CS 716: Introduction to communication networks

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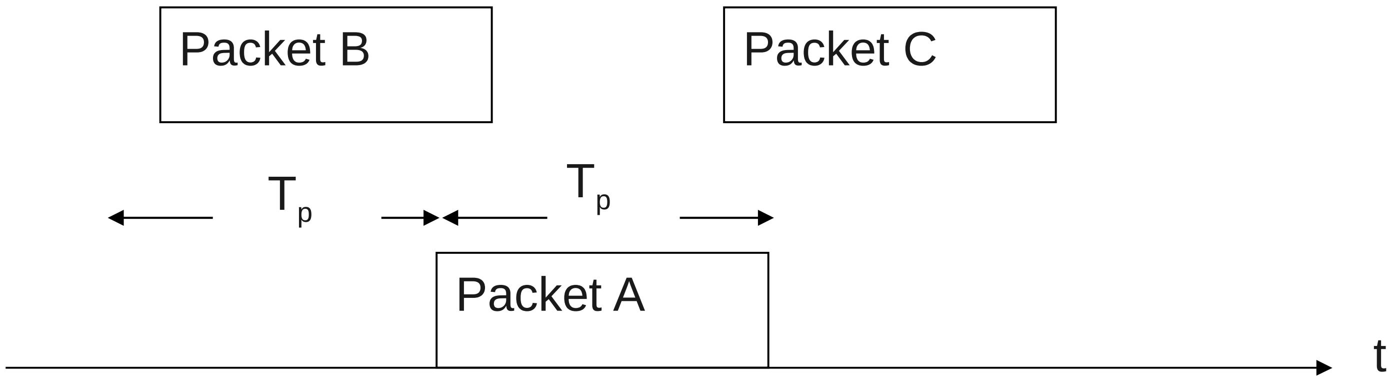
Contention-based MAC: ALOHA

- 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= ??



ALOHA: Vulnerable interval

- Suppose packet A sent at time t_0
- If pkt B sent any time in [t_0 - T_p to t_0]
  - end of packet B collides with beginning of packet A
- If pkt C sent any time in [t_0 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?

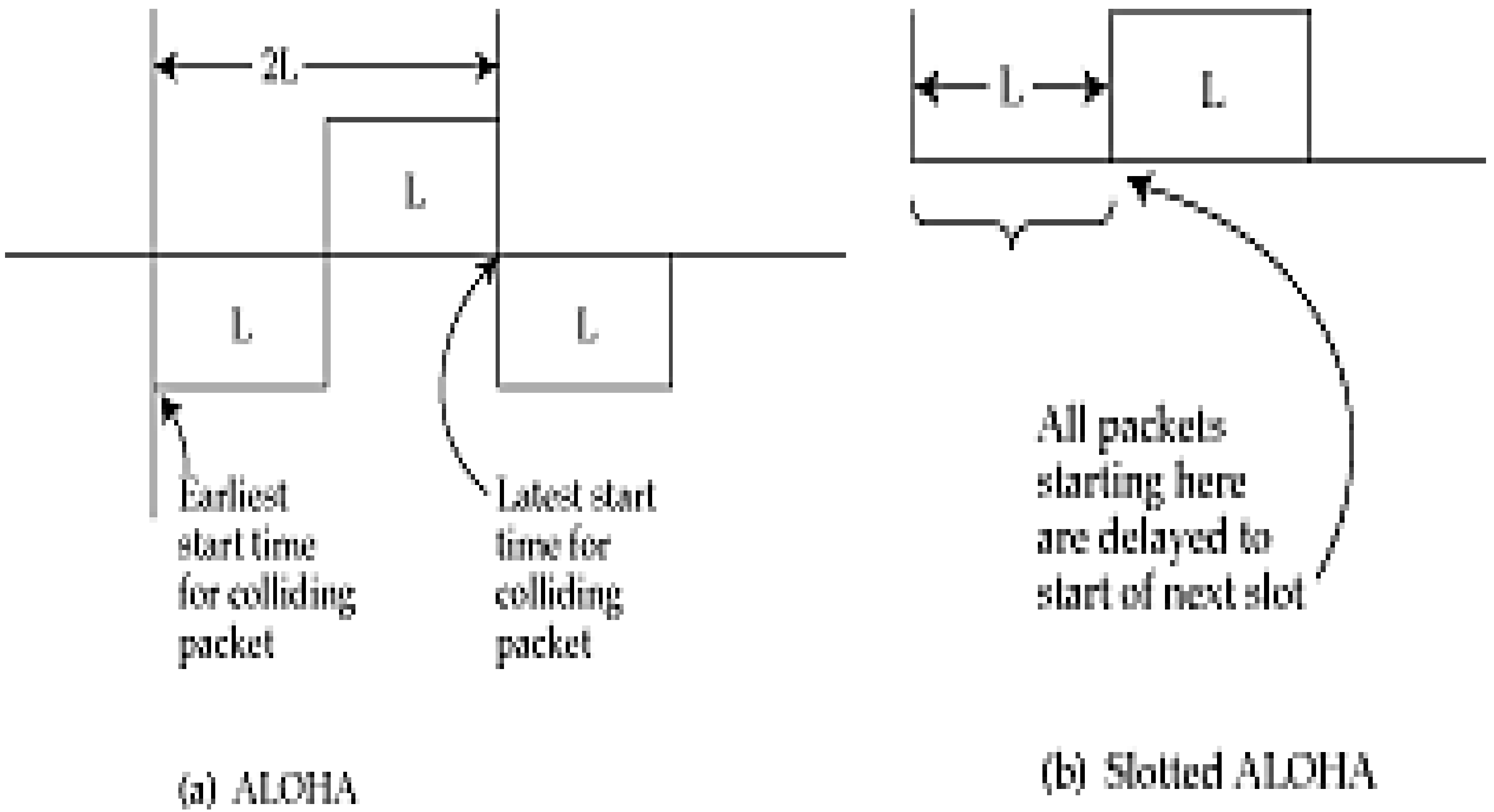
Slotted ALOHA

- 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



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.

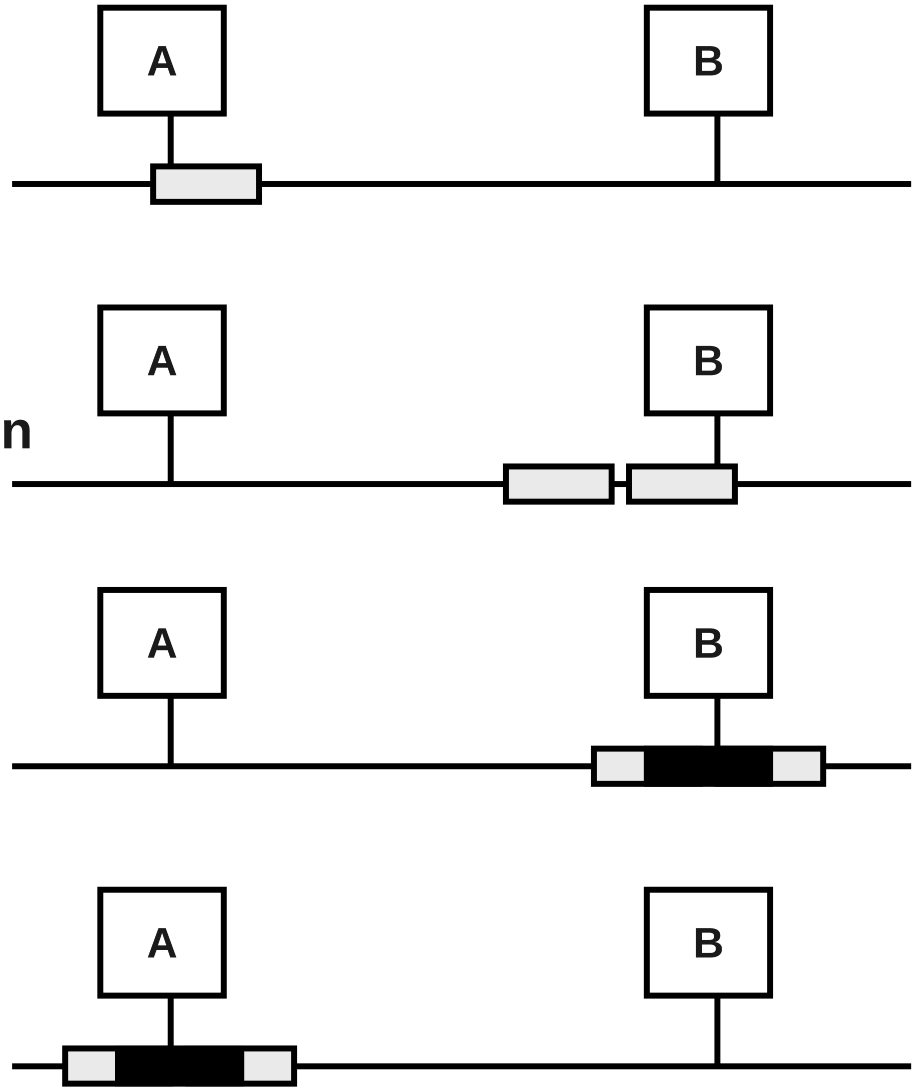
Contention Interval - 2D

t = 0: A begins transmission

t = D - ε : packet almost at B
B begins transmission

t = D: B detects collision,
stops transmitting

t = 2D - ε : A detects collision



Minimum frame size

t = 0: A begins transmission

t = D - ε : packet almost at B
B begins transmission

t = D: B detects collision,
stops transmitting

t = 2D - ε : 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^{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^{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?

Pre-amble (7)	S F D	Destinatio n Address	Source Address (6)	L (2	Data (46-1500)	FCS (4)

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 3x10^8 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.
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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?