P5. a. Propagation speed = 100 km/hr

Total distance = 150 km

Transmission delay = 12 s x 10 cars = 120 s = 2 mins x 3 tollbooths = 6 mins / 60 mins = .1 hr

Propagation delay = total distance / propagation speed = 150 km / 100 km/hr = 1.5 hr

End-to-end delay = transmission delay + propagation delay = .1 hr + 1.5 hr = 1.6 hr

b. Transmission delay = 12 s x 8 cars = 96 s = 1.6 mins x 3 tollbooths = 4.8 mins = .08 hr

End-to-end delay = transmission delay + propagation delay = .08 hr + 1.5 hr = 1.58 hr

P6. a. dprop = d/s, where d = distance, but in this case (m), and s = propagation speed. Therefore, dprop = m/s .

b. dtrans = packet size / bit rate, where packet size = L and bit rate = R. Therefore, dtrans = L/R.

c. end-to-end delay = dprop + dtrans = m/s + L/R.

d. dtrans is the time taken by the host to push out the packet. So, if t = dtrans, then that means that at that time t, the last bit of the packet has just been pushed out or transmitted.

e. At t = dtrans, the first bit of the packet has already been pushed out but since dprop > dtrans, meaning that it takes longer for the packet to travel between hosts than it takes for Host A to push out the entire packet, the first bit of the packet has not reached Host B.

f. At t = dtrans, the first bit of the packet has already been pushed out but since dprop < dtrans, meaning that it takes longer for Host A to push out the entire packet then it takes for the packet to travel between hosts, the first bit of the packet has already reached Host B.

g. Since dprop = dtrans, then . So . After substituting, we get m.

P7. Host A converts analog signal to digital bit stream = 64 kbps = 64 x 103 pbs. The size of the packet of bits = 56 bytes = 56 x 8 bits. The transmission rate = 2 mbps = 2 x 106 bps. The propagation delay = 10 msec = .010 sec.

Time required to generate all bits in packet = = .007 sec

Transmission delay = L/R = = .000224 sec

Total time elapsed = .007 + .000224 + .010 = .017224 sec.

P10. = .006 sec

= .02 sec

= .006 sec

= .016 sec

= .006 sec

= .004 sec

End-to-end delay = .006 + .02 + .006 + .016 + .006 + .004 + .003 + .003 = .064 sec

P20. Rs = server link rate

Rc = client link rate

R = network link rate

M = client-server pair

Throughput = min{Rs, Rc, R/M}

P31. a. Time to send file from source to first packet switch = = 4 sec.

Total time to send file from source to destination = 4 sec x 3 stops = 12 sec.

b. Time to send first packet to first packet switch = = .005 sec.

When first packet is being is fully received at 2nd packet switch, second packet is being fully received at 1st packet switch which would be at .005 sec x 2 = .010 sec.

c. Total time taken when message segmentation is being used is .015 for first packet to go all the way, then .005 for every packet afterwards, or 799 packets. Therefore, total time = .015 sec + 799 packets x .005 sec = 4.01 sec. Using message segmentation is significantly faster (1/3 of the time without message segmentation).