

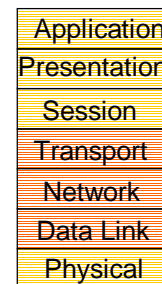
CSE/EE 461 – Lecture 5

From Aloha to Ethernet

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Last Time ...

- Error detection and correction
- Redundant bits are added to messages to protect against transmission errors.
- Two recovery strategies are retransmissions (ARQ) and error correcting codes (FEC)
- The Hamming distance tells us how much error can safely be tolerated.



This Lecture

- Key Focus: How do multiple parties share a wire? We want the benefits of statistical multiplexing ...
- This is the Medium Access Control (MAC) portion of the Link Layer
- Randomized access protocols:
 1. Aloha
 2. CSMA variants
 3. Classic Ethernet

Application
Presentation
Session
Transport
Network
Data Link
Physical

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L5.3

1. ALOHA

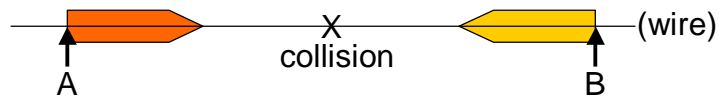
- Wireless links between the Hawaiian islands in the 70s
- Want distributed allocation
 - no special channels, or single point of failure
- Aloha protocol:
 - Just send when you have data!
 - There will be some collisions of course ...
 - Detect errored frames and retransmit a random time later
- Simple, decentralized and works well for low load
 - For many users, analytic traffic model, max efficiency is 18%

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L5.4

2. Carrier Sense Multiple Access

- We can do better by listening before we send (CSMA)
 - good defense against collisions only if “a” is small (LANs)



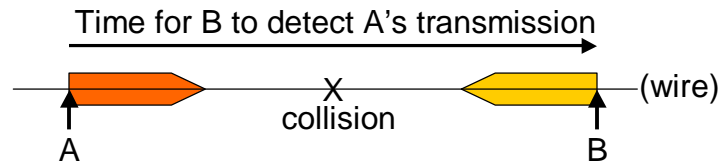
- “a” parameter: number of packets that fit on the wire
 - $a = \text{bandwidth} * \text{delay} / \text{packet size}$
 - Small ($\ll 1$) for LANs, large ($\gg 1$) for satellites

What if the Channel is Busy?

- 1-persistent CSMA
 - Wait until idle then go for it
 - Blocked senders can queue up and collide
- non-persistent CSMA
 - Wait a random time and try again
 - Less greedy when loaded, but larger delay
- p-persistent CSMA
 - If idle send with prob p until done; assumed slotted time
 - Choose p so $p * \# \text{ senders} < 1$; avoids collisions at cost of delay

CSMA with Collision Detection

- Even with CSMA there can still be collisions. Why?



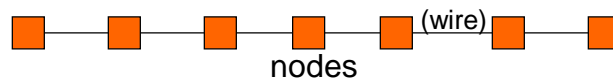
- For wired media we can detect all collisions and abort (CSMA/CD):
 - Requires a minimum frame size ("acquiring the medium")
 - B must continue sending ("jam") until A detects collision

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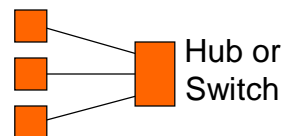
L5.7

3. Classic Ethernet

- IEEE 802.3 standard wired LAN (1-persistent CSMA/CD)
- Classic Ethernet: 10 Mbps over coaxial cable
 - baseband signals, Manchester encoding, preamble, 32 bit CRC



- Newer versions are much faster
 - Fast (100 Mbps), Gigabit (1 Gbps)
- Modern equipment isn't one long wire
 - hubs and switches



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Ethernet Frames

Preamble (8)	Source (6)	Dest (6)	Len (2)	Payload (var)	Pad (var)	CRC (4)
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- Min frame 64 bytes, max 1500 bytes
- Max length 2.5km, max between stations 500m (repeaters)
- Addresses unique per adaptor; globally assigned
- Broadcast media is readily tapped:
 - Promiscuous mode; multicast addresses

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Binary Exponential Backoff

- Build on 1-persistent CSMA/CD
- On collision: jam and exponential backoff
 - Jamming: send 48 bit sequence to ensure collision detection
- Backoff:
 - First collision: wait 0 or 1 frame times at random and retry
 - Second time: wait 0, 1, 2, or 3 frame times
 - Nth time ($N \leq 10$): wait 0, 1, ..., 2^{N-1} times
 - Max wait 1023 frames, give up after 16 attempts
 - Scheme balances average wait with load

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Ethernet Capture

- Randomized access scheme is not fair
- Stations A and B always have data to send
 - They will collide at some time
 - Suppose A wins and sends, while B backs off
 - Next time they collide and B's chances of winning are halved!

Ethernet Performance

- Much better than Aloha or CSMA!
 - Works very well in practice
- Source of protocol inefficiency: collisions
 - More efficient to send larger frames
 - Acquire the medium and send lots of data
 - Less efficient as the network grows in terms of frames
 - recall $a = \text{delay} / (\text{frame size} * \text{transmission rate})$
 - “a” grows as the path gets longer (satellite)
 - “a” grows as the bit rates increase (Fast, Gigabit Ethernet)

Key Concepts

- Ethernet (CSMA/CD): randomness can lead to an effective distributed means of sharing a channel