Problem 1

- In CSMA/CD, after the fifth collision
  - What is the probability that a node chooses K=4?
  - How long will the adapter wait to retransmit on a 10 Mbps Ethernet?

SOLUTION

- K = 4 selected from {0, 1, 2, 3, 4 ... 31} since $2^5 = 32$
  - Probability of any specific value being drawn = 1/32 = 0.03125 = 3.125%
  - for 10Mbps Ethernet, each bit takes 0.1μs to transmit. then K * 512-bit-times is (4)*(512)*(0.1μs) = 0.2 ms

Problem 1 continued

- Nodes A and B are on a 10Mbps link with d_{prop} = 225 bit-times between nodes. If A transmits, and before it is done B begins to transmit:
  - Can A finish before it detects that B has begun?
  - (If yes, then A believes its transmission was successful and collision-free)

- Ethernet frame
  - header+CRC = 26 bytes; data field minimum = 46 bytes

SOLUTION

- *Worst case*: **A** transmits smallest frame possible and **B** waits until the last moment to begin its transmission

- **A**'s minimum frame size = (26 + 46) x 8 = 576 bits. At $t = 0$, **A** begins transmission. At $t = 576$ bit-times, **A** would finish transmitting.

- **B**'s last moment start: In the worst case, B begins transmitting at time $t = 224$ bit-times. At time $t = 224 + 225 = 449$ bit-times, **B**'s first bit arrives at **A**. Because $449 < 576$, A aborts before completing the transmission of the packet, as it is supposed to do.

Thus A cannot finish transmitting before it detects that B transmitted. This implies that if A does not detect the presence of a host, then no other host begins transmitting while A is transmitting.

Problem 2

Suppose two nodes, *A* and *B*, are attached to opposite ends of a 900 m cable, and that they each have one frame of 1,000 bytes (including all headers and preambles) to send to each other. Both nodes attempt to transmit at time t=0. Suppose there are four hubs between *A* and *B*, each inserting a 20-bit delay. Assume the transmission rate is 10 Mbps, and CSMA/CD with backoff intervals of multiples of 512 bits is used. After the 1st collision, *A* draws K=0 and *B* draws K=1 in the exponential backoff protocol. Ignore the jam signal and the 96 bit-time delay.

(a) What is the one-way propagation delay (including hub delays) between *A* and *B* in seconds? Assume that the signal propagation speed is 2×10^8 m/sec.
(b) At what time (in seconds) is *A*'s packet completely delivered to *B*?
(c) Now suppose that only *A* has a packet to send and that the hubs are replaced with switches. Suppose that each switch has a 20-bit processing delay in addition to a store-and-forward delay. At what time, in seconds, is *A*'s packet delivered at *B*?

a)

$$\frac{900m}{2 \cdot 10^8 m/\sec} + 4 \cdot \frac{20bits}{10 \times 10^6 bps}$$

$$= (4.5 \times 10^{-6} + 8 \times 10^{-6}) \sec$$
$$= 12.5 \mu \sec$$

b)

- At time $t = 0$, both A and B transmit.
- At time $t = 12.5 \mu \sec$, A detects a collision.
- At time $t = 25 \mu \sec$ last bit of B's aborted transmission arrives at A. (A picks K = 0 and (ignoring jam signal) waits for the channel to be idle. The channel becomes idle at time t = 25μs. This is the time last bit from B arrives at A.)
- A retransmits at t = 25μs (ignoring 96-bit time delay). Thus At time $t = 25 + 12.5 = 37.5 \mu \sec$ first bit of A's retransmission arrives at B.
- At time $t = 37.5 \mu \sec + \dfrac{1000bits}{10 \times 10^6 bps} = 137.5 \mu \sec$ A's packet is completely delivered at B. → A finishes transmission at time t = 125μs. Last bit from A arrives at B at time 137.5μs.

c) $12.5 \mu \sec + 5 \cdot 100 \mu \sec = 512.5 \mu \sec$ →

Each switch introduces additional 1000-bit store-and-forward delay and 20-bit processing delay. Total delay introduced is 4080-bit time or 408 μs. Transmission delay is 1000-bit time or 100 μs. Propagation delay is 4.5 μs. A's packet reaches B at time

408 + 100 + 4.5 = 512.5μs