CS 716: Introduction to communication networks

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Contention-based MAC: ALOHA

- Users transmit whenever they have data to send

- Collisions occur, and if packet is lost, then source has to retransmit

- Collision are detected by
  - listening while transmitting
  - loss of acknowledgements

- If collision, then sender waits random time to avoid repeated collision
Vulnerable interval

- For a given frame, the time when no other frame may be transmitted if a collision is to be avoided.
- Assume all packets have same length \( L \) and require \( T_p \) seconds for transmission.
- Each packet vulnerable to collisions for time \( V_p = ?? \)

![Diagram showing packets A, B, and C with vulnerable intervals]

\( T_p \) seconds
ALOHA: Vulnerable interval

- Suppose packet A sent at time $t_0$
- If pkt B sent any time in $[t_0 - T_p \text{ to } t_0]$  
  - end of packet B collides with beginning of packet A  
- If pkt C sent any time in $[t_0 \text{ to } t_0 + T_p]$  
  - start of packet C will collide with end of packet A  
- Total vulnerable interval for packet A is $2T_p$

- Can we do something to improve the efficiency?
Slotted ALOHA

- A simple way to double ALOHA’s capacity
- Make sure transmissions start on a slot boundary
- Halves vulnerability interval
- Requires global synchronization
- Master station generates synchronization pulses for time-slots
- Used in cellular phone uplink
Slotted ALOHA

(a) ALOHA

Earliest start time for colliding packet

Latest start time for colliding packet

(b) Slotted ALOHA

All packets starting here are delayed to start of next slot
Carrier Sense Multiple Access

- Listen before you speak

- Check whether the medium is active before sending a packet (i.e. *carrier sensing*)

- If medium is idle, then transmit

- If collision happens, then detect and resolve
Activity: Group Discussion

Suppose your group now has to work out the details:

- What are needed to enable collision detection?
- How does a station recover from collision?

- Hint: Typical Ethernet (10BaseT; 100BaseT) has
  - A minimum frame size (64 bytes).
  - A maximum segment length (100 meters?).
  - Think about why these are required and how these numbers are arrived at.
Concept: MAC Detailed design

Example: Ethernet (IEEE 802.3)
1 - Persistent CSMA

- Sense the channel.
- IF the channel is *idle*, THEN transmit.
- IF the channel is *busy*, THEN continue to listen until channel is *idle*.
- Now transmit immediately.
P - Persistent CSMA

- Sense the channel.
- IF the channel is *idle*, THEN
  - with probability \( p \) transmit and
  - with probability \( (1-p) \) delay for *one time slot* and start over.
- IF the channel is *busy*, THEN delay *one time-slot* and start over.

- Time slot is usually set to the maximum propagation delay.
- as \( p \) decreases,
  - stations wait longer to transmit, but
  - the number of collisions decreases
Non-Persistent CSMA

- Sense the channel.
- IF the channel is *idle*, THEN transmit.
- If the channel is *busy*, THEN wait a *random amount of time* and start over.

- Random time needs to be chosen appropriately.
Collision detection (CSMA/CD)

- All aforementioned scheme can suffer from collision.

- Device can detect collision by:
  - Listen while transmitting.
  - Transmit for 2 * propagation delay.
  - Jamming signal.
Contestion Interval - 2D

$t = 0$: A begins transmission

$t = D - \varepsilon$: packet almost at B
   B begins transmission

$t = D$: B detects collision,
   stops transmitting

$t = 2D - \varepsilon$: A detects collision
Minimum frame size

\[ t = 0: \text{A begins transmission} \]

\[ t = D - \varepsilon: \text{packet almost at B} \]
\[ \quad \text{B begins transmission} \]

\[ t = D: \text{B detects collision, stops transmitting} \]

\[ t = 2D - \varepsilon: \text{A detects collision} \]
Minimum frame size

- It takes A a complete RTT (2D) to detect collision

- When B detects collision (gets more power than it is putting out) it generates 48-bit noise burst (“Jam” bits) to warn all other stations

- Min. frame size equal to number of bits transmitted during one RTT:
  - slotTime: number of bits transmitted by a source during the max. RTT (2D = 51.2 μsec) for any Ethernet network.
  - Collisions must be detected by sources while still transmitting

- All frames must be at least 1 slot (on 10Mbps, this is 512 bits)
Collision recovery

- On collision detection wait for random time before retrying.

- Binary Exponential Backoff Algorithm:
  - Reduces the chances of two waiting stations picking the same random time.
Binary Exponential Backoff

1. On detecting 1\textsuperscript{st} collision for packet x
   station A chooses a number r between 0 and 1.
   waits for r * slot time and transmit.

k. On detecting k\textsuperscript{th} collision for packet x
   choose r between 0,1,..,(2^k –1)

- When value of k becomes high (10), give up.
- Randomization increase with larger window, but delay increases.
- Slot time is 2 * propagation delay.
Frame: Ethernet (IEEE 802.3)

- CSMA/CD with jamming
- Ethernet Address (48 bits)
  - Example: 08:00:0D:01:74:71
- Ethernet Frame Format
  - Why 46-1500 bytes?
Activity: Pair-Solo

Consider two nodes communicating using the CSMA/CD protocol (as in Ethernet).

- Suppose the bandwidth is 100 Mbps, the frame size is 1500 bytes and propagation speed is $3 \times 10^8$ m/sec.
- Calculate the maximum possible distance between the nodes such that the sender can detect any collision.

- Pair - Discuss the solution approach with your neighbour.
- Solo - Work out the answer by yourself.
At the end of this topic

You should be able to do:

- Determine what MAC protocol would be suitable for a given scenario.
- Evaluate tradeoff between two MAC protocols for a given scenario.
- Describe CSMA and its variations.
- Describe the collision detection mechanism in Ethernet.
- Perform binary exponential back-off calculations.
- Perform throughput calculations for TDMA and CSMA.
Reflection

- What did I learn in today's class?
- Each student to mention one point.

- Take-home questions:
  - How can collision detection (CD) be changed into a collision avoidance (CA) mechanism?
  - What are the pros and cons of CD v/s CA?