Shared Access Networks

- Outline
  - Bus (Ethernet)
  - Token ring (FDDI)
  - Wireless (802.11)

Ethernet Overview

- History
  - developed by Xerox PARC in mid-1970s
  - roots in Aloha packet-radio network
  - standardized by Xerox, DEC, and Intel in 1978
  - similar to IEEE 802.3 standard
- CSMA/CD
  - carrier sense
  - multiple access
  - collision detection
- Frame Format

64	48	48	16		32	8
Preamble	Dest addr	Src addr	Type	Body	CRC	Postamble

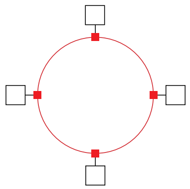
- Addresses
  - unique, 48-bit unicast address assigned to each adaptor
  - example: `8:0:2b:e4:b1:2`
  - broadcast: all `1`s
  - multicast: first bit is `1`
- Bandwidth: 10Mbps, 100Mbps, 1Gbps
- Length: 2500m (500m segments with 4 repeaters)
- Problem: Distributed algorithm that provides fair access

Transmitter Algorithm

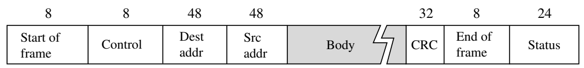
- If line is idle...
  - send immediately
  - upper bound message size of 1500 bytes
  - must wait 9.6μs between back-to-back frames
- If line is busy...
  - wait until idle and transmit immediately
  - called *1-persistent* (special case of *p-persistent*)
- If collision...
  - jam for 32 bits, then stop transmitting frame
  - minimum frame is 64 bytes (header + 46 bytes of data)
  - delay and try again
    - ∗ 1st time: 0 or 51.2μs
    - ∗ 2nd time: 0, 51.2, or 102.4μs
    - ∗ 3rd time: 0, 51.2, 102.4, or 153.6μs
    - ∗ n^{th} time: $k\times$ 51.2 μs, for randomly selected k=0..$2^n - 1$
    - ∗ give up after several tries (usually 16)
    - ∗ exponential backoff

Token Ring Overview

- Examples
  - 16Mbps IEEE 802.5 (based on earlier IBM ring)
  - 100Mbps Fiber Distributed Data Interface (FDDI)



- Idea
  - frames flow in one direction: upstream to downstream
  - special bit pattern (token) rotates around ring
  - must capture token before transmitting
  - release token after done transmitting
    - ∗ immediate release
    - ∗ delayed release
  - remove your frame when it comes back around
  - stations get round-robin service
- Frame Format



Timed Token Algorithm

- Token Holding Time (THT): upper limit on how long a station can hold the token.
- Token Rotation Time (TRT): how long it takes the token to traverse the ring.

  $$\mathsf{TRT} \leq \mathsf{ActiveNodes} \times \mathsf{THT} + \mathsf{RingLatency}$$

- Target Token Rotation Time (TTRT): agreed-upon upper bound on TRT.
- Algorithm
  - each node measures TRT between successive arrivals of the token
  - if measured TRT > TTRT, then token is late so don't send data
  - if measured TRT < TTRT, then token is early so OK to send data
  - define two classes of traffic
    - synchronous data: can always send
    - asynchronous data: can send only if token is early
  - worse case: 2×TTRT between seeing token
  - not possible to have back-to-back rotations that take 2×TTRT time

Token Maintenance

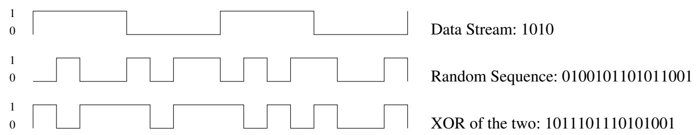
- Lost Token
  - no token when initializing ring
  - bit error corrupts token pattern
  - node holding token crashes
- Generating a Token (and agreeing on TTRT)
  - execute when join ring or suspect a failure
  - each node sends a special *claim frame* that includes the node's *bid* for the TTRT
  - when receive claim frame, update bid and forward
  - if your claim frame makes it all the way around the ring:
    - your bid was the lowest
    - everyone knows TTRT
    - you insert new token
- Monitoring for a Valid Token
  - should see valid transmission (frame or token) periodically
  - maximum gap = ring latency + max frame ≤ 2.5ms
  - set timer at 2.5ms and send claim frame if it fires

Wireless LANs

- IEEE 802.11
- Bandwidth: 1 or 2 Mbps
- Physical Media
  - spread spectrum radio (2.4GHz)
  - diffused infrared (10m)

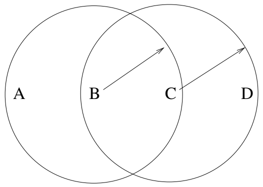
Spread Spectrum

- Idea
  - spread signal over wider frequency band than required
  - originally designed to thwart jamming
- Frequency Hopping
  - transmit over random sequence of frequencies
  - sender and receiver share...
    - ∗ pseudorandom number generator
    - ∗ seed
  - 802.11 uses 79 × 1MHz-wide frequency bands
- Direct Sequence
  - for each bit, send XOR of that bit and n random bits
  - random sequence known to both sender and receiver
  - called an n-bit *chipping code*
  - 802.11 defines an 11-bit chipping code



Collision Avoidance

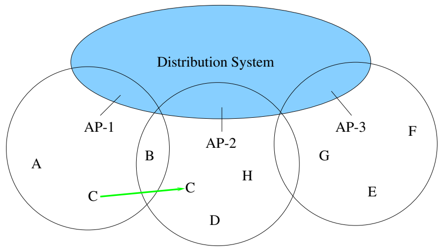
- Similar to Ethernet
- Problem: *hidden* and *exposed* nodes



- MACAW: Multiple Access w/ Collision Avoidance for Wireless
  - sender transmits RequestToSend (RTS) frame
  - receiver replies with ClearToSend (CTS) frame
  - neighbors...
    - ∗ see CTS ⟶ keep quiet
    - ∗ see RTS but not CTS ⟶ ok to transmit
  - receiver sends ACK when has frame
    - ∗ neighbors silent until see ACK
  - collisions
    - ∗ no collision detection
    - ∗ know when don't receive CTS
    - ∗ exponential backoff

Supporting Mobility

- Case 1: *ad hoc* networking
- Case 2: *acces points* (AP)
  - tethered
  - each mobile node associates with an AP



- Scanning (selecting an AP)
  - node sends Probe frame
  - all APs w/in reach reply with ProbeResponse frame
  - node selects one AP; sends it AssociationRequest frame
  - AP replies with AssociationResponse frame
  - new AP informs old AP via tethered network
- When
  - active: when join or move
  - passive: AP periodically sends Beacon frame