Network Architecture and Protocols I

Problem 1

Consider sending a packet of F bits over a path of Q links. Each link transmits at R bps. The network is lightly loaded so that there are no queuing delays. Propagation delay is negligible.

a. Suppose the network is a packet-switched virtual-circuit network. Denote the VC setup time by t_s seconds. Suppose the sending layers add a total of h bits of header to the packet. How long does it take to send the file from source to destination?

b. Suppose the network is a packet-switched datagram network and a connectionless service is used. Now suppose each packet has $2h$ bits of header. How long does it take to send the packet?

c. Finally, suppose that the network is a circuit-switched network. Further suppose that the transmission rate of the circuit between source and destination is R bps. Assuming t_s setup time and h bits of header appended to the packet, how long does it take to send the packet?

Problem 2

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 $t = d_{trans}$, 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 $s = 2.5 \cdot 10^8$, $L = 100$ bits, and $R = 28$ kbps. Find the distance m so that d_{prop} equals d_{trans}.

Problem 3

Perform a Traceroute between source and destination on the same continent at three different hours of the day.

a. Find the average and standard deviation of the round-trip delays at each of the three hours.

b. Find the number of routers in the path at each of the three hours. Did the paths change during any of the hours?

c. Try to identify the number of ISP networks that the Traceroute packets pass through from source to destination. Routers with similar names and/or similar IP addresses should be considered as part of the same ISP. In your experiments, do the largest delays occur at the peering interfaces between adjacent ISPs?

d. Repeat the above for a source and destination on different continents. Compare the intracontinent and intercontinent results.

Problem 4

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 $2.5 \cdot 10^8$ meters/sec.

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).

Problem 5

In modern packet-switched networks, 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 1.21 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 1.21. Suppose each link in the figure is 1.5 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 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 second 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.

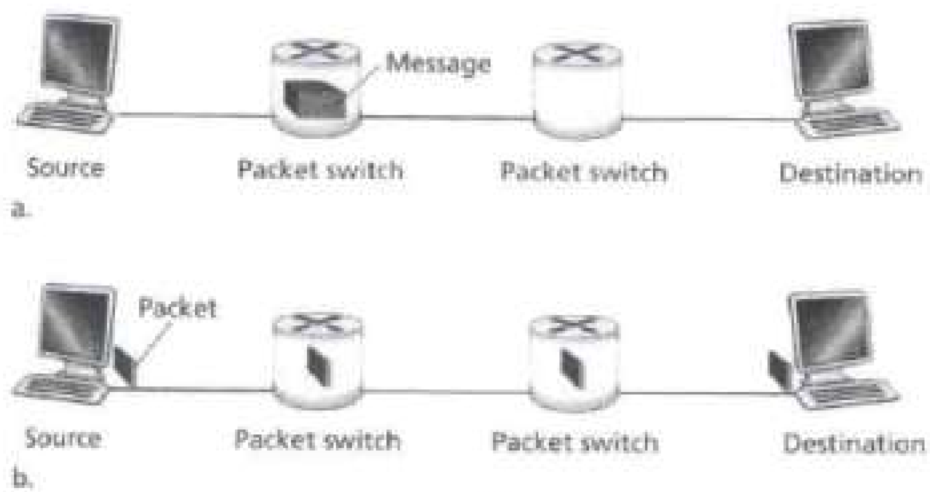

Figure 1.21 ♦ End-to-end message transport: (a) without message segmentation; (b) with message segmentation.