# Chap 1.

## Review Questions

- The word protocol is often used to describe diplomatic relations. Give an example of a diplomatic protocol.

- What advantage does a circuit-switched network have over a packet-switched network? What advantages does TDM have over FDM in a circuit-switched network?

- 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?

## Problems

- I-1. 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:
  A. Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why?
  B. 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?

- I-2. Review the car-caravan analogy in Section 1.4. Assume a propagation speed of 100 km/hour.
  A. Suppose the caravan travels 200 km, beginning in front of one tollbooth, passing through a second tollbooth, and finishing just before a third tollbooth. What is the end-to-end delay?
  B. Repeat (a), now assuming that there are seven cars in the caravan instead of ten.

- I-3. 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.

- I-4. 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)?

- I-5. 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. Calculate the bandwidth-delay product, $R \cdot d_{prop}$.
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.

# Chap 2.

## Review Questions

- For a P2P file-sharing application, do you agree with the statement, "There is no notion of client and server sides of a communication session?" Why or why not?

- Describe how Web caching can reduce the delay in receiving a requested object. Will Web caching reduce the delay for all objects requested by a user or for only some of the objects? Why?

- Why is it said that FTP sends control information "out-of-band"?

- Why do HTTP, FTP, SMTP, and POP3 run on top of TCP rather than on UDP?

## Problems

- II-1. Suppose within your Web browser you click on a link to obtain a Web page. The IP

address for the associated URL is not cached in your local host, so a DNS lookup is necessary to obtain the IP address. Suppose that n DNS servers are visited before your host receives the IP address from DNS; the successive visits incur an RTT of $RTT_1$ ..., $RTTI_n$. Further suppose that the Web page associated with the link contains exactly one object, consisting of a small amount of HTML text. Let RTT0 denote the RTT between the local host and the server containing the object. Assuming zero transmission time of the object, how much time elapses from when the client clicks on the link until the client receives the object?