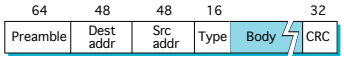
Shared Access Networks

Outline

- Bus (Ethernet)
- Token ring (IBM, FDDI, RPR)
- Wireless (802.11, WiMAX)

Ethernet Overview

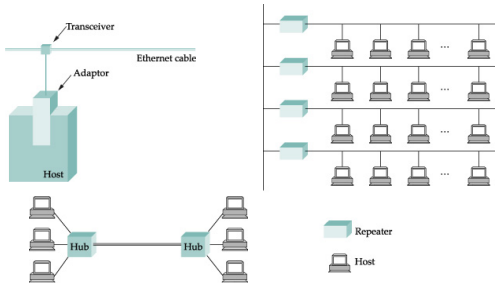
- History
  - developed by Xerox PARC in mid-1970s
  - roots in Aloha packet-radio network
  - standardized by Xerox, DEC, and Intel in 1978
  - similar to IEEE 802.3 standard
- CSMA/CD
  - carrier sense
  - multiple access
  - collision detection
- Frame Format



Ethernet (cont)

- Addresses
  - unique, 48-bit unicast address assigned to each adapter
  - example: `8:0:e4:b1:a0:2`
  - multicast: first bit is `1`
- Bandwidth: 10Mbps, 100Mbps, 1Gbps
- Length: 2500m (500m segments with 4 repeaters)
- Problem: Distributed algorithm that provides fair access

Ethernet



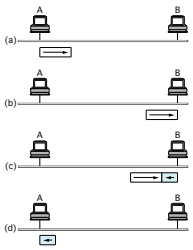
Transmit Algorithm

- 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)

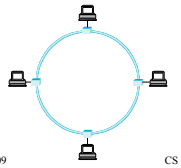
- If collision…
  - jam for 32 bits, then stop transmitting frame
  - minimum frame is 64 bytes (header + 46 bytes of data)
  - delay and try again
    - 1st time: 0 or 51.2us
    - 2nd time: 0, 51.2, 102.4, or 153.6us
    - *nth* time: k x 51.2us, for randomly selected k=0..2^n - 1
    - give up after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

Collisions



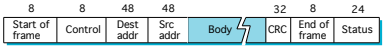
Token Ring Overview

- Examples
  - IEEE 802.5 (based on earlier IBM Token Ring)
  - Fiber Distributed Data Interface (FDDI)
  - IEEE 802.17 (Resilient Packet Ring or RPR)



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



Timed Token Algorithm

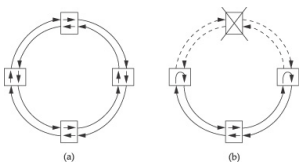
- Token Holding Time (THT)
  - upper limit on how long a station can hold the token
- Token Rotation Time (TRT)
  - how long it takes the token to traverse the ring
  - **`TRT`** <= **`ActiveNodes`** `X` **`THT`** + **`RingLatency`**

Token Maintenance

- Lost Token
  - no token when initializing ring
  - bit error corrupts token pattern
  - node holding token crashes
- Monitoring for a Valid Token
  - should periodically see valid transmission (frame or token)
  - timer: NumStations * THT + RingLatency
  - set timer and send claim frame if it fires

FDDI

- Runs on fiber
- Consists of dual ring



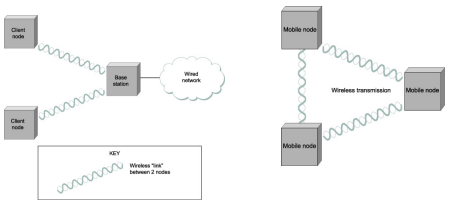
Resilient Packet Ring (802.17)

- Focus on resiliency, bandwidth efficiency, QoS
- 2 counter-rotating optical fiber rings
- Both rings used simultaneously (bandwidth)
- Receiver removes RPR frame (bandwidth)
- No tokens! Instead: buffer insertion
- 3 classes supported (QoS):
  - class A: low latency, low jitter
  - class B: predictable latency and jitter
  - class C: best-effort
- Uses wrapping and steering (resiliency)
  - wrapping: similar to FDDI
  - steering: inform other nodes of failure, can use opposite direction

Wireless

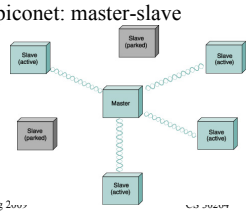
- Bluetooth:
  - 10m, 2.1Mbps (shared), peripheral devices to computer
- Wi-Fi 802.11:
  - 100m, 54Mbps (shared), computer to base stations
- WiMAX 802.16:
  - 10km, 70Mbps (shared), link buildings and towers
- 3G Cellular:
  - tens of km, 384+ Kbps (not shared), cell phone to tower

Modes of Communication



Bluetooth (802.15.1)

- 2.45GHz band, range of 10m
- version 2.0: 2.1Mbps, low power consumption
- piconet: master-slave



Wi-Fi

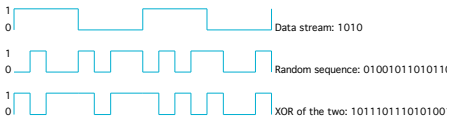
- IEEE 802.11b: 2.4GHz band, 11Mbps
- IEEE 802.11a: 5GHz band, 54Mbps
- IEEE 802.11g: 2.4GHz band, 54Mbps

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

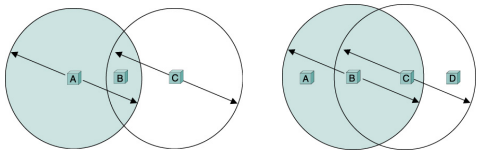
Spread Spectrum (cont)

- 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



Collisions Avoidance

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

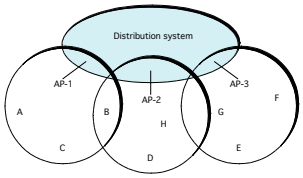


MACA

- Multiple Access with Collision Avoidance
- 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
  - known when CTS not received
  - 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

802.11

- Up to 2312 bytes of data
- 32-bit CRC
- 4 addresses, usage depends on mode:
  - Addr1 is target, Addr2 is source
  - Addr1 is ultimate target, Addr2: immediate sender, Addr3 is intermediate target, Addr4: original source

WiMAX

- Worldwide Interoperability for Microwave Access
- standardized by WiMAX Forum, IEEE 802.16
- typical distance: 1-6miles, up to 30miles
- "subscriber stations" (e.g., antenna on roof)
- up to 70Mbps
- Time Division Duplexing (TDD)
- Frequency Division Duplexing (FDD)

Cell Phone Technologies

- Uses base stations, area served called "cell"
- 1G: analog
- 2G, 2.5G (e.g., GSM): digital
- GPRS: General Packet Radio Service (typically 30-70Kbps)
- 3G:
  - UMTS (Universal Mobile Telecommunications System)