

Lecture 25:

Ethernet

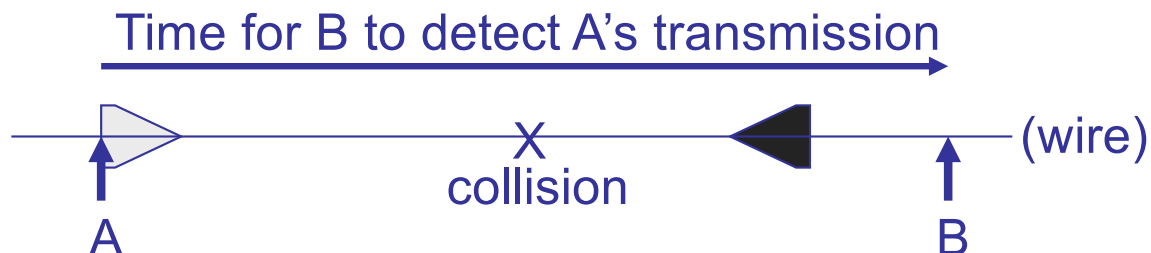
CSE 123: Computer Networks
Alex C. Snoeren



CSMA/CD



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



- If nodes can detect collisions, abort! (CSMA/CD)
 - ♦ Requires a minimum frame size (“acquiring the medium”)
 - ♦ *B* must continue sending (“jam”) until *A* detects collision
- Requires a **full duplex** channel
 - ♦ Wireless is typically half duplex; need an alternative

Collision Detection (CD)



- How can A know that a collision has taken place?
 - ◆ Worst case:
 - » Latency between nodes A & B is d
 - » A sends a message at time t and B sends a message at $t + d - \epsilon$ (just before receiving A's message)
 - ◆ B knows there is a collision, but not A... A must keep transmitting until it can tell if a collision occurred
 - ◆ How long? $2 * d$
- Hence, Ethernet frames have a minimum length
 - ◆ IEEE 802.3 specifies max value of $2d$ to be $51.2\mu s$
 - ◆ At 10Mbps it takes $0.1\mu s$ to transmit one bit

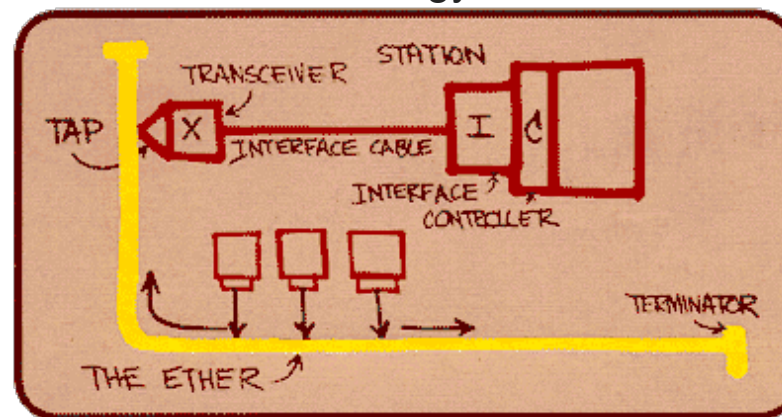
What is the minimum length of an Ethernet frame?

- A. 18 bytes**
- B. 64 bytes**
- C. 512 bytes**
- D. None of the above**

Ethernet



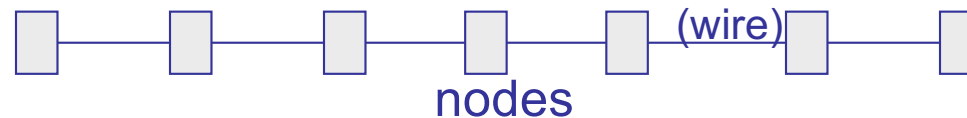
- First **local area network** (LAN)
 - ◆ Developed in early '70s by Metcalfe and Boggs at PARC
 - ◆ Originally 1Mbps, now supports 10Mbps, 100Mbps, 1Gbps 10Gbps, 40Gbps, and 100Gbps flavors (400G in dev)
- Currently *the* dominant LAN technology
 - ◆ Becoming the dominant WAN technology



Classic Ethernet



- IEEE 802.3 standard wired LAN
(modified 1-persistent CSMA/CD)
- Classic Ethernet: 10 Mbps over coaxial cable
 - ♦ All nodes share same wire
 - ♦ Max length 2.5km, max between stations 500m



- Framing
 - ♦ Preamble, 32-bit CRC, variable length data
 - ♦ Unique 48-bit address per host (bcast & multicast addrs too)

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

Exponential Backoff



- Problems with random delay with fixed mean
 - ◆ Few senders = unnecessary delay
 - ◆ Many senders = unnecessary collisions
- Binary exponential back-off balances delay w/load
 - ◆ First collision: wait 0 or 1 min frame times at random, retry
 - ◆ Second time: wait 0, 1, 2, or 3 times
 - ◆ N th time ($n \leq 10$): wait 0, 1, ..., $2^n - 1$ times
 - ◆ Max wait 1023 frames; give up after 16 attempts

What is the maximum number of stations on an Ethernet?
A. 2 nodes
B. 15 nodes
C. 1024 nodes
D. Unlimited

Capture Effect



- Randomized access scheme is not fair
- Suppose stations *A* and *B* always have data to send
 - ◆ They *will* collide at some time
 - ◆ Both pick random number of “slots” (0, 1) to wait
 - ◆ Suppose *A* wins and sends
 - ◆ Next time they collide, *B*’s chance of winning is halved
 - » *B* will select from 0,1,2,3 due to exponential back-off
- *A* keeps winning: said to have *captured* the channel

Ethernet Performance



- Much better than Aloha or CSMA in practice
- Source of protocol inefficiency: still collisions
 - ♦ More efficient to send larger frames
 - » Acquire the medium and send lots of data
 - ♦ Less efficient if
 - » More hosts – more collisions needed to identify single sender
 - » Smaller packet sizes – more frequent arbitration
 - » Longer links – collisions take longer to observe, more wasted bandwidth



Contention-free Protocols

- Problem with fixed partitioning:
 - ♦ Inefficient at low load (idle channels)
- Problem with contention-based protocols:
 - ♦ Inefficient at high load (collisions)
- Ideal(?): Contention-free protocols
 - ♦ Try to do both by explicitly taking turns
 - ♦ Can potentially also offer guaranteed bandwidth, latency, etc.

Contention-free Approaches



Polling

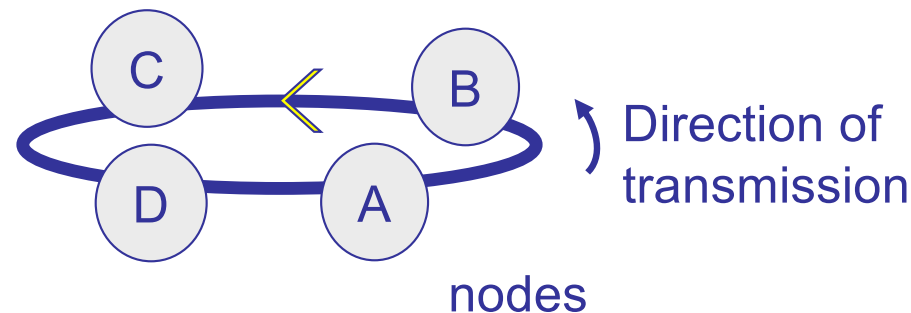
- Master node “invites” slave nodes to transmit in turn
 - ♦ Request to Send (RTS), Clear to Send (CTS) messages
- Problems:
 - ♦ Polling overhead
 - ♦ Latency
 - ♦ Single point of failure (master)

Token Passing

- Control **token** passed from one node to next sequentially.
- Point-to-point links can be fast
- Problems:
 - ♦ Token overhead
 - ♦ Latency
 - ♦ Single point of failure (token)



Token Ring (802.5)



- Token rotates “permission to send” around nodes
- Sender injects packet into ring and removes later
 - ◆ Maximum **token holding time** (THT) bounds access time
 - ◆ Early or delayed token release
 - ◆ Round robin service, acknowledgments and priorities
- Monitor nodes ensure health of ring (alerts on failures)



Why Did Ethernet Win?

- Failure modes
 - ◆ Token rings – network unusable
 - ◆ Ethernet – node detached
- Good performance in common case
- Completely distributed, easy to maintain/administer
- Easy incremental deployment
- Volume → lower cost → higher volume



Summary of Media Access

- Fixed partitioning (FDMA, TDMA, CDMA)
 - ◆ Guaranteed bandwidth for each user, but wasteful when not used and can't allocate different bandwidth to different users
- Contention-based protocols (CSMA, CSMA/CD)
 - ◆ Try and backoff if fail; dynamic allocation of bandwidth on demand, works well at load load but collisions a problem at high load
- Contention-free protocols (Token Ring, RTS/CTS)
 - ◆ Explicit turn-taking; strong guarantees on access time and can make bandwidth guarantees, but complex and fragile to failure

For Next Time



- Guest lecture (Prof. Schulman) Wednesday
- Read 2.7 in P&D