CSC2209
Computer Networks

MAC Protocols + Routing

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Administrivia

- TONS seminar Fridays at 3pm in BA1170
- *"Balancing distance and lifetime in delay constrained multihop wireless networks"*. Ben Liang ECE U. of T.

- Start brainstorming project ideas!
  - Lots of suggestions available
    - Project suggestion on course's website
    - News writeups contain suggestions
    - Lectures' slides contain suggestions

Question

- Would it be useful to setup a 1-2 hour meeting to discuss project suggestions?
  - Serves to bring everyone on the same page

- If yes, when?

Outline

1. ALOHA
2. CSMA MAC protocols
3. Ethernet
4. Measured capacity of an Ethernet

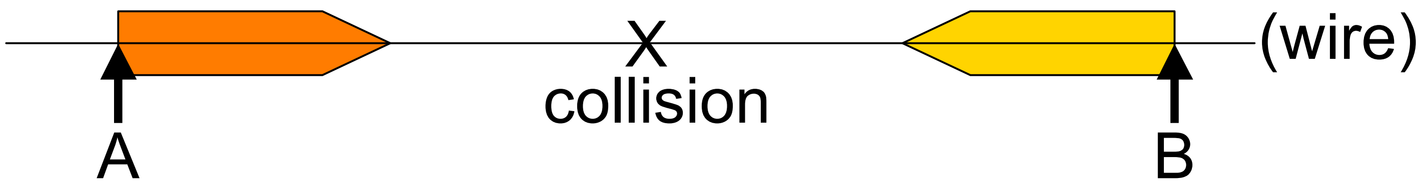
1. ALOHA

- 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%

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)



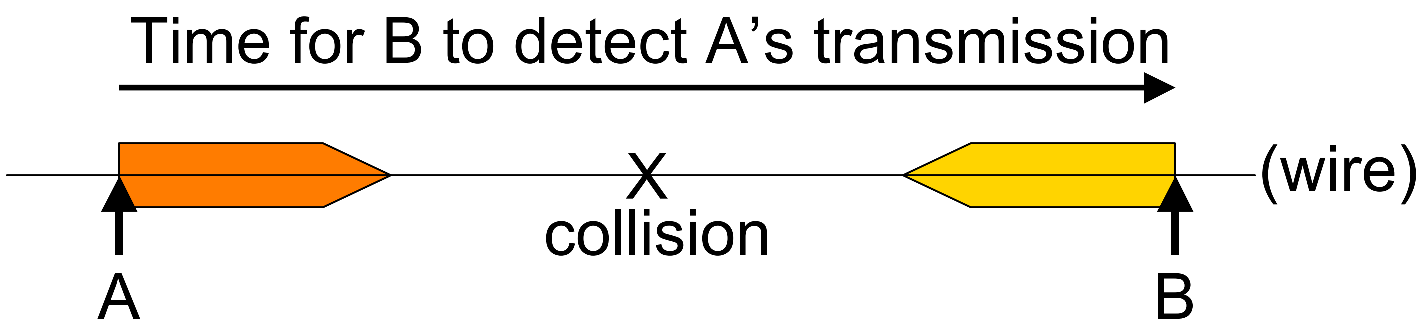
- “a” parameter: number of packets that fit on the wire
  - a = bandwidth * delay / packet size
  - Small (<<1) for LANs, large (>>1) for satellites

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 * # senders < 1; avoids collisions at cost of delay

CSMA with Collision Detection

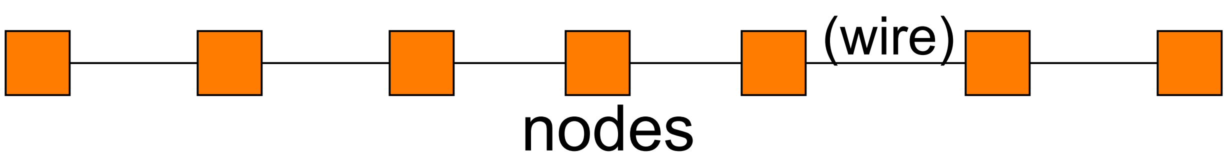
- Even with CSMA there can still be collisions. Why?



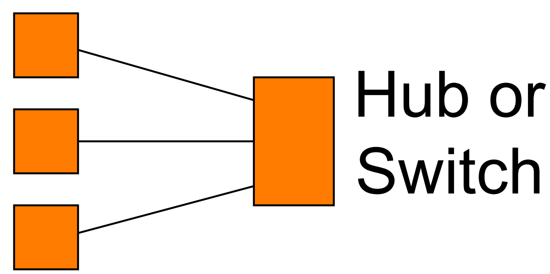
- For wired media we can detect all collisions and abort (CSMA/CD):
  - Requires a minimum frame size ("acquiring the medium")
  - B must continue sending ("jam") until A detects collision

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



Modern (Ethernet II) Frames

Preamble (8)	Dest (6)	Source (6)	Type (2)	Payload (var)	Pad (var)	CRC (4)

- Min frame 64 bytes, max 1500 bytes
- Max length 2.5km, max between stations 500m (repeaters)
- Addresses unique per adaptor; 6 bytes; globally assigned
- Broadcast media is readily tapped:
  - Promiscuous mode; multicast addresses

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<=10): wait 0, 1, …, 2^N-1 times
  - Max wait 1023 frames, give up after 16 attempts
  - Scheme balances average wait with load

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" = delay * bandwidth / frame size
    - "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

4. Measured Capacity of Ethernet

- Systematic Ethernet evaluation
- Contributions:
  - Measured-based analysis of performance
  - Present implementation issues
  - "Systems-approach to networking"
- Non-contributions:
  - Synthetic measurements

Theoretical Studies' Limitations

- Unrealistic assumptions:
  - Infinite populations, Poisson arrivals, uniform packet sizes, worst-case analysis
- Inconsistent definitions of offered load:
  - Flow control not considered
- Average case vs. worst-case
  - The average load is really low
- Myths:
  - Ethernet saturates at an offered load of 37%
  - Latency shoots up after 37%

Findings

- Ethernet performs well under high load
  - Xput fall with # of hosts
  - Fairness increases with # of hosts
  - Latency increases linearly with # of hosts
- Bimodal packet size distribution
  - Even a few packets can boost utilization
- Problems due to implementation
  - Buggy firmware (garbled packets, broadcast storm)
  - Linear back-off instead of exponential

What’s Missing?

What’s Missing?

- “Semi-experimental” study
  - Is this science or engineering?
- Only considered balanced topologies
  - Unequal clusters can lead to unfairness
- Only considered aggregate statistics
  - Do corner-cases occur?

Ethernet Trends

- Newer standards: 100Mbps (Fast Ethernet), 1Gbps, 10Gbps
- Switch rather than contention:
  - Is contention relevant anymore?
- Reasons for success:

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- Switch rather than contention:
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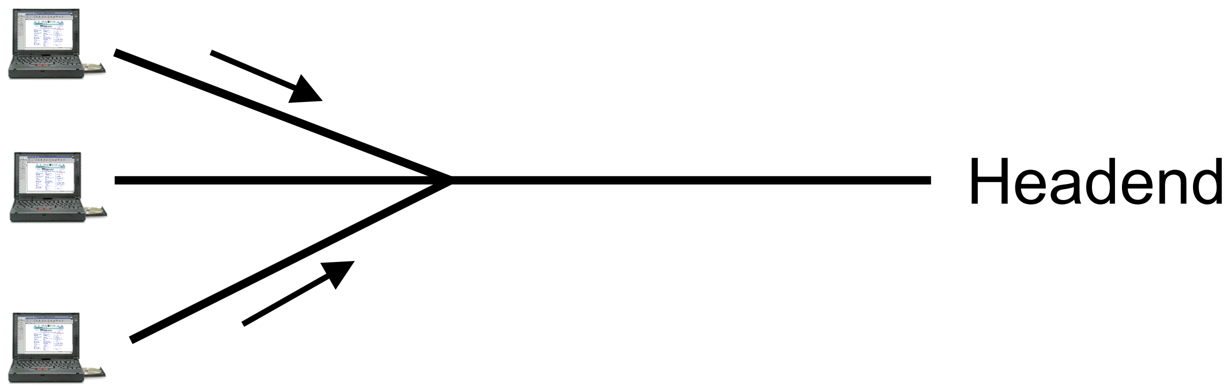
- Reasons for success:
  - Low connection cost
  - Robustness
  - Flexible (protocol changes are easy)

Cable Modems (DOCSIS)

- Broadcast medium for hosts don't hear each other (head-end coordination)



- Downstream: head-end coordination
- Upstream: reserve slots with ALOHA

Research on Wired MAC's anymore

- Ideas?

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- Ideas?

- Sure: faster MACs are being proposed all the time:
  - How would a 1Tbps MAC work?
    - Build a simulator??? How?!

Next class

- Papers review
  - V. Bharghavan, A. Demers, S. Shenker, L. Zhang. *MACAW: a media access protocol for wireless LAN's*. Sigcomm 94.

- Review due at 11am