

第一章作业

第一题:

P3. Consider an application that transmits data at a steady rate (for example, the sender generates an N -bit unit of data every k time units, where k is small and fixed). Also, when such an application starts, it will continue running for a relatively long period of time. Answer the following questions, briefly justifying your answer:

- Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why?
- Suppose that a packet-switched network is used and the only traffic in this network comes from such applications as described above. Furthermore, assume that the sum of the application data rates is less than the capacities of each and every link. Is some form of congestion control needed? Why?

第二题:

P4. Consider the circuit-switched network in [Figure 1.13](#). Recall that there are 4 circuits on each link. Label the four switches A, B, C, and D, going in the clockwise direction.

- What is the maximum number of simultaneous connections that can be in progress at any one time in this network?
- Suppose that all connections are between switches A and C. What is the maximum number of simultaneous connections that can be in progress?
- Suppose we want to make four connections between switches A and C, and another four connections between switches B and D. Can we route these calls through the four links to accommodate all eight connections?

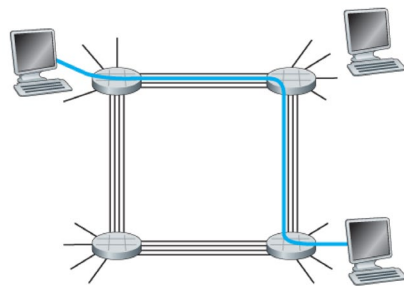


Figure 1.13 A simple circuit-switched network consisting of four switches and four links

第三题:

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.

- Express the propagation delay, d_{prop} , in terms of m and s .
- Determine the transmission time of the packet, d_{trans} , in terms of L and R .
- Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.
- Suppose Host A begins to transmit the packet at time $t=0$. At time $t=d_{\text{trans}}$, where is the last bit of the packet?
- Suppose d_{prop} is greater than d_{trans} . At time $t=d_{\text{trans}}$, where is the first bit of the packet?
- Suppose d_{prop} is less than d_{trans} . At time $t=d_{\text{trans}}$, where is the first bit of the packet?
- Suppose $s=2.5 \cdot 10^8$, $L=120$ bits, and $R=56$ kbps. Find the distance m so that d_{prop} equals d_{trans} .

第四题:

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 $2.5 \cdot 10^8$ 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?

第五题:

P12. A packet switch receives a packet and determines the outbound link to which the packet should be forwarded. When the packet arrives, one other packet is halfway done being transmitted on this outbound link and four other packets are waiting to be transmitted. Packets are transmitted in order of arrival. Suppose all packets are 1,500 bytes and the link rate is 2 Mbps. What is the queuing delay for the packet? More generally, what is the queuing delay when all packets have length L , the transmission rate is R , x bits of the currently-being-transmitted packet have been transmitted, and n packets are already in the queue?

P13.

- 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?
- Now suppose that N such packets arrive to the link every LN/R seconds. What is the average queuing delay of a packet?

第六题:

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 .

P21. Consider [Figure 1.19\(b\)](#). Now suppose that there are M paths between the server and the client. No two paths share any link. Path k ($k=1, \dots, M$) consists of N links with transmission rates $R_{1k}, R_{2k}, \dots, R_{Nk}$. If the server can only use one path to send data to the client, what is the maximum throughput that the server can achieve? If the server can use all M paths to send data, what is the maximum throughput that the server can achieve?

第七题:

P24. Suppose you would like to urgently deliver 40 terabytes data from Boston to Los Angeles. You have available a 100 Mbps dedicated link for data transfer. Would you prefer to transmit the data via this link or instead use FedEx over-night delivery? Explain.

P25. Suppose two hosts, A and B, are separated by 20,000 kilometers and are connected by a direct link of $R=2$ Mbps. Suppose the propagation speed over the link is $2.5 \cdot 10^8$ meters/sec.

- Calculate the bandwidth-delay product, $R \cdot d_{prop}$.

- b. Consider sending a file of 800,000 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 .

第八题:

P30. Consider the airline travel analogy in our discussion of layering in [Section 1.5](#), and the addition of headers to protocol data units as they flow down the protocol stack. Is there an equivalent notion of header information that is added to passengers and baggage as they move down the airline protocol stack?

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.

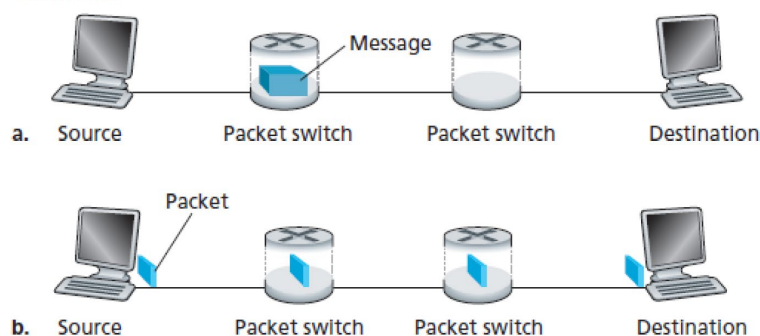


Figure 1.27 End-to-end message transport: (a) without message segmentation; (b) with message segmentation

第九题:

P33. Consider sending a large file of F bits from Host A to Host B. There are three links (and two switches) between A and B, and the links are uncongested (that is, no queuing delays). Host A segments the file into segments of S bits each and adds 80 bits of header to each segment, forming packets of $L = 80 + S$ bits. Each link has a transmission rate of R bps. Find the value of S that minimizes the delay of moving the file from Host A to Host B. Disregard propagation delay.