EE450: Introduction to Computer Networks
Solutions to HW #1

Problem 4(10 points)

a) (3 points)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) (3 points)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) (4 points)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.

Problem 5(6 points)

Tollbooths are 75 km apart, and the cars propagate at 100km/hr. A tollbooth services a car at a rate of one car every 12 seconds.

a) (4 points)There are ten cars. It takes 120 seconds, or 2 minutes, for the first tollbooth to service the 10 cars. Each of these cars has a propagation delay of 45 minutes (travel 75 km) before arriving at the second tollbooth. Thus, all the cars are lined up before the second tollbooth after 47 minutes. The whole process repeats itself for traveling between the second and third tollbooths. It also takes 2 minutes for the third tollbooth to service the 10 cars. Thus the total delay is 96 minutes.

b) (2 points)Delay between tollbooths is 8*12 seconds plus 45 minutes, i.e., 46 minutes and 36 seconds. The total delay is twice this amount plus 8*12 seconds, i.e., 94 minutes and 48 seconds.

Problem 6(14 points)

a) (2 points) $d_{prop} = m / s$ seconds.

b) (2 points) $d_{trans} = L / R$ seconds.

c) (2 points) $d_{end-to-end} = (m / s + L / R)$ seconds.

d) (2 points)The bit is just leaving Host A.

e) (2 points)The first bit is in the link and has not reached Host B.

f) (2 points)The first bit has reached Host B.
g) (2 points)Want

$m = \frac{L}{R}s = \frac{120}{56 \times 10^3}\left(2.5 \times 10^8\right) = 536$ km.

Problem 7(11 points)

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. (4 points)

The time required to transmit the packet is

$\frac{56 \cdot 8}{2 \times 10^6}$ sec= 224μ sec. (4 points)

Propagation delay = 10 msec.
The delay until decoding is

7msec $+ 224\mu$ sec + 10msec = 17.224msec (3 points)

A similar analysis shows that all bits experience a delay of 17.224 msec.

Problem 12(8 points)

(4 points)The arriving packet must first wait for the link to transmit 4.5 *1,500 bytes = 6,750 bytes or 54,000 bits.

(4 points)Since these bits are transmitted at 2 Mbps, the queuing delay is 27 msec. Generally, the queuing delay is (*nL* + (*L* - *x*))/*R*.

Problem 25(17 points)

a) (4 points)

$$R = 2Mbps$$

$$d_{prop} = \frac{Length\ of\ the\ link}{Propagation\ Speed} = \frac{20 * 10^6}{2.5 * 10^8} = 80ms$$

$$R.d_{prop} = 2 * 10^6 \ \ * 80 * 10^{-3} = 160{,}000\ bits$$

b) (4 points)

$$Maximum\ number\ of\ bits\ on\ the\ link\ at\ any\ given\ time$$
$$= Mininmum(R.dprop, file\ size) = Minimim(160000\ ,\ 800000)$$
$$= 160\ 000\ bits$$

c) (2 points)
The bandwidth-delay product of a link is the maximum number of bits that can be in the link.

d) (3 points)

$$Width\ \ of\ the\ bit = \frac{Length\ of\ the\ link}{Bandwidth\_Delay\ Product} = 125\ meters$$

125 meters is longer than a football field

e) (4 points) s/R

Problem 27(11 points)

a) (4 points)

$$R = 1Gbps$$

$$d_{prop} = \frac{Length\ of\ the\ Link}{Propagation\ Speed} = \frac{20 *\ 10^6}{2.5 * 10^8} = 80ms$$

$$R.d_{prop} = 1 * 10^9 \ \ * 80 * 10^{-3} = 80{,}000{,}000\ bits$$

b) (4 points)

$$Maximum\ number\ of\ bits\ on\ the\ link\ at\ any\ given\ time$$
$$= Mininmum(R.dprop, file\ size) = Minimim(80\ 000\ 000\ ,\ 800\ 000)$$
$$= \mathbf{800\ 000}\ bits$$

c) (3 points)

$$Width\ \ of\ the\ bit = \frac{Length\ of\ the\ link}{Bandwidth\_Delay\ Product} = \frac{20 * 10^6}{80{,}000{,}000} = .25\ meters$$

Problem 28(11 points)

a) (4 points)

$$t_{trans} = \frac{Length\ of\ the\ packet}{Transmission\ Rate} = \frac{800000}{2 * 10^6} = 400ms$$

$$t_{prop} = \frac{Length\ of\ the\ Link}{Propagation\ Speed} = \frac{20 * 10^6}{2.5 * 10^8} = 80ms$$

$$Total\ delay = t_{trans} + t_{prop} = 400ms + 80ms = 480ms$$

b) (5 points) 20 * (t_{trans} + 2 t_{prop}) = 20*(20 msec + 2*80 msec) = 3.6 sec.

c) (2 points) Breaking up a file takes longer to transmit because each data packet and its corresponding acknowledgement packet add their own propagation delays.

Problem 29(12 points)

Recall geostationary satellite is 36,000 kilometers away from earth surface.

a) (4 points)

$$t_{prop} = \frac{Total\ Distance}{Propagation\ Speed} = \frac{36 * 10^6}{2.4 * 10^8} = 150ms$$

b) (4 points)

$$R.d_{prop} = 10 * 10^6 * 150 * 10^{-3} = 1{,}500{,}000\ bits$$

c) (4 points) The photo size should be large enough such that the satellite will keep transmitting for the entire minute. Since the transmitter is able to send 10 Mbits every second, the in one minute it can send 60* 10Mbits = 600,000,000 bits. So the photo size should be 600,000,000 bits to have a continuous transmission