

Computer Networks

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



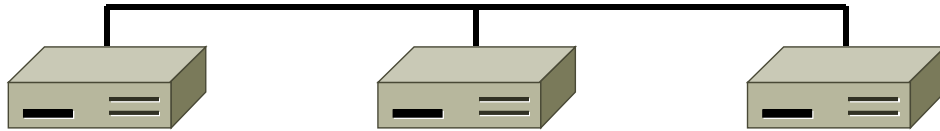
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Topic

- 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

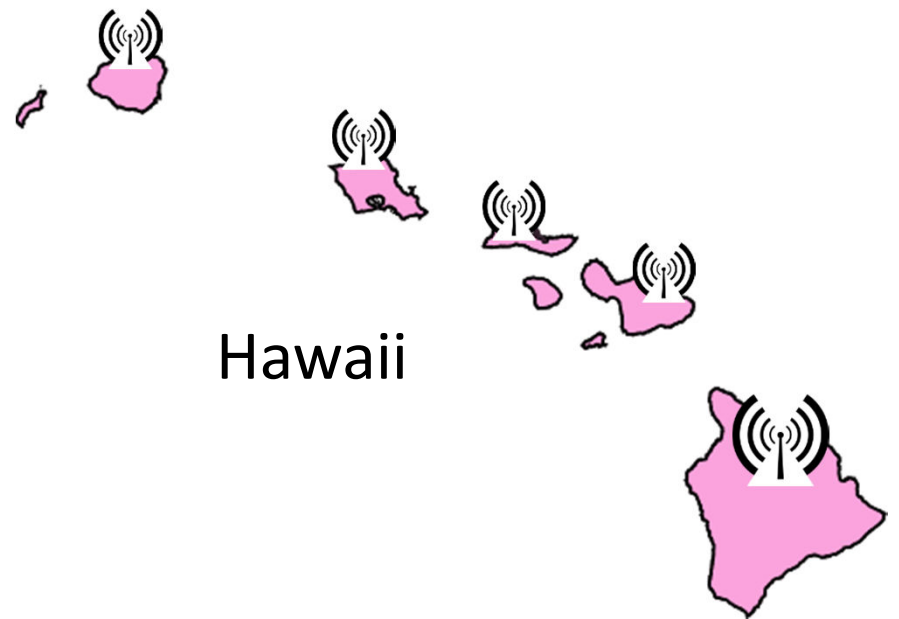
Topic (2)

- 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 ...

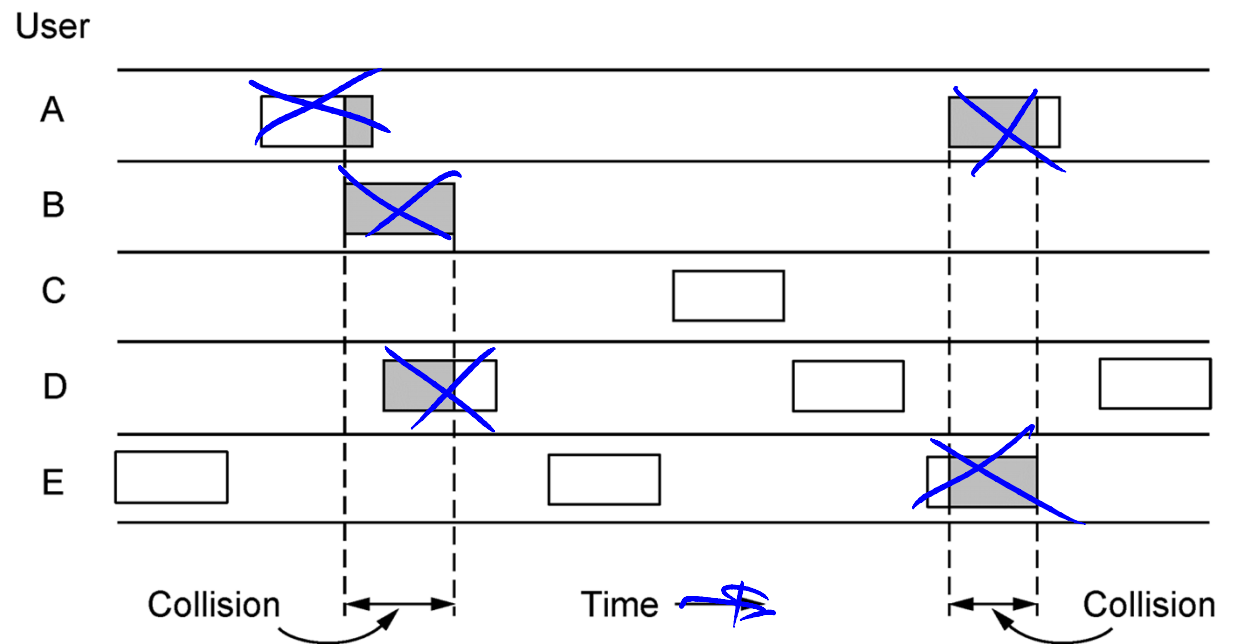


ALOHA Protocol

- 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?

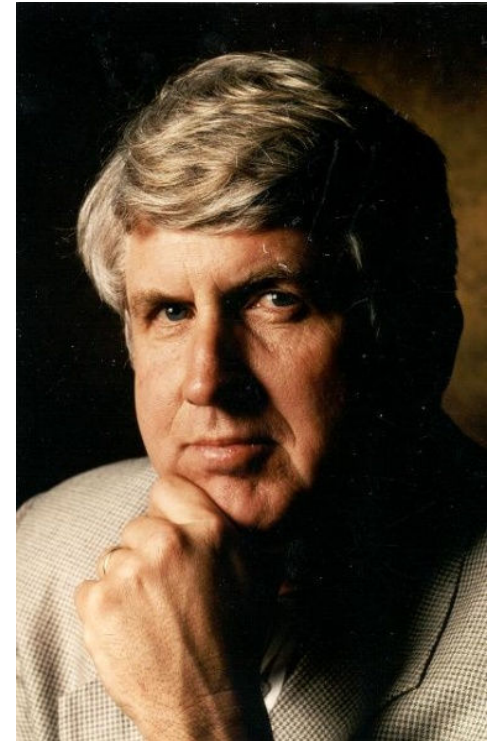
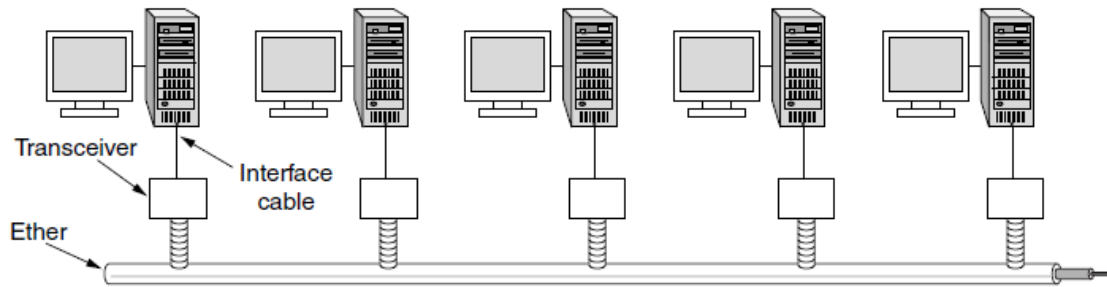


ALOHA Protocol (3)

- 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



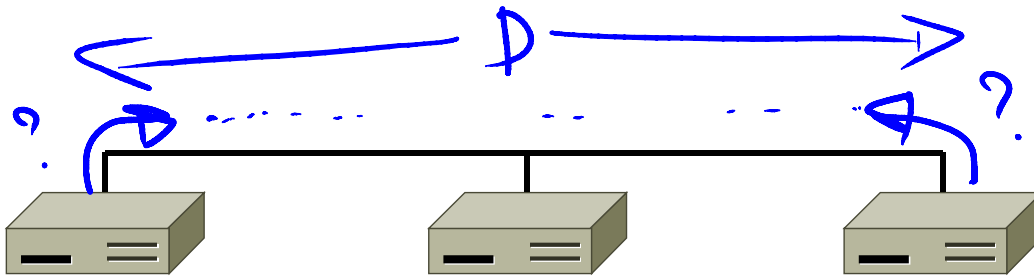
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CSMA (Carrier Sense Multiple Access)

- 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)

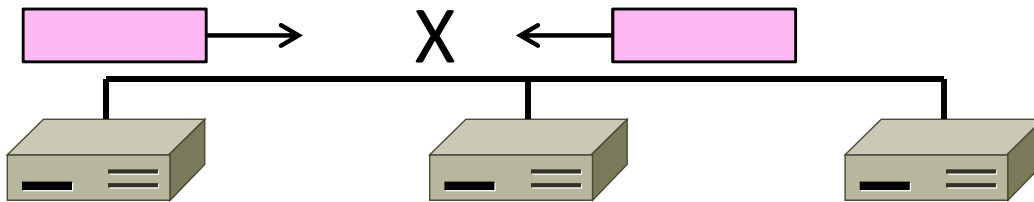
- Still possible to listen and hear nothing when another node is sending because of delay



CSMA (3)

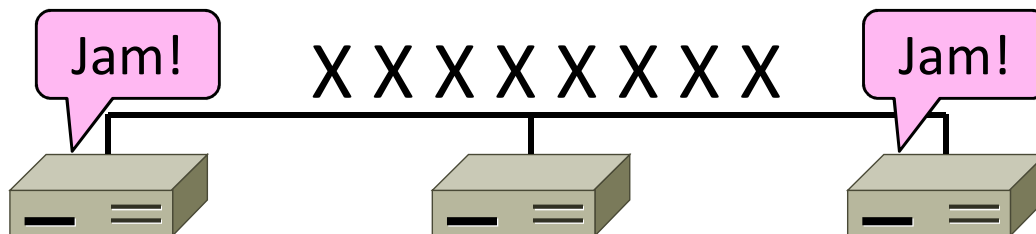
- CSMA is a good defense against collisions only when BD is small

Σ 1 packet



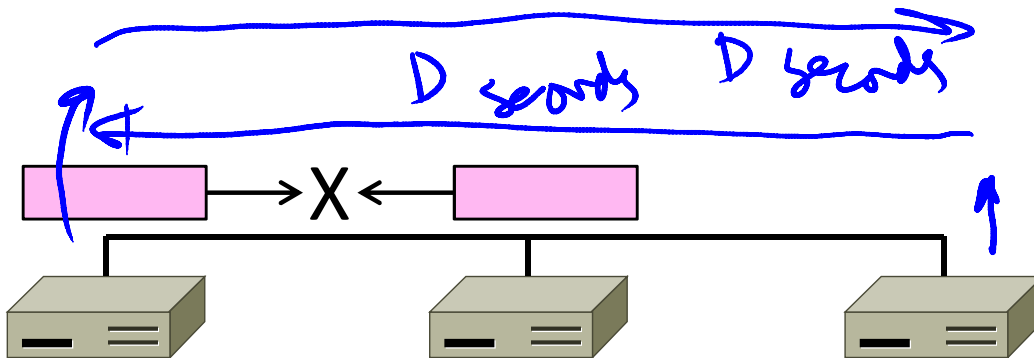
CSMA/CD (with Collision Detection)

- 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



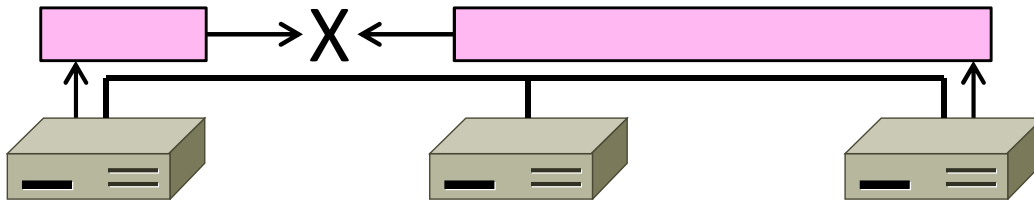
CSMA/CD Complications

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



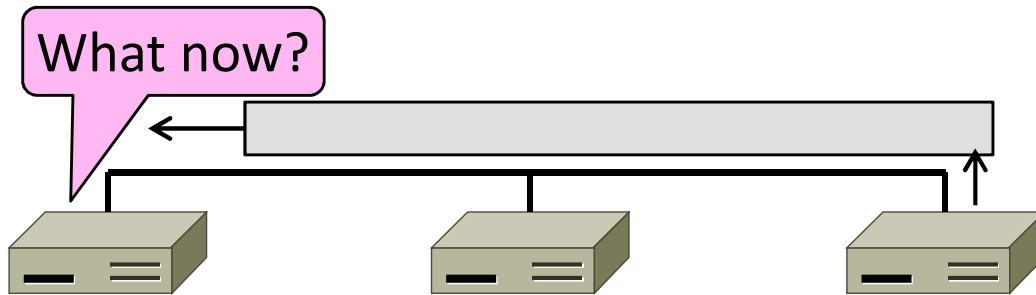
CSMA/CD Complications (2)

- 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”

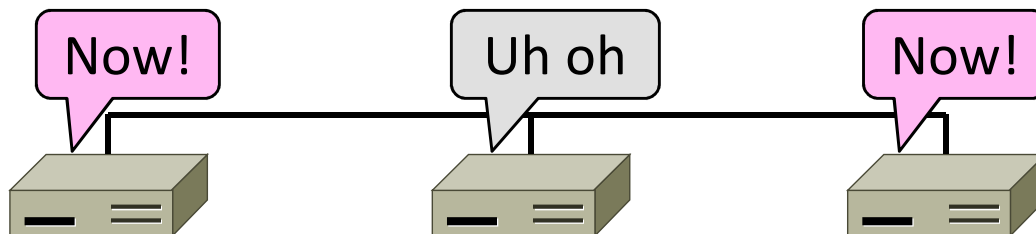
- What should a node do if another node is sending?



- Idea: Wait until it is done, and send

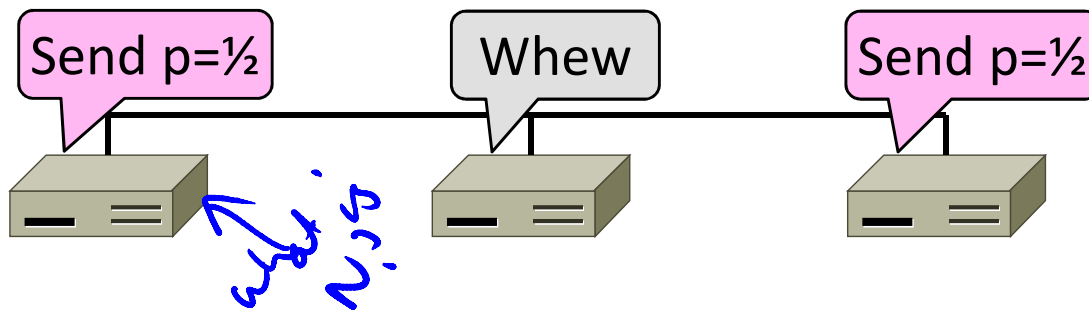
CSMA “Persistence” (2)

- 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 $1/N$

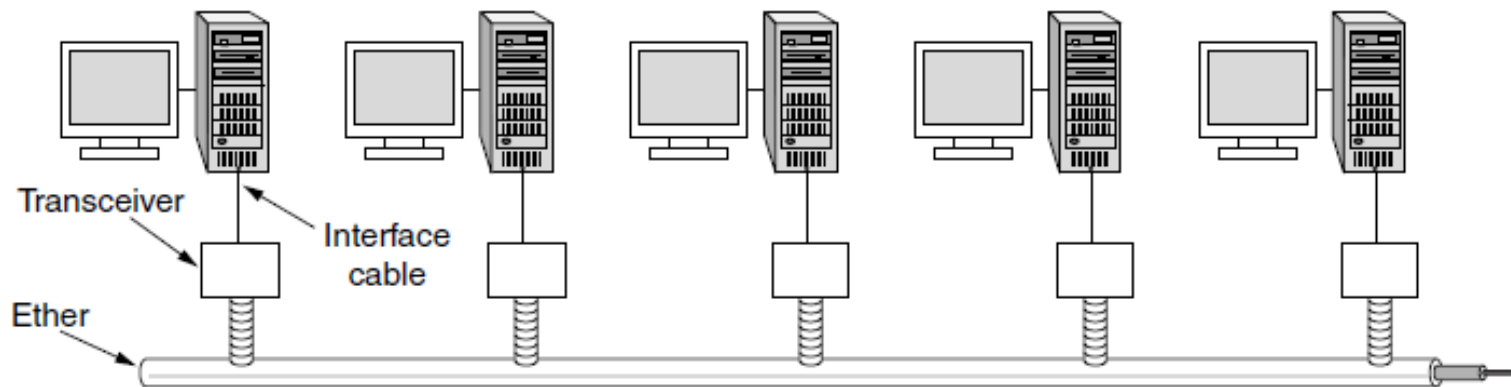


Binary Exponential Backoff (BEB)

- ~~△~~ 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

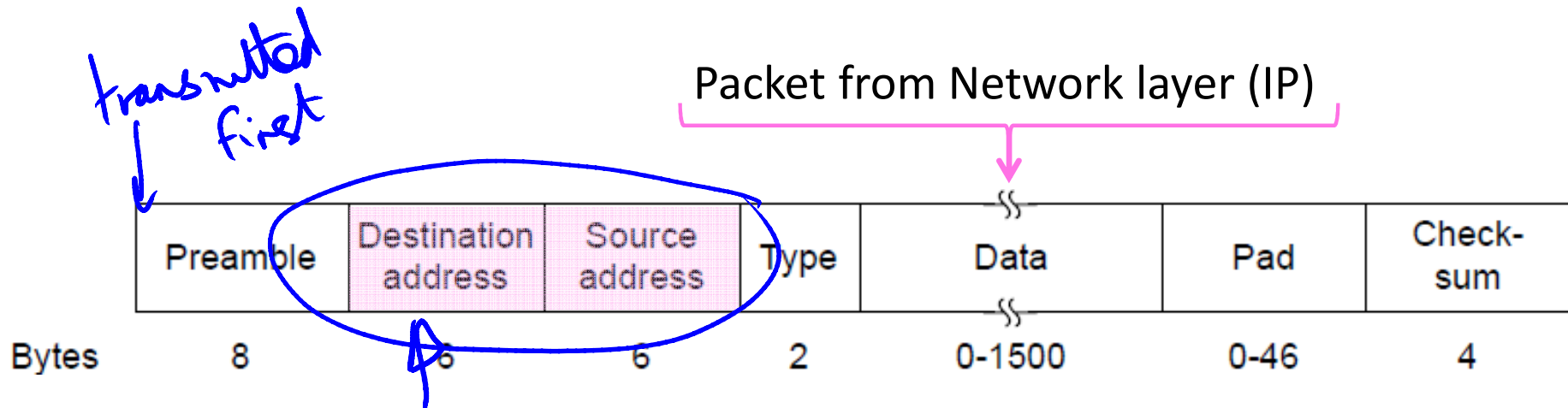
Classic Ethernet, or IEEE 802.3

- 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”



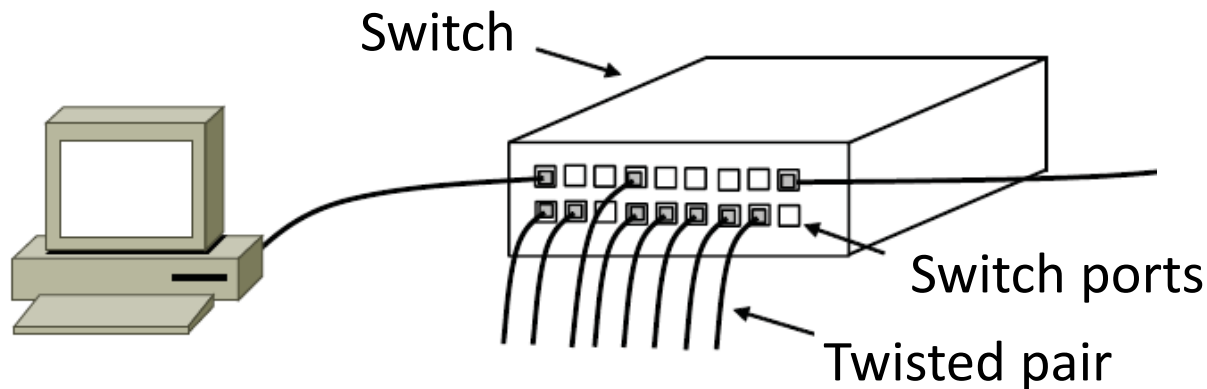
Ethernet Frame Format

- 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



END

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