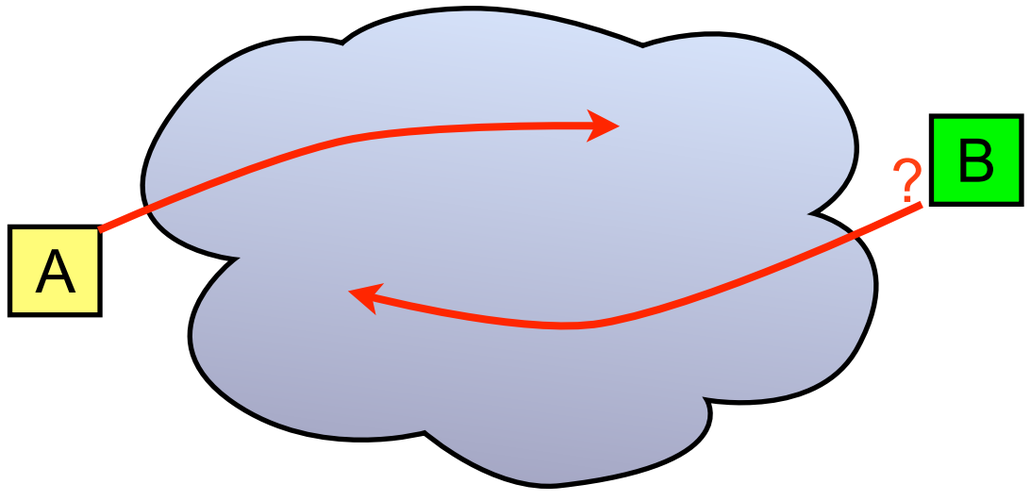
- Wireless network developed at the University of Hawaii (1970)
  - The first wireless packet switched network
- Simplest contention-based MAC
  - Try to transmit whenever data is available
  - If a collision occurs, wait random amount of time then retransmit; repeat until successful
- Simple, but poor performance
  - Low channel utilisation; long delays



Carrier Sense Multiple Access

- When propagation delay low, listen before sending
  - If another transmission is active: back-off as if collision occurred, without sending anything
  - If link is idle, send data immediately
- Improves utilisation
  - Active transmissions not disrupted by collisions
  - Only the new sender backs-off if the channel is active

Why does propagation delay matter?



A starts transmitting

B listens, hears no traffic (message from A hasn't reached it yet)

B starts transmitting

Collision occurs, as messages overlap in transit; smaller propagation delay → less likely to occur

CSMA/CD

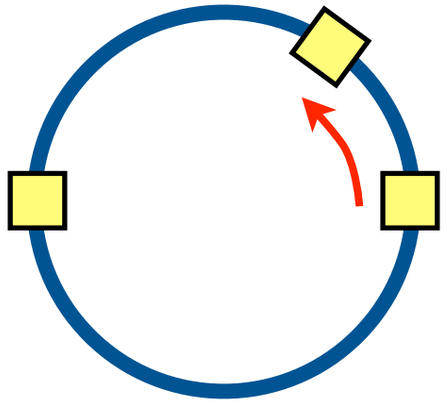
- High propagation delay → increased collision rate
- CSMA updated with collision detection (CSMA/CD)
  - Listen to channel before, *and while*, transmitting data
  - If collision occurs, immediately stop sending, back-off, and retransmit
    - Collision still corrupts both packets
    - But, time channel is blocked due to collisions is reduced – better performance than plain CSMA

- Examples: Ethernet, 802.11 Wi-Fi

CSMA/CD: How to Back-Off?

- CSMA/CD uses back-off to avoid/resolve collisions
- How long is the back-off interval?
  - Should be random – to avoid deterministic repeated collisions
  - Should increase with the number of collisions that affect a transmission – repeated collisions signal congestion; reduce transmission rate allows the network to recover
- Good strategy:
  - Initial back-off interval x seconds ± 50%
  - Each repeated collision before success, $x \rightarrow 2x$

Token-based MAC

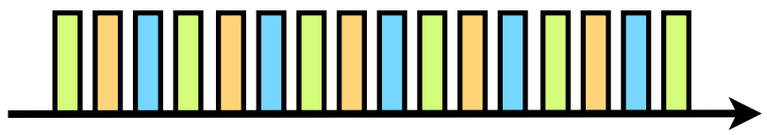


Token Ring

- Contention-based MAC protocols have poor worst case performance
  - Repeated collisions can cause arbitrarily long delays and unpredictable variation in throughput
- Alternative: token-based protocols
  - Hosts circulate a token on the ring when they have no data to send
  - Host wanting to send waits for, and removes, the token, sends one packet, then restarts the token circulating
  - Token circulation enforces round robin transmission, bounds maximum wait time before host can transmit
    - Enforces fairness between hosts on the ring, but reduces utilisation
  - Example: IBM Token Ring

Slotted MAC

- Split channel access into transmission slots
  - Time division media access (TDMA) – control *when* hosts can transmit data
  - Frequency slots – control which frequency bands hosts use to transmit data
- Controller assigns each host a transmission slot
  - Gives a limited, but guaranteed, capacity per-sender
  - Bounds delay variation due to channel access
  - Provides fairness guarantee
- Example: GSM mobile phones



124 frequency bands, each 200 kHz wide
8 slots TDM within each frequency band

Design Trade-Off

- Which is best – contention, token, or slotted MAC?
  - As usual, it depends on the application
  - Contention protocols cheaper, hardware more readily available, but cannot guarantee real-time performance
  - Token-based or slotted protocols offer stricter performance guarantees, but are more expensive and need less widely available hardware

Summary

- Media access control protocols
  - Contention-based protocols – CSMA/CD
  - Token ring
  - Slotted – TDMA
- Fairness, throughput, and latency variation