EE450: Solutions to HW #1

Problem 4

a) Between the switch in the upper left and the switch in the upper right we can have 4 connections. Similarly we can have four connections between each of the 3 other pairs of adjacent switches. Thus, this network can support up to 16 connections.

b) We can *4* connections passing through the switch in the upper-right-hand corner and another *4* connections passing through the switch in the lower-left-hand corner, giving a total of *8* connections.

c) Yes. For the connections between A and C, we route two connections through B and two connections through D. For the connections between B and D, we route two connections through A and two connections through C. In this manner, there are at most 4 connections passing through any link.

P5.

a. Total Distance/Propagation speed = 175/100 = 1hr 45min of propagation delay.

3*2 = 6 mins of transmission delay (2 mins per tollbooth for 10 cars, starting from the first

booth)

Total = 1 hour 51mins = 111 minutes

b. If 8 cars:

Propagation delay: same i.e., 1 hour 45 mins

Transmission delay: 12sec*8 cars = 96 second or 1.6mins

New total delay = 105 + 3(1.6) = 109.8 minutes

Problem 6

a) $d_{prop} = m / s$ seconds.

b) $d_{trans} = L / R$ seconds.

c) $d_{end\text{-}to\text{-}end} = (m / s + L / R)$ seconds.

d) The bit is just leaving Host A.

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

f) The first bit has reached Host B.

g) We want $m = \frac{L}{R} s = \frac{1500\times 8}{10\times 10^6}(2.5 \times 10^8) = 3 \times 10^5 = 300$ km.

Problem 7

Consider the first bit in a packet. Before this bit can be transmitted, all of the bits in the packet must be generated. This requires

$\frac{56 \cdot 8}{64 \times 10^3}$ sec=7msec.

The time required to transmit the packet is $\frac{\mathbf{56 \times 8}}{\mathbf{10 \times 10^6}}$ sec$=$ $\mathbf{44.8\mu}$ sec.

Propagation delay = 10 msec.
The delay until decoding is $\mathbf{7m + 44.8\mu + 10m = 17.0448m}$ sec.

A similar analysis shows that all bits experience a delay of 17.0448 msec.

Problem 10

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 connecting the first and the second link requires L/R_2 to transmit the packet onto the second link; the packet propagates over the second link in d_2/s_2. Similarly, we can find the delay caused by the second switch and the third link: L/R_3, d_{proc}, and d_3/s_3.
Adding these five delays gives

$$d_{end\text{-}end} = L/R_1 + L/R_2 + L/R_3 + d_1/s_1 + d_2/s_2 + d_3/s_3 + d_{proc} + d_{proc}$$

To answer the second question, we simply plug the values into the equation to get 4.8 + 4.8 + 4.8 + 20+16 + 4 + 3 + 3 = 60.4 msec.

Problem 12

The arriving packet must first wait for the link to transmit 4.5 *1,500 bytes = 6,750 bytes or 54,000 bits. Since these bits are transmitted at 2.5 Mbps, the queuing delay is 21.6 msec. Generally, the queuing delay is $(nL + (L - x))/R$.

Problem 20

Throughput = $min\{R_s, R_c, R/M\}$

Problem 21

If only use one path, the max throughput is given by:

$$\max\{\min\{R_1^1, R_2^1, ?, R_N^1\}, \min\{R_1^2, R_2^2, ?, R_N^2\}, ?, \min\{R_1^M, R_2^M, ?, R_N^M\}\}.$$

If use all paths, the max throughput is given by $\sum_{k=1}^{M} \min\{R_1^k, R_2^k, ?, R_N^k\}$.

Problem 25:

a. BW x Delay = (5M) (20,000) (1000)/(2.5X10^8) = 400,000 bits
b. Same as part "a"
c. The BW x delay product is the maximum number of bits that can be inserted onto the link (i.e., fill-in the pipe) in one direction.
d. The Bit length (This is measured in meters which is not the same as the bit duration which is measure in sec) = L/(BW x Delay) = (20X10^6)/(0.4X10^6) = 50 meters which is shorter than a football field which is 100 yards or approximately 92 meters.

Problem 28

a. The transfer delay = Transmission Time + Propagation delay = (800,000)/5M + 20,000,000/2.5x10^8 = 160 + 80 = 240 msec
b. Total delay = 20*(Transmission delay + 2*Propagation delay) = 20(40,000/5M + 2(80)) = 20(8+160) = 3.36 sec
c. Breaking up a file takes longer to transmit because each data packet and its corresponding acknowledgement packet add their own propagation delays.