ECE 358: Problem Set 1

Problem 1. Consider two hosts A and B separated by 2 nodes (switches or routers), A wants to send a file of size M = 15 Mbits over to B. Each link has the same data rate C = 1.5 Mb/s.

a) Assume message switching, how long would it take for the whole file to be received by B? Explain your assumptions. Comment. Write first the formula giving the time in terms of C, M, and possibly other parameters.
b) Assume packet switching and that all packets have the same size L=1500 bits, how long would it take for the whole file to be received by B? Explain your assumptions. Write first the formula giving the time in terms of C, M, and possibly other parameters. Comment and compare.

Problem 3 In the following 6 questions, we are sending a 30 Mbit MP3 file from a source host to a destination host. All links in the path between source and destination have a transmission rate of 10 Mbps. Assume that the propagation speed is $2 * 10^8$ meters/sec, and the distance between source and destination is 10,000 km.

1) Initially suppose there is only one link between source and destination. Also suppose that message switching is used, with the message consisting of the entire MP3 file. The transmission delay is:

a) 50 milliseconds
b) 3 seconds
c) 3.05 seconds
d) none of the above.

2) Referring to the above question, the end-to-end delay (transmission delay plus propagation delay) is

a) 6 seconds
b) 3.05 seconds
c) 3 seconds
d) none of the above

3) Referring to the above question, how many bits will the source have transmitted when the first bit arrives at the destination?

a) 50,000 bits
b) 1 bit
c) 30,000,000 bits
d) none of the above

4) Now suppose there are two links between source and destination, with one router connecting the two links. Each link is 5,000 km long. Again suppose the MP3 file is sent as one message. Suppose there is no congestion, so that the message is transmitted onto the second link as soon as the router receives the entire message. The end-to-end delay is

a) 6.05 seconds
b) 6.1 seconds
c) 3.05 seconds

d) none of the above

5) Now suppose that the MP3 file is broken into 3 packets, each of 10 Mbits. Ignore headers that may be added to these packets. Also ignore router processing delays. Assuming store and forward packet switching at the router, the total delay is

a) 3.05 seconds
b) 4.05 seconds
c) 6.05 seconds
d) none of the above

6) Now suppose there is only one link between source and destination, and there are 10 FDM channels in the link. The MP3 file is sent over one of the channels. The end-to-end delay is

a) 30.05 seconds
b) 30 seconds
c) 300 microseconds
d) none of the above

Problem 4. Consider two hosts, Hosts A and B, connected by a single link of rate R bps. Suppose that the two hosts are separated by m meters, and suppose the propagation speed along the link is *s* meters/sec. Host A is to send a packet of size L bits to Host B.

a. Express the propagation delay, d_{prop} in terms of m and *s.*
b. Determine the transmission time of the packet, d_{trans} in terms of L and R.
c. Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.
d. Suppose Host A begins to transmit the packet at time t = 0. At time t = d_{trans}, where is **the** last bit of the packet?
e. Suppose d_{prop} is greater than d_{trans}. At time t = d_{trans}, where is the first bit of the packet?
f. Suppose d_{prop} is less than d_{trans}. At time t = d_{trans}, where is the first bit of the packet?
g. Suppose s = 2.5 10^8, L = 1000 bits, and R = 284 kbps. Find the distance m so that d_{prop} equals d_{trans}.

Problem 6*: 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. Try the following 3 cases: a “fluid” (water-like) case, a message switching case and a packet switching case.
b. Suppose the file is 4 million bytes. Roughly, how long will it take to transfer the file to Host B for each of these 3 cases?

The following problems were taken from an earlier version of the textbook.

P6: In this problem we consider sending real-time voice from Host A to Host B over a packet-switched network (VoIP). Host A converts analog voice to a digital 64 kbps bit stream on the fly. Host A then groups the bits into 48-byte packets. There is one link between Host A and B; its transmission rate is 1 Mbps and its propagation delay is 2 msec. As soon as Host A gathers a packet, it sends it to Host B. As soon as Host B receives an entire packet, it converts the packet's bits to an analog signal. How much time elapses from the time a bit is created (from the original analog signal at Host A) until the bit is decoded (as part of the analog signal at Host B)?

P8: Consider the discussion in Section 1.3 of statistical multiplexing in which an example is provided with a 1 Mbps link. Users are generating data at a rate of 100 kbps when busy, but are busy generating data only with probability p = 0.1. Suppose that the 1 Mbps link is replaced by a 1 Gbps link.
a. What is N, the maximum number of users that can be supported simultaneously under circuit switching?
b. Now consider packet switching and a user population of M users. Give a formula (in terms of p, M, N) for the probability that more than N users are sending data.

P9: 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. Let d_i, s_i and R_i denote the length, propagation speed, and the transmission rate of link i, for i=l ,2. The packet switch delays each packet by d_{proc}. Assuming no queuing delays, in terms of d_i, s_i and R_i (i=1,2), and L, what is the total end-to-end delay for the packet? Suppose now the packet is 1,000 bytes, the propagation speed on both links is 2.5 10^8 ms, the transmission rates of both links is 1 Mbps, the packet length is 1,000 bytes, 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?

P18: Suppose two hosts, A and B, are separated by 10,000 kilometers and are connected by a direct link of R = 1 Mbps. Suppose the propagation speed over the link is 2.5 10^8 meters/sec.
a. Calculate the bandwidth-delay product, $R.d_{prop}$
b. Consider sending a file of 400,000 bits from Host A to Host B. Suppose the file is sent continuously as one large message. What is the maximum number of bits that will be in the link at any given time?
c. Provide an interpretation of the bandwidth-delay product.
d. What is the width (in meters) of a bit in the link? Is it longer than a football field?
e. Derive a general expression for the width of a bit in terms of the propagation speed *s*, the transmission rate *R*, and the length of the link *m*.

P19: Referring to problem P18, suppose we can modify R. For what value of R is the width of a bit as long as the length of the link?

P21: Refer again to problem P18.
a. How long does it take to send the file, assuming it is sent continuously?
b. Suppose now the file is broken up into 10 packets with each packet containing 40,000 bits. Suppose that each packet is acknowledged by the receiver and the transmission time of an acknowledgment packet is negligible. Finally, assume that the sender cannot send a packet until the preceding one is acknowledged. How long does it take to send the file?
c. Compare the results from (a) and (b).

P24: In modern packet-switched networks, the source host segments long, application-layer messages (for example, an image or a music tile) into smaller packets and sends the packets into the network. The receiver then reassembles the packets back into the original message. We refer to this process as message segmentation. Figure 1.24 illustrates the end-to-end transport of a message with and without message segmentation. Consider a message that is $7.5 \cdot 10^6$ bits long that is to be sent from source to destination in Figure 1.24. Suppose each link in the figure is 1.5 Mbps. Ignore propagation, queuing, and processing delays.

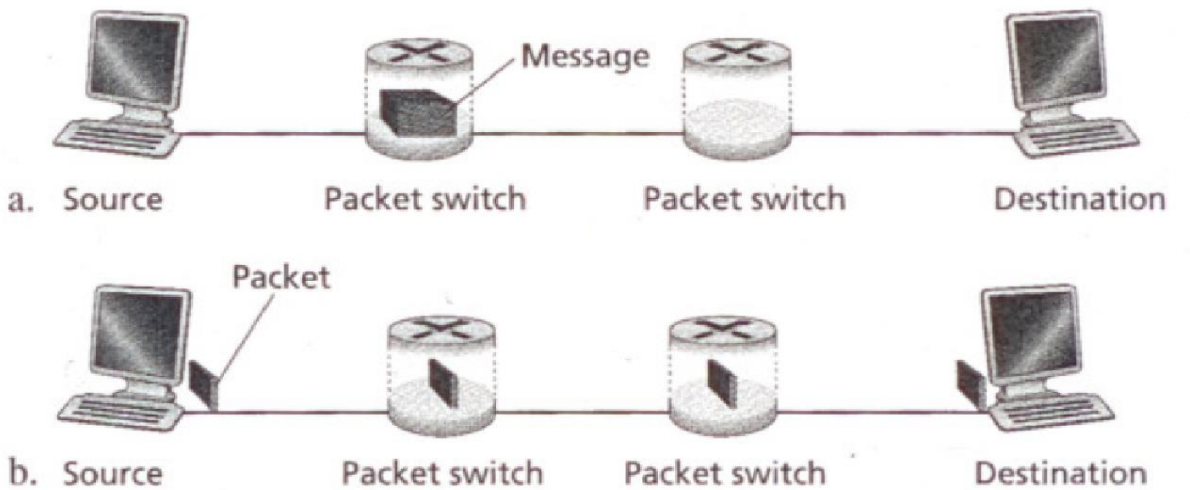

Figure 1.24 ♦ End-to-end message transport: (a) without message segmentation; (b) with message segmentation.

a. Consider sending the message from source to destination without message segmentation. How long does it take to move the message from the source host to the first packet switch? Keeping in mind that each switch uses store-and-forward packet switching, what is the total time to move the message from source host to destination host?

b. Now suppose that the message is segmented into 5,000 packets, with each packet being 1,500 bits long. How long does it take to move the first packet from source host to the first switch? When the first packet is being sent from the first switch to the second switch, the second packet is being sent from the source host to the first switch. At what time will the second packet be fully received at the first switch?

c. How long does it take to move the file from source host to destination host when message segmentation is used? Compare this result with your answer in part (a) and comment.

d. Discuss the drawbacks of message segmentation.