Review Minggu ke-2a

1. Consider sending a packet from a source host to a destination host over a fixed route. List the delay components in the end-to-end delay. Which of these delays are constant and which are variable?

2. A user can directly connect to a server through either long-range wireless or a twisted-pair cable for transmitting 1500 bytes file. The transmission rates of the wireless and wired media are 2 and 100 Mbps, respectively. Assume that the propagation speed in air 3 x 10^8 m/s, while the speed in the twisted pair is 2 x 10^8 m/s. If the user is located 1 km away from the server, what is the nodal delay when using each of the two technologies?

3. How long does it take to **transmit** a packet of length 1,000 bytes a link of distance 5,000 km, propagation speed 2.5x10^8 m/s and transmission rate 1 Mbps? Generally, how long does it take to transmit a packet of length L over a link of distance d, propagation speed s, and transmission rate R bps? Does this delay depend on the length of the link? Does this delay depend on the propagation speed of the link?

4. How long does it take a packet of length 1,000 bytes to **propagate** over a link of distance 2,500 km, propagation speed 2.5 · 10^8 m/s, and transmission rate 2 Mbps? More generally, how long does it take a packet of length L to propagate over a link of distance d, propagation speed s, and transmission rate R bps? Does this delay depend on packet length? Does this delay depend on transmission rate?

5. Consider two packet switches directly connected by a link of 5000 km, propagation speed 2.5x10^8m/s and transmission rate 1 Mbps. How long does it take to move a packet of length 1,000 bytes from one packet switch to the other packet switch? Generally, how long does it take to move a packet of length L over a link of distance d, propagation speed s, and transmission rate R bps?

6. Consider a packet of length L which begins at end system A, travels over one link to a packet switch, and travels from the packet switch over a second link to a destination end system B. Let d_i, s_i and R_i denote the length, propagation speed, and transmission rate of link i, for i = 1, 2. The packet switch delays each packet by d_{proc}. Assuming no queuing delays, in terms of d_i, s_i , R_i, (i=1,2) and L, what is the total end-to-end delay for the packet? Suppose the packet is 1,000 bytes, the propagation speed on both links is 2.5x10^8 m/s, the transmission rates of both links is 1 Mbps, the packet switch processing delay is 1 msec, the length of the first link is 4,000 km, and the length of the last link is 1,000 km. For these values, what is the end-to-end delay?

7. A packet switch receives a packet and determines the outbound link to which the packet should be forwarded. At packet arrival, one other packet is half transmitted on this outbound link and three other packets are waiting to be transmitted. Packets are transmitted in order of arrival. Suppose all packets are 1,000 bytes and the link rate is 1 Mbps. What is the queuing delay for the packet? Generally, what is the queuing delay when all packets have length L bits, the transmission rate is R, x bits of the currently transmitted packet have been transmitted, and N packets are already in the queue?

8. Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates R1 = 500 kbps, R2 = 2 Mbps, and R3 = 1 Mbps.
   a) Assuming no other traffic in the network, what is the throughput for the file transfer?
   b) Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?

9. Suppose end system A wants to send a large file to end system B. At a very high level, describe how end system A creates packets from the file. When one of these packets arrives to a packet switch, what information in the packet does the switch use to determine the link onto which the packet is forwarded? Why is packet switching in the Internet analogous to driving from one city to another and asking directions along the way?

10. Consider the scenario shown below, with four different servers connected to four different clients over four three-hop paths. The four pairs share a common middle hop with a transmission capacity of R = 200 Mbps. The four links from the servers to the shared link have a transmission capacity of R_S = 60 Mbps. Each of the four links from the shared middle link to a client has a transmission capacity of R_C = 90 Mbps per second. You might want to review the figure below before answering the following questions:
    1. What is the maximum achievable end-end throughput (in Mbps) for each of four client-to-server pairs, assuming that the middle link is fair-shared (i.e., divides its transmission rate equally among the four pairs)?
    2. Which link is the bottleneck link for each session?
    3. Assuming that the senders are sending at the maximum rate possible, what are the link utilizations for the sender links (R_S), client links (R_C), and the middle link (R)?