Announcements

- Project #4 Due this week
- Midterm #2 – Week from today in class
- No Tuesday office hours this week
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
    - \( A = k \left[ p \right]^{1} \left[ 1-p \right]^{k-1} \)
    - \( A \rightarrow 1/e \) as \( k \rightarrow \infty \)
  - probability a contention interval has \( j \) slots is \( A \left[ 1-A \right]^{j-1} \)
  - mean number of slots per contention is:
    
    \[
    \sum_{j=1}^{\infty} jA(1-A)^{j-1} = \frac{1}{A}
    \]
    
    mean contention interval is then \( 2\tau/A \)
Ethernet Performance (cont.)

- Ethernet Channel efficiency is then:

\[
\frac{P}{P + \frac{2\pi}{A}} = \frac{1}{1 + \frac{2BLe}{cF}}
\]

B = bandwidth
L = cable length
c = speed of light
F = frame length

- Traffic models
  - traditional analysis assume Poisson arrival
  - recent studies have demonstrated self similar properties
    - traffic variance does not decrease with wider samples
Variations on Ethernet

- **Traditional Ethernet is a bus**
  - limited to one host at a time

- **Switched Ethernet**
  - make hub smarter
  - different ports can each form their own Ethernet segment
    - frames for other segment travel over backplane
  - individual stations retain the same card and cabling

- **Token Bus**
  - rings have bounded worst case times
  - token bus forms a logical ring out of a single bus
Bridges

- Split one logical LAN into multiple physical LANs
  - permit mixing types of 802.X networks
    - 100 Megabit Ethernet with 10Mbps
    - token ring with Ethernet
  - extend the physical network
    - limits on cable length
  - improve security
  - reduce traffic

- Forward traffic between the physical layers
  - regenerate the signal
  - convert between 802.X formats
    - this is non-trivial
Learning Bridges

- **Transparent to users**
  - traffic just gets to the correct location
  - no software configuration required

- **Selectively forward traffic among segments**
  - used 48bit Ethernet addresses
  - at first, forward all traffic via flooding
  - use **source** address to learn where a host is located
    - do not forward a packet if the destination is known to be on the local network

- **need to have a spanning tree to prevent loops**
  - use lowest serial number to elect root
  - compute shortest path to root as the spanning tree
  - some bridge may be disabled to ensure a tree
Source Routing Bridge

- Each host knows how to reach other hosts
  - it builds a full path to that host
- Every LAN and bridge has a number
  - a LAN has a 12 bit identifier
  - a bridge a 4 bit id
- To discover a route
  - broadcast a discovery packet
  - destination responds
    - bridges fill in their information in the response
    - results in a full path to the remote destination
Source vs. Transparent Bridges

- **Source Bridges**
  - always use optimal routes
  - could exploit multiple paths between two LANs for load sharing

- **Transparent Bridges**
  - require no changes to nodes
    - nodes are now more complex
  - no need to configure the bridges
    - source bridges need LAN and Bridge IDs
FDDI

- Fiber base ring
  - two rings, one clockwise the other counter clockwise
  - use LEDs to send data

- Encoding
  - uses 4 of 5 encoding
  - loses self clocking property of Manchester encoding
    - uses long frame header to compensate

- Supports Synchronous traffic
  - each sync frame has 96 bytes of data every 125µs
    - supports 4 T-1 lines
    - up to 16 synchronous slots may be used

- Timers
  - token holding timer: forces a node to give up the token
  - token rotation timers: recovers from lost token if its not seen
Fast Ethernet

- **Based on hubs**
  - advantages of hubs rendered bus cables useless
  - limits cable length to 100 meters for copper
  - can be switched or use a single collision domain

- **Signals**
  - 100Base-T4
    - uses 4 pair cat 3 wiring
    - 33Mbps in each direction and two reversible channels
    - 25Mhz with trinary signaling and 4 bits per baud
  - 100Base-TX
    - two pairs of cat 5 wiring
    - 125Mhz with 4bits our of 5 for data
Hippi

- **KISS based path to almost 1Gbps**
  - no options
  - use copper interface
- **Parallel Connection**
  - 32 bits wide
  - 18 control bits
  - 50 twisted pair wires
- **Connections**
  - uses a cross-bar switch
  - sends in groups of 256 words
- **Error checking**
  - parity bit per word
  - parity word at the end of each frame
    - over the vertical 256 bits