Solutions to Assignment 1 Questions

1) Problem P1, Chapter 1

a) We can have *n* connections between each of the four pairs of adjacent switches. This gives a maximum of *4n* connections.

b) We can *n* connections passing through the switch in the upper-right-hand corner and another *n* connections passing through the switch in the lower-left-hand corner, giving a total of *2n* connections.

2) Problem P5, Chapter 1

a) $d_{prop} = \frac{m}{s} \, seconds$

b) $d_{trans} = \frac{L}{R} \, seconds$

c) $d_{end-to-end} = \left(\frac{m}{s} + \frac{L}{R}\right) seconds$

d) The bit is just leaving Host A

e) The bit is in the link and has not reached Host B

f) The bit has reached Host B

g) Want $m = \frac{L}{R}S = \frac{100}{20 \times 10^3}(2.5 \times 10^8) = 893 \, km$

3) Problem P12, Chapter 1

a) The first end system requires L/R_1 to transmit the packet onto the first link; the packet propagates over the first link in d_1/s_1; the packet switch adds a processing delay of d_{proc}; after receiving the entire packet, the packet switch requires L/R_2 to transmit the packet onto the second link; the packet propagates over the second link in d_2/s_2. Adding these five delays gives

$$d_{end-to-end} = \frac{L}{R_1} + \frac{L}{R_2} + \frac{d_1}{s_1} + \frac{d_2}{s_2} + d_{proc}$$

b) To answer the second question, we simply plug the values into the equation to get 8 + 8 + 24 + 12 + 2 = 54 msec.

4) Problem P11, Chapter 1

a) The queuing delay is 0 for the first transmitted packet, *L/R* for the second transmitted packet, and generally, *(n-1)L/R* for the nth transmitted packet. Thus, the average delay for the *N* packets is

$$\frac{\frac{L}{R} + \frac{2L}{R} + \cdots + \frac{(N-1)L}{R}}{N} = \frac{L}{RN(1 + 2 + \cdots + (N-1))} = \frac{LN(N-1)}{2RN} = \frac{(N-1)L}{2R}$$

Note that here we used the well-known fact that

$$1 + 2 + \cdots + n = \frac{N(N+1)}{2}$$

5) Problem P24, Chapter 1

a)

1. Time to send message from source host to first packet switch $= \frac{8 \times 10^6}{2 \times 10^6} \sec = 4\ sec$

2. With store-and-forward switching, the total time to move message from source host to destination host $= 4 \sec \times 3\ hops = 12\ sec$

b)

1. Time to send 1st packet from source host to first packet switch $= \frac{2 \times 10^3}{2 \times 10^6} \sec = 1 msec$

2. Time at which 2nd packet is received at the first switch = time at which 1st packet is received at the second switch $= 2 \times 1\ msec = 2\ msec$

c) Time at which 1st packet is received at the destination host $= 1\ msec \times 3\ hops = 3\ msec$. After this, every 1 $msec$ one packet will be received; thus time at which last (4000th) packet is received $= 3\ msec + 3999 \times 1\ msec = 4.002\ sec$.