Announcements

- Reading
  - Today: 4.4 and 4.5
  - Thursday: 7.1
- Midterm #2 was returned
  - average was 47.2
  - standard deviation was 14
- Revised project propsals were returned
  - average score was 41
  - standard deviation was 4 (not much variance here!)
- Scores for the project demo were returned
  - average score was 5.7 out of 10

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 $[p^1(1-p)^{k-1}]$
    - with p = 1/k, A --> 1/*e* as k --> infinity
  - 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 $2\tau/A$

Ethernet Performance (cont.)

- Ethernet Channel efficiency is then:

$$\frac{P}{P + 2\tau / A} = \frac{1}{1 + 2BLe / cF}$$

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 there 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
  - looses 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