Data Link Layer: CSMA/CD

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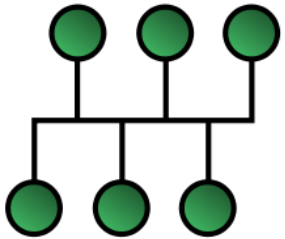
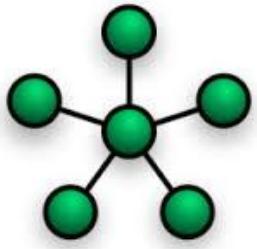
Recap

Listen before talk

- We covered the ideas behind CSMA (Carrier Sense Multiple Access) class of protocols
- Ethernet MAC: 1-persistent CSMA/CD
  - Applicable for Bus or Star topology in shared mode

half-duplex



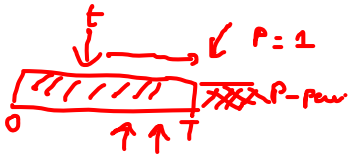


Ethernet MAC

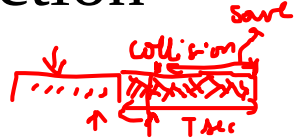
- CSMA/CD: Carrier Sense Multiple Access (1-persistent) with Collision Detection

  - 'Listen before talk'
  - Simultaneous talking, stop talking → reduces wastage of resource
- Following explanation applicable to 10Mbps Ethernet

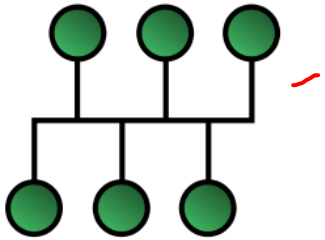
Ethernet MAC

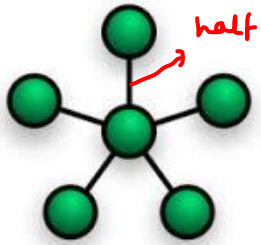


- Ethernet MAC: "1-persistent" CSMA/CD
  - Carrier Sense Multiple Access / Collision Detection
    - Listen before talk
    - Simultaneous talk, stop talking → reduces wastage
  - Applicable for Bus or Star topology in shared mode



- Following explanation applicable to 10Mbps Ethernet





Ethernet MAC

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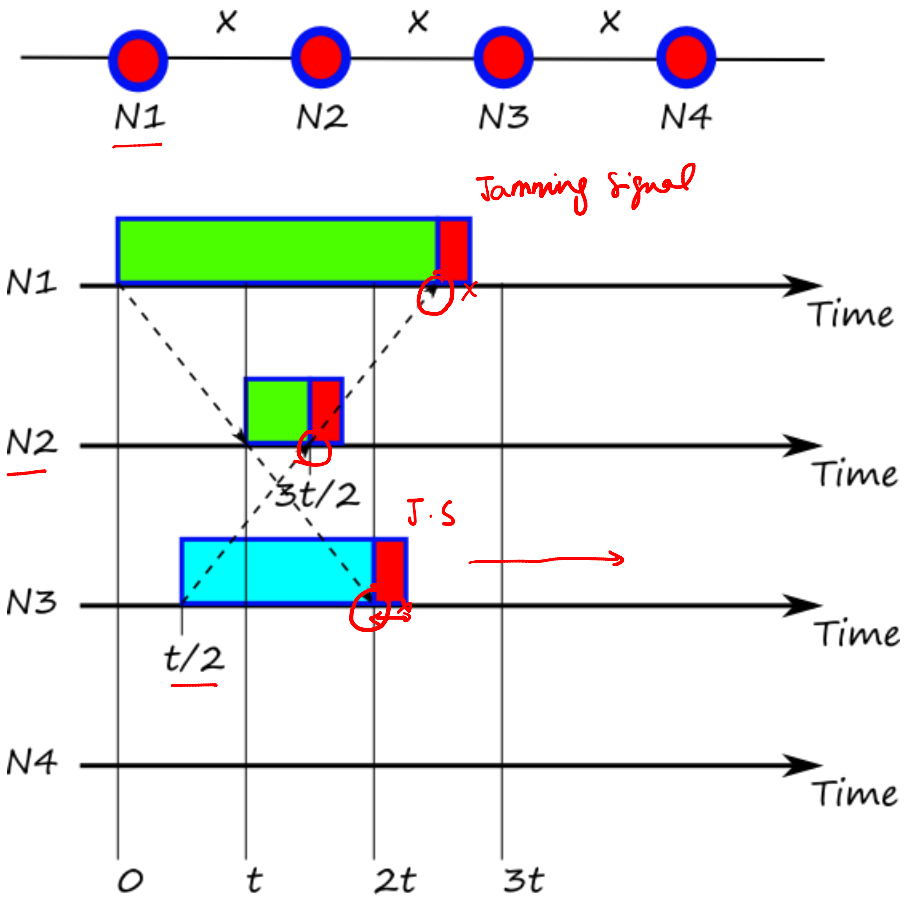
Collision Detection

- Cases under which collision occurs?

  - Two stations waiting for channel to become idle
  - Two stations attempting transmission at same time on an idle channel

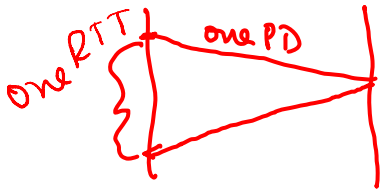
  - Two stations attempting transmission at slightly different times on an idle channel
    - Effect of propagation delay



t = time taken by signal to propagate distance x

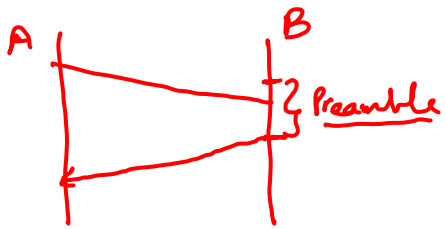
Collision Detection

- Collision detection done by hardware
- Propagation delay affects efficiency
  - Longer the propagation delay, higher chances of collision
- Worst case delay of detecting collision?
  - One RTT



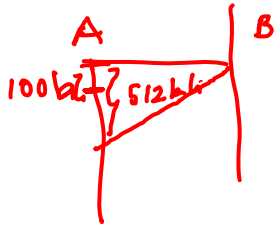
Collision Detection

- On detecting collision send a jamming signal of 32 bits
- Why jamming signal?
  - Runt Frame is 96 bits (64 bits preamble + 32 jamming)
  - Jamming extends the frame to allow collision detection



Frame Size

- Minimum frame size is 64 bytes (512 bits)
  - 46 bytes of payload (18 byte header)



- Why this restriction?
  - A host must transmit for one RTT to detect all collisions
  - This RTT for 2500m long cable with 4 repeaters is about 51.2us (10Mbps -> 512 bits)
- Maximum number of hosts: 1024 in a collision domain

CSMA/CD

- Adaptor has a frame to send:

1. If channel idle (for 96 bit time), start transmission. If busy, wait until channel idle (+96 bits time) and then transmit.
2. If no collision detected, done
3. If collision detected, stop transmission, send jamming signal. Enter exponential backoff

(For 10Mbps, bit time is 0.1us)

Exponential Backoff

- When transmitting a frame after nth collision
  - Wait for K*512 bit times and return to step 1
  - K chosen at random from {0,1,2 ….. 2^m-1} m = min (n,10)
  - 1st collision: choose K from {0,1}
  - 2nd collision: choose K from {0,1,2,3}
  - After 10th collisions, choose K from {0,1,2,3,4,…,1023}
  - Maximum number of transmissions of a frame: 16 (15 retransmissions)
  - Size of k grows exponentially after each collision

Exponential Backoff

- Why exponential backoff?
  - Adapts to current load
  - Not very fair (Capture effect)
- Why 512 bit time?
  - Ensures that if a node chose a lower value of K than any other node, it can transmit without collision

low, small value of K ✓

high → 10 nodes $K = \{0, 1\}$

A K = 0

B K = 1

B 51.2 μs

Efficiency

- Long run fraction of 'useful' time on the channel
  - Large number of nodes with large number of frames to transmit
- Efficiency = $1 / [1+5(T_{prop}/T_{tx})]$
  - T_{prop} = max prop time between 2 nodes in LAN
  - T_{tx} = time to transmit a frame
  - As T_{prop} approaches 0 or T_{tx} becomes large, efficiency approaches 1

large frame size - 1500B
max dist < few hundred mt.
fewer # per segment < 200 Hosts
Eff > 85%
$T_{Prop} \to 0$, ? $E \to 1$
T_x Large

Summary

- CSMA family of protocols improve upon Aloha
  - Persistent and non-persistent tradeoffs
- Ethernet MAC adds another feature ‘CD’ to improve performance further
  - Requires additional functionality and adds some restrictions (length and number of hosts)
  - Overall performance is quite good
- Ahead: Ethernet Switching