| **COMPUTER SCIENCE**

CS6330/CS4330: COMPUTER NETWORKS
ASSIGNMENT 1

P2. **Equation 1.1** gives a formula for the end-to-end delay of sending one packet of length *L* over *N* links of transmission rate *R*. Generalize this formula for sending *P* such packets back-to-back over the *N* links.

P6. This elementary problem begins to explore propagation delay and transmission delay, two central concepts in data networking. Consider two 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 $t = d_{\mathrm{trans}}$, where is the first bit of the packet?
f. Suppose d_{prop} is less than d_{trans}. At time $t = d_{\mathrm{trans}}$, where is the first bit of the packet?
g. Suppose $s = 2.5 \cdot 10^8$, $L = 120\ \mathrm{bits}$, and $R = 56\,\mathrm{kbps}$. Find the distance *m* so that d_{prop} equals d_{trans}.

P8. Suppose users share a 3 Mbps link. Also suppose each user requires 150 kbps when transmitting, but each user transmits only 10 percent of the time. (See the discussion of packet switching versus circuit switching in **Section 1.3**.)

a. When circuit switching is used, how many users can be supported?
b. For the remainder of this problem, suppose packet switching is used. Find the probability that a given user is transmitting.

P10. Consider a packet of length *L* that begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches. Let d_i, s_i, and R_i denote the length, propagation speed, and the transmission rate of link *i*, for $i = 1, 2, 3$. The packet switch delays each packet by d_{proc}. Assuming no queuing delays, in terms of d_i, s_i, R_i, $(i = 1, 2, 3)$, and *L*, what is the total end-to-end delay for the packet? Suppose now the packet is 1,500 bytes, the propagation speed on all three links is $2.5 \cdot 10^8 \mathrm{m/s}$, the transmission rates of all three links are 2 Mbps, the packet switch processing delay is 3 msec, the length of the first link is 5,000 km, the length of the second 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?

P11. In the above problem, suppose $R_1 = R_2 = R_3 = R$ and $d_{\mathrm{proc}} = 0$. Further suppose the packet switch does not store-and-forward packets but instead immediately transmits each bit it receives before waiting for the entire packet to arrive. What is the end-to-end delay?

P13.

a. Suppose *N* packets arrive simultaneously to a link at which no packets are currently being transmitted or queued. Each packet is of length *L* and the link has transmission rate *R*. What is the average queuing delay for the *N* packets?

P20. Consider the throughput example corresponding to **Figure 1.20(b)**. Now suppose that there are *M* client-server pairs rather than 10. Denote R_s, R_c, and *R* for the rates of the server links, client links, and network link. Assume all other links have abundant capacity and that there is no other traffic in the network besides the traffic generated by the *M* client-server pairs. Derive a general expression for throughput in terms of R_s, R_c, *R*, and *M*.

P31. In modern packet-switched networks, including the Internet, the source host segments long, application-layer messages (for example, an image or a music file) 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 1.27** illustrates the end-to-end transport of a message with and without message segmentation. Consider a message that is $8 \cdot 10^6$ bits long that is to be sent from source to destination in **Figure 1.27**. Suppose each link in the figure is 2 Mbps. Ignore propagation, queuing, and processing delays.

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 800 packets, with each packet being 10,000 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. In addition to reducing delay, what are reasons to use message segmentation?
e. Discuss the drawbacks of message segmentation.

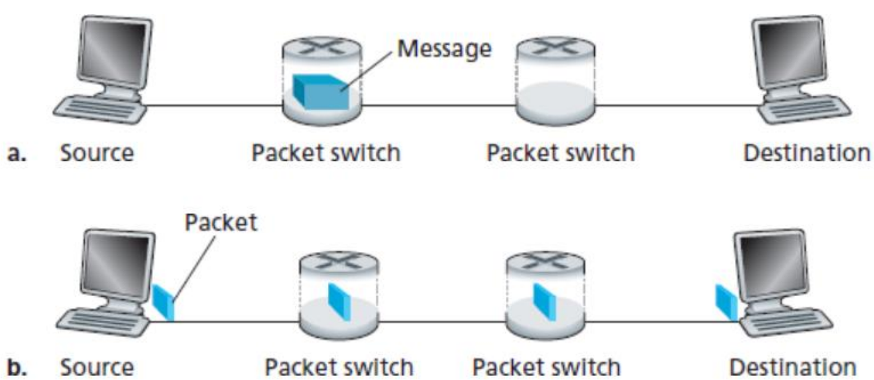

Figure 1.27 End-to-end message transport: (a) without message segmentation; (b) with message segmentation

WIRESHARK LAB 1: GETTING STARTED

The lab has been uploaded to the Canvas system under the Wireshark Labs section. You are required to:

1. **submit** screenshots of your work
2. **answer** the questions in the lab document.