Announcements

- Project #4 Due next week
- Reading
  - Chapter 4 (4.3)
Collision Detection

- If a sender senses a collision
  - stop sending at once
  - apply random backoff

- “contention” period
  - after contention period, there will be no collision
  - send for for $2\tau$ (max propagation delay)
    - need $2\tau$ since might be a collision at far end at $\tau - \varepsilon$
Collision Free Protocols

- **Use an allocation scheme**
  - must be dynamic (based on load) or we are reduced to TDM
- **Bit Map Reservation Protocol**
  - round of allocation (contention period)
  - everyone who indicated a desire to send goes in turn
  - requires an overhead of one bit per **per station** per round
- **Binary Countdown**
  - reservation round send your host address
    - uses a “wired or” to compute winner
    - as soon as a station senses a 1 where it sent 0 it backs off
  - winner sends packet
  - gives higher priority to higher numbered hosts
    - can “rotate” station number after successful transmission
Wireless Shared Channels

- Every node may not be in range of every other node
  - a is in range to send to b, but not c
  - b can send to a or c
  - c can send to b

- Collisions
  - carrier sense will not work due to range
  - must avoid any host sending that is in range of sender or receiver
Wireless Networks (MACA)

- Stations send data into the air
  - not all stations can “see” all other stations
- Need to avoid collisions between sender and receiver
  - possible for the sender to not be able to sense collision
- Use a two stage protocol
  - send a RTS (request to send)
  - receiver responds CLS (clear to send)
- Hosts that hear a RTS or CLS wait and don’t send
  - collisions still possible since two RTS frames may collide
Ethernet Cable Options

- **10base5: Thicknet - first Ethernet**
  - Thick cable, doesn’t bend well
  - vampire taps used to “tap” the network
  - max run is 500 meters

- **10Base2: Thin coax (cheaper net),**
  - uses “T” connectors
  - max run is 200 meters

- **10baseT: twisted pair**
  - uses a central hub
  - easier to find faults and problems
  - max run is 100 meters to hub
Manchester Encoding

- **Problem: How to send zero/ones?**
  - need to know timing information
  - when does on bit end?
- **Answer: Force many transitions**
  - every bit is half low and half high
  - 1 is high then low
  - 0 is low then high
  - but this doubles bandwidth
- **Differential Manchester Encoding**
  - better noise immunity
  - 0 is a transition at the start, 1 none
  - both transition during the middle
**Ethernet Frame Format**

<table>
<thead>
<tr>
<th>Bytes</th>
<th>7</th>
<th>1</th>
<th>2 or 6</th>
<th>2 or 6</th>
<th>2</th>
<th>0-1500</th>
<th>0-46</th>
<th>4</th>
</tr>
</thead>
<tbody>
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<tr>
<td></td>
<td>Preamble</td>
<td>Destination address</td>
<td>Source address</td>
<td>Data</td>
<td>Pad</td>
<td>Checksum</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Preamble used to sync clock**
- **Addresses**
  - 48 bits
  - if it starts with a 0 it is globally unique (assigned by IEEE)
  - if it starts with a 1 it is locally unique
- **Length**
  - 0 to 1500 bytes
  - **min** length is 46 bytes
    - ensures frame reaches end of cable before end of frame is sent
- **Checksum**
  - 32 bit CRC to detect garbled data at link level
Collision Management

- Binary Exponential Backoff
  - after collision, divide into slot times
  - after first collision, wait either 0 or 1 slot times
  - after second collision, wait either 0, 1, 2, or 3 slot times
  - limited to 1023 slots
  - after 16 collisions, link layer gives up

- Performance
  - each station wants to transmit with probability $p$, then
    - $A = k \left( p^1 (1-p)^{k-1} \right)$
    - $A \rightarrow 1/e$ as $k \rightarrow \infty$
  - probability a contention interval has $j$ slots is $A(1-A)^{j-1}$
  - mean number of slots per contention is:
    \[ \sum_{j=0}^{\infty} jA(1-A)^{j-1} = \frac{1}{A} \]
    mean contention interval is then $2\tau/A$