Introduction to Computer Networks

Randomized Multiple Access
(§4. 2.1-4.2.2, 4.3.1-4.3.3)

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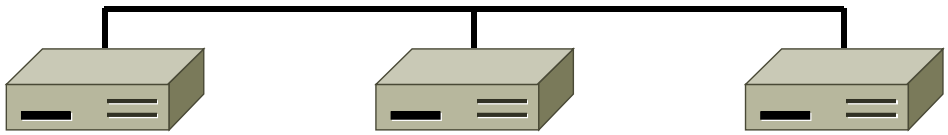
Topic

- How do nodes share a single link? Who sends when, e.g., in WiFI?
  - Explore with a simple model



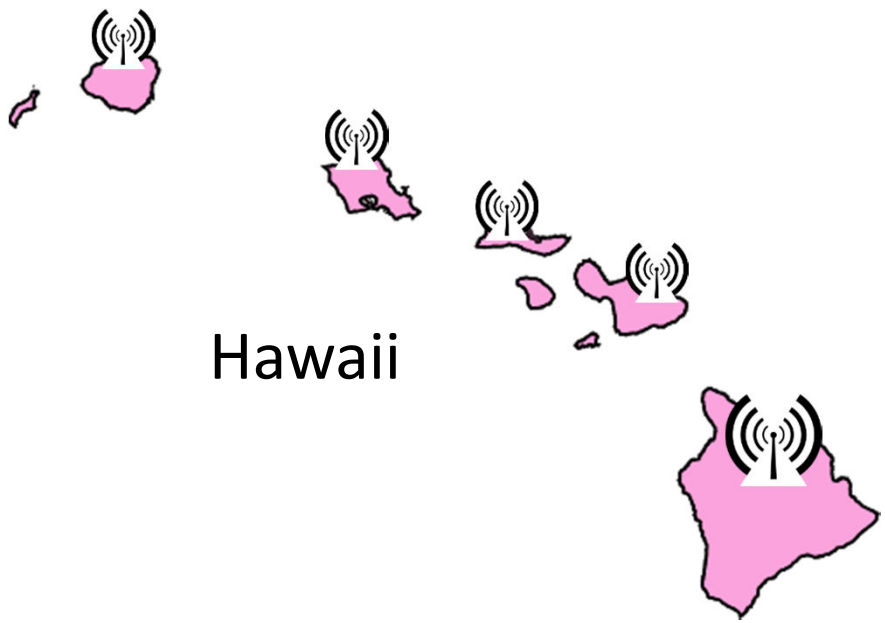
- Assume no-one is in charge; this is a distributed system

Topic (2)

- We will explore random multiple access control (MAC) protocols
  - This is the basis for classic Ethernet
  - Remember: data traffic is bursty

ALOHA Network

- Seminal computer network connecting the Hawaiian islands in the late 1960s
  - When should nodes send?
  - A new protocol was devised by Norm Abramson …

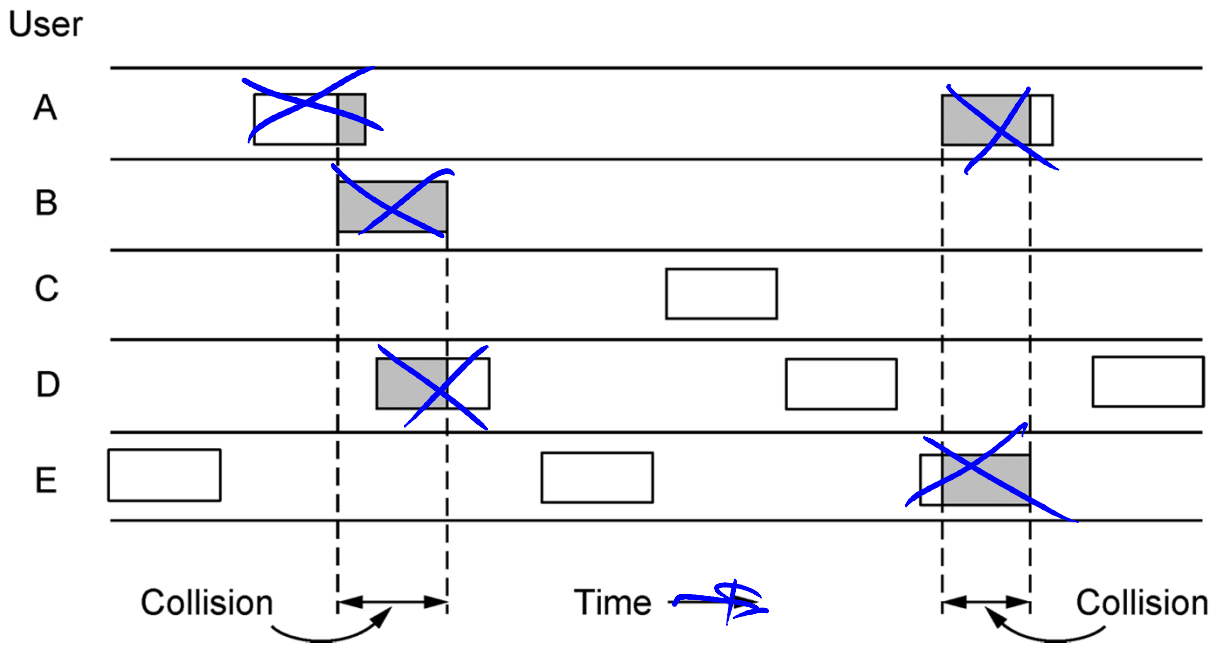


ALOHA Protocol

- Simple idea:
  - Node just sends when it has traffic.
  - If there was a collision (no ACK received) then wait a random time and resend
- That's it!

ALOHA Protocol (2)

- Some frames will be lost, but many may get through…
- Good idea?

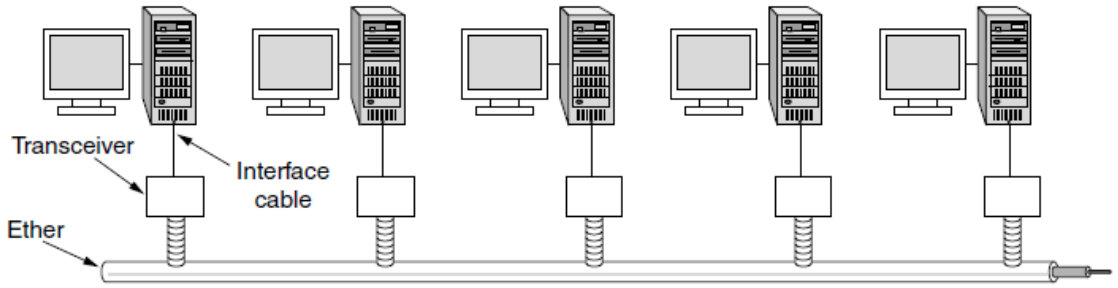


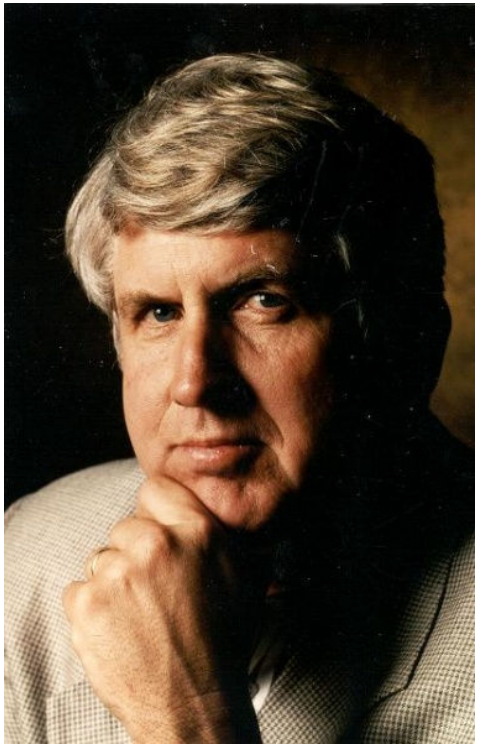
ALOHA Protocol (3)

- Simple, decentralized protocol that works well under low load!
- Not efficient under high load
  - Analysis shows at most 18% efficiency
  - Improvement: divide time into slots and efficiency goes up to 36%
- We'll look at other improvements

Classic Ethernet

- ALOHA inspired Bob Metcalfe to invent Ethernet for LANs in 1973
  - Nodes share 10 Mbps coaxial cable
  - Hugely popular in 1980s, 1990s





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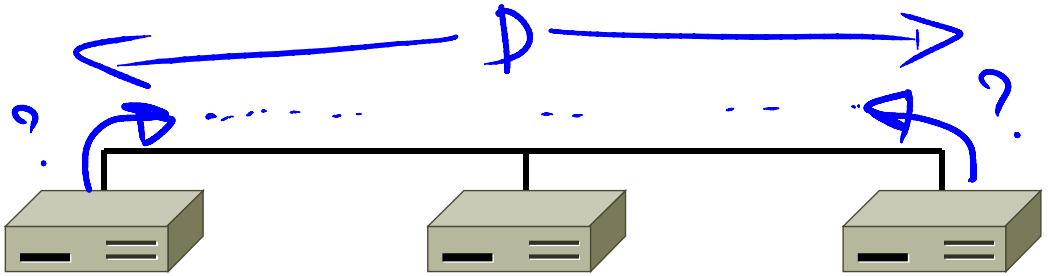
CSMA (Carrier Sense Multiple Access)

- Improve ALOHA by listening for activity before we send (Doh!)
  - Can do easily with wires, not wireless
- So does this eliminate collisions?
  - Why or why not?

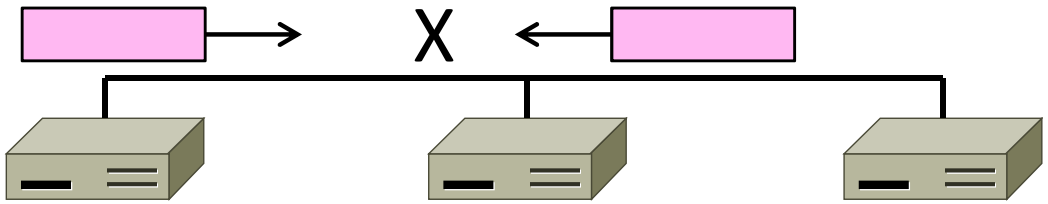
CSMA (2)

- Still possible to listen and hear nothing when another node is sending because of delay



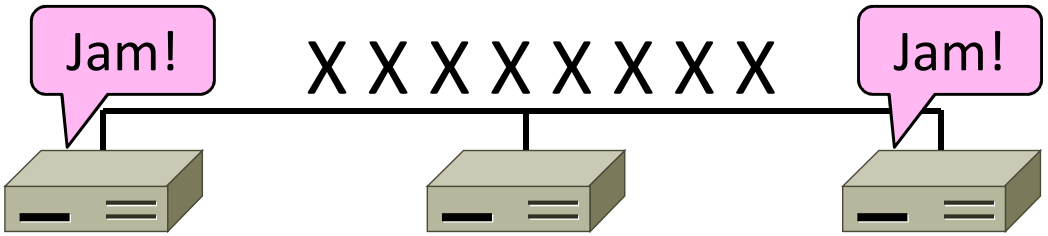
CSMA (3)

- CSMA is a good defense against collisions only when BD is small



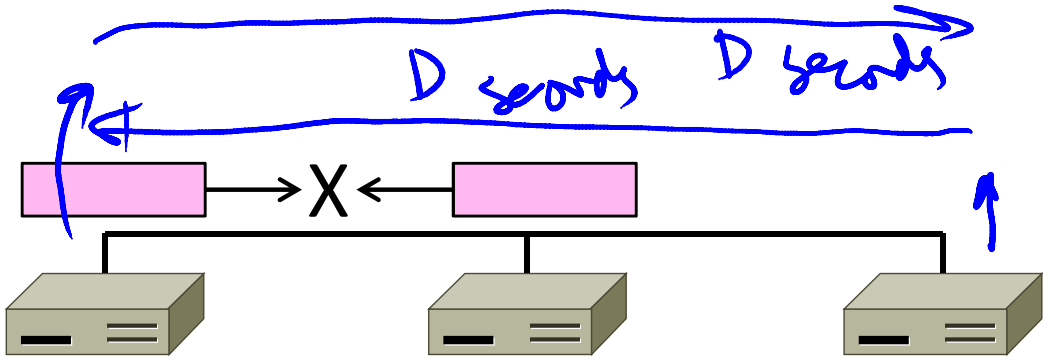
CSMA/CD (with Collision Detection)

- Can reduce the cost of collisions by detecting them and aborting (Jam) the rest of the frame time
  - Again, we can do this with wires



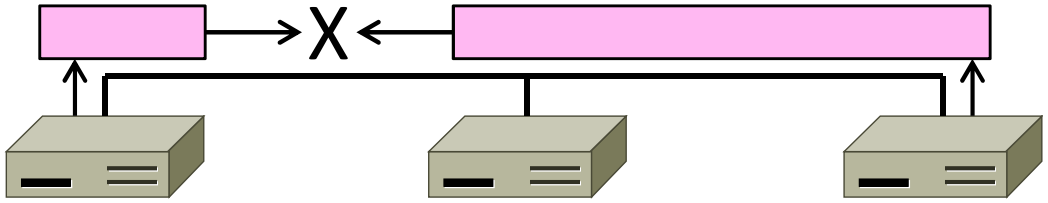
CSMA/CD Complications

- Want everyone who collides to know that it happened
  - Time window in which a node may hear of a collision is 2D seconds



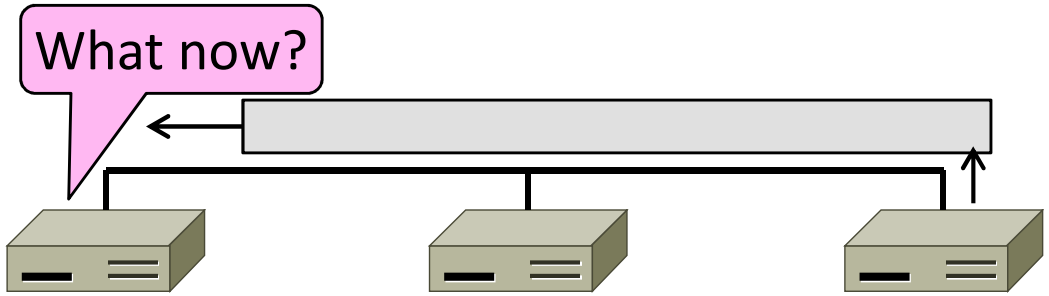
CSMA/CD Complications (2)

- Impose a minimum frame size that lasts for 2D seconds
  - So node can't finish before collision
  - Ethernet minimum frame is 64 bytes



CSMA "Persistence"

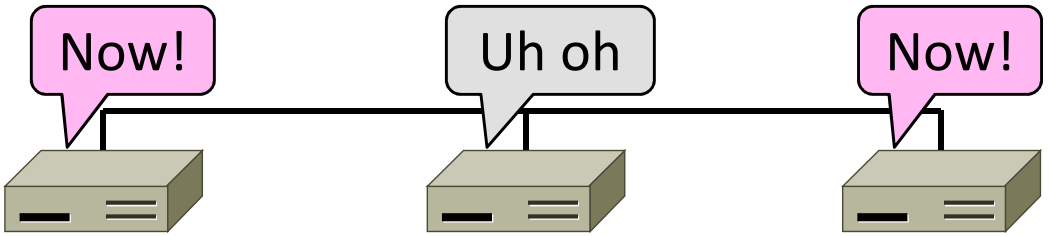
- What should a node do if another node is sending?



- Idea: Wait until it is done, and send

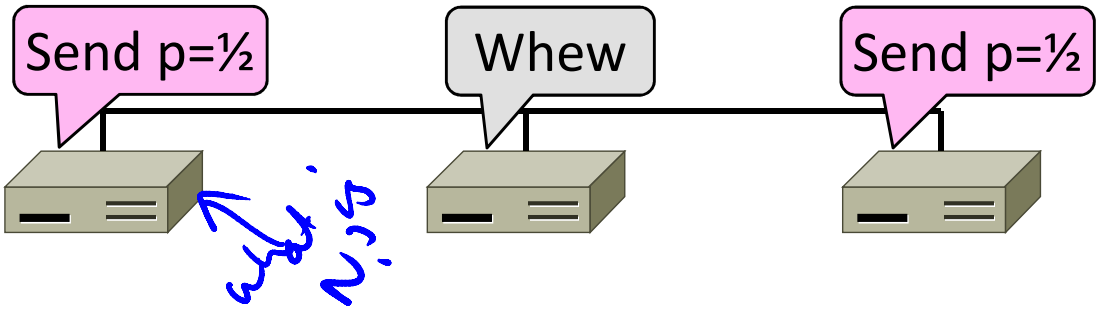
CSMA "Persistence" (2)

- Problem is that multiple waiting nodes will queue up then collide
  - More load, more of a problem



CSMA "Persistence" (3)

- Intuition for a better solution
  - If there are N queued senders, we want each to send next with probability 1/N



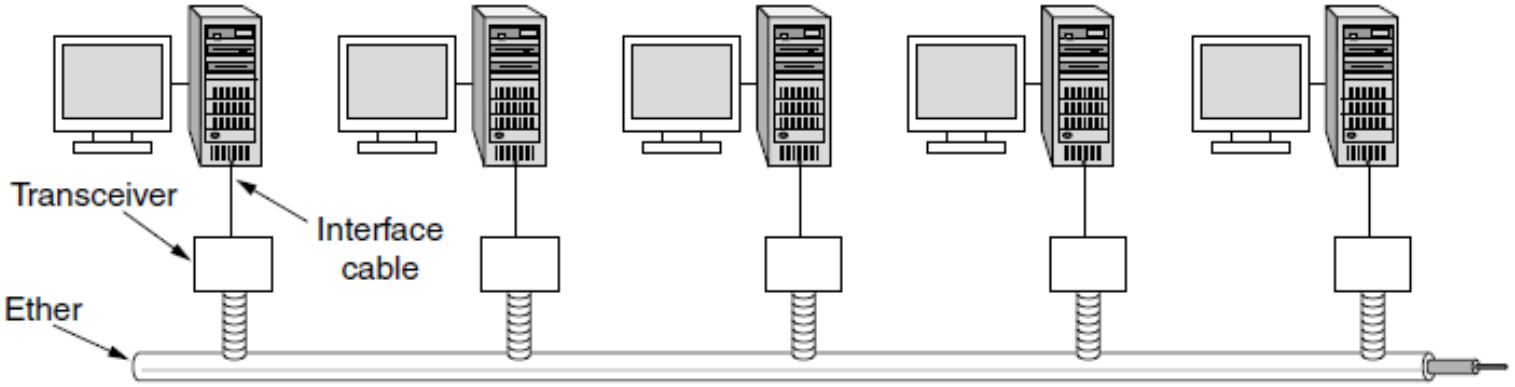
Binary Exponential Backoff (BEB)

- Cleverly estimates the probability
  - 1st collision, wait 0 or 1 frame times
  - 2nd collision, wait from 0 to 3 times
  - 3rd collision, wait from 0 to 7 times …

- BEB doubles interval for each successive collision
  - Quickly gets large enough to work
  - Very efficient in practice

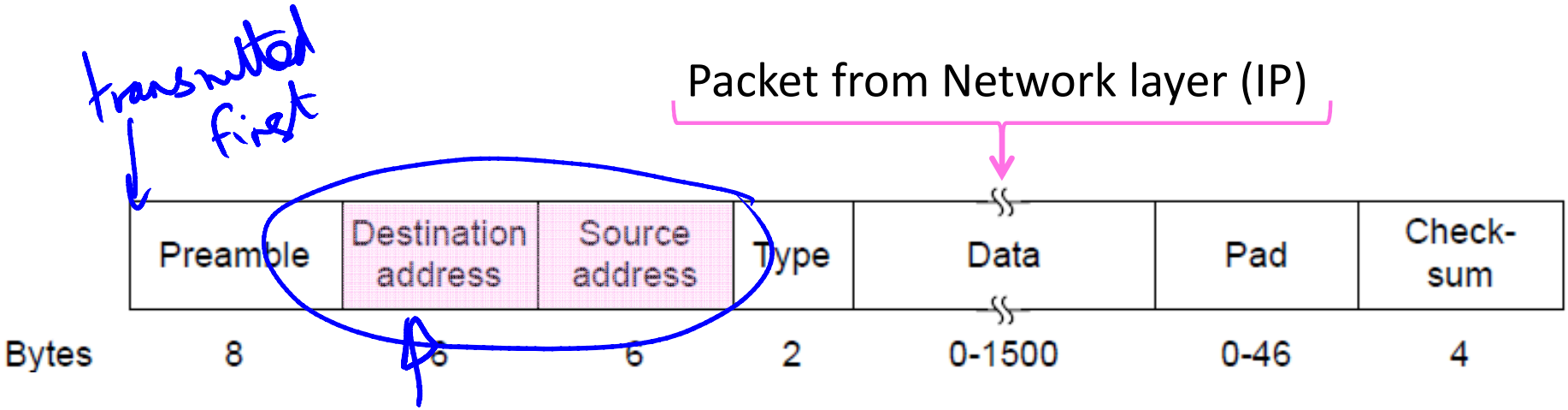
Classic Ethernet, or IEEE 802.3

- Most popular LAN of the 1980s, 1990s
  - 10 Mbps over shared coaxial cable, with baseband signals
  - Multiple access with "1-persistent CSMA/CD with BEB"



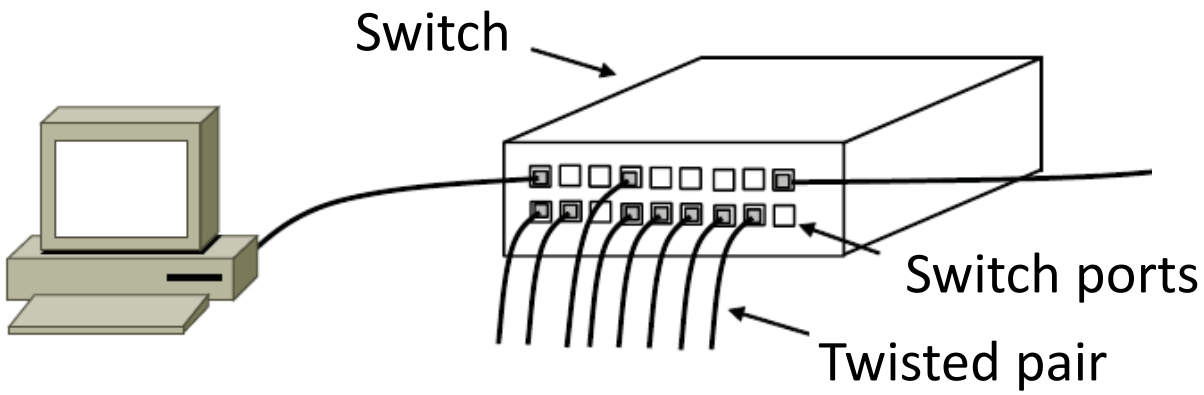
Ethernet Frame Format

- Has addresses to identify the sender and receiver
- CRC-32 for error detection; no ACKs or retransmission
- Start of frame identified with physical layer preamble



Modern Ethernet

- Based on switches, not multiple access, but still called Ethernet
  - We'll get to it in a later segment



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