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

<table>
<thead>
<tr>
<th>Preamble</th>
<th>Dest. addr</th>
<th>Src. addr</th>
<th>Type</th>
<th>Body</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>48</td>
<td>48</td>
<td>16</td>
<td>32</td>
<td></td>
</tr>
</tbody>
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Ethernet (cont)

- Addresses
  - unique, 48-bit unicast address assigned to each adapter
  - example: \texttt{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
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
  - \( TRT = \text{ActiveNodes} \times \text{THT} + \text{RingLatency} \)

### 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: \( \text{NumStations} \times \text{THT} + \text{RingLatency} \)
  - 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

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

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: 1-6 miles, up to 30 miles
- “subscriber stations” (e.g., antenna on roof)
- up to 70 Mbps
- 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 30-70 Kbps)
- 3G:
  - UMTS (Universal Mobile Telecommunications System)