Shared Access Networks

Outline

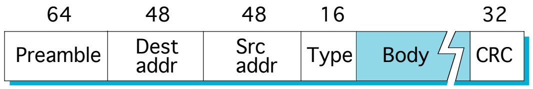
Bus (Ethernet)

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



Ethernet (cont)

- Addresses
  - unique, 48-bit unicast address assigned to each adapter
  - example: **`8:0: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

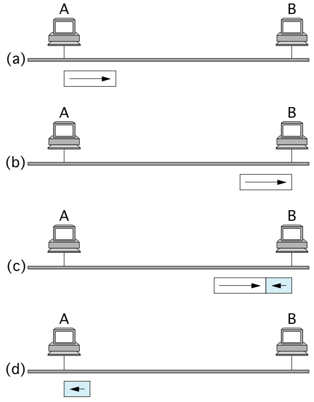
Transmit Algorithm

- If line is idle…
  - send immediately
  - upper bound message size of 1500 bytes
  - must wait 9.6us between back-to-back frames
- If line is busy…
  - wait until idle and transmit immediately
  - called *1-persistent* (special case of *p-persistent*)

Algorithm (cont)

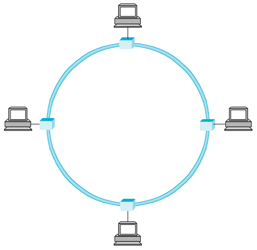
- If collision…
  - jam for 32 bits, then stop transmitting frame
  - minimum frame is 64 bytes (header + 46 bytes of data)
  - delay and try again
    - 1st time: 0 or 51.2us
    - 2nd time: 0, 51.2, 102.4, or 153.6us
    - *nth* time: *k* x 51.2us, for randomly selected *k*=0..2^n - 1
    - give up after several tries (usually 16)
    - exponential backoff

Collisions



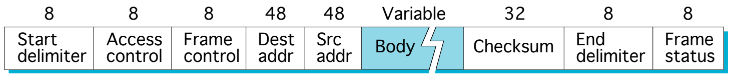
Token Ring Overview

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



Token Ring (cont)

- 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



8	8	8	48	48	Variable	32	8	8
Start delimiter	Access control	Frame control	Dest addr	Src addr	Body	Checksum	End delimiter	Frame status

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
  - `TRT` <= `ActiveNodes` x `THT` + `RingLatency`
- Target Token Rotation Time (TTRT)
  - agreed-upon upper bound on TRT

Algorithm (cont)

- Each node measures TRT between successive tokens
  - if measured-TRT > TTRT: token is late so don't send
  - if measured-TRT < TTRT: token is early so OK to send
- Two classes of traffic
  - synchronous: can always send
  - asynchronous: can send only if token is early
- Worse case: 2xTTRT between seeing token
- Back-to-back 2xTTRT rotations not possible

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
  - send a *claim frame* that includes the node's TTRT *bid*
  - when receive claim frame, update the 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

Maintenance (cont)

- Monitoring for a Valid Token
  - should periodically see valid transmission (frame or token)
  - maximum gap = ring latency + max frame < = 2.5ms
  - set timer at 2.5ms and send claim frame if it fires

Wireless LANs

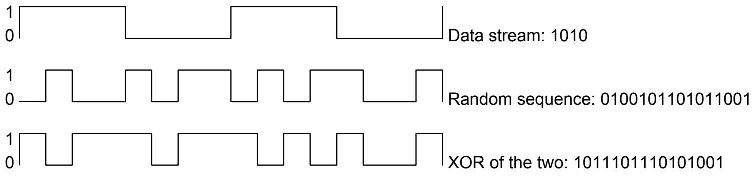
- IEEE 802.11
- Bandwidth: 1 - 11 Mbps
- Physical Media
  - spread spectrum radio (2.4GHz)
  - diffused infrared (10m)

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 x 1MHz-wide frequency bands

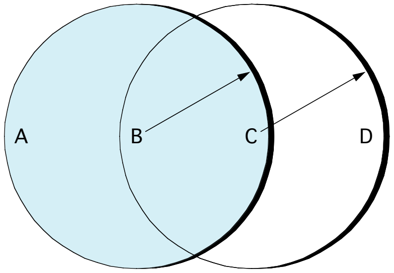
Spread Spectrum (cont)

- Direct Sequence
  - for each bit, send XOR of that bit and *n* random bits
  - random sequence known to both sender and receiver
  - called *n*-bit *chipping code*
  - 802.11 defines an 11-bit chipping code


1
0
Data stream: 1010
1
0
Random sequence: 0100101101011001
1
0
XOR of the two: 1011101110101001

Collisions Avoidance

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

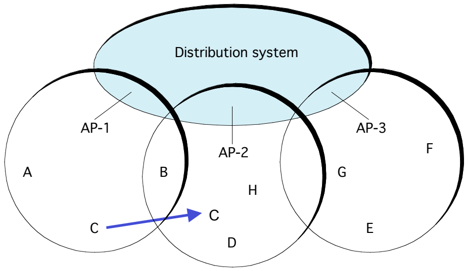


MACAW

- Sender transmits **RequestToSend** (RTS) frame
- Receiver replies with **ClearToSend** (CTS) frame
- Neighbors…
  - see CTS: keep quiet
  - see RTS but not CTS: ok to transmit
- Receive sends ACK when has frame
  - neighbors silent until see ACK
- Collisions
  - no collisions detection
  - known when don’t receive CTS
  - exponential backoff

Supporting Mobility

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



Mobility (cont)

- Scanning (selecting an AP)
  - node sends **Probe** frame
  - all AP’s w/in reach reply with **ProbeResponse** frame
  - node selects one AP; sends it **AssociateRequest** 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