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

Problem 1 continued

- Nodes A and B are on a 10Mbps link with $d_{\text{prop}} = 225$ 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 = $(26 + 46) \times 8 = 576$ 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 \times 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?

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

\[ = (4.5 \times 10^{-6} + 8 \times 10^{-6}) \text{sec} \]

\[ = 12.5 \mu\text{sec} \]

b) • At time \( t = 0 \), both A and B transmit.
   • At time \( t = 12.5 \mu\text{sec} \), A detects a collision.
   • At time \( t = 25 \mu\text{sec} \) 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 = 25\mu s. This is the time last bit from B arrives at A.)
   • A retransmits at \( t = 25 \mu\text{sec} \) (ignoring 96-bit time delay). Thus At time \( t = 25 + 12.5 = 37.5 \mu\text{sec} \) first bit of A's retransmission arrives at B.
   • At time \( t = 37.5 \mu\text{sec}+ \frac{1000\text{bits}}{10 \times 10^6 \text{bps}} = 137.5 \mu\text{sec} \) A's packet is completely delivered at B. \( \rightarrow \) A finishes transmission at time \( t = 125 \mu\text{sec} \). Last bit from A arrives at B at time 137.5\mu s.

c) 12.5\mu sec + 5 \times 100\mu sec = 512.5\mu sec \rightarrow

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

\[ 408 + 100 + 4.5 = 512.5 \mu s \]