

CSCE 416: Homework 1

Chapter 1

R1. What is the difference between a host and an end system? List several different types of end systems. Is a Web server an end system?

R13. Suppose users share a 2 Mbps link. Also suppose each user transmits continuously at 1 Mbps when transmitting, but each user transmits only 20 percent of the time. (See the discussion of statistical multiplexing in Section 1.3.)

- When circuit switching is used, how many users can be supported?
- For the remainder of this problem, suppose packet switching is used. Why will there be essentially no queuing delay before the link if two or fewer users transmit at the same time? Why will there be a queuing delay if three users transmit at the same time?
- Find the probability that a given user is transmitting.
- Suppose now there are three users. Find the probability that at any given time, all three users are transmitting simultaneously. Find the fraction of time during which the queue grows.

R16. 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?

R18. How long does it take a packet of length 1,000 bytes to propagate over a link of distance 2,500 km, propagation speed $2.5 \cdot 10^8$ m/s, and transmission rate 2 Mbps? More generally, how long does it take a packet of length L to propagate over a link of distance d , propagation speed s , and transmission rate R bps? Does this delay depend on packet length? Does this delay depend on transmission rate?

R19. 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 $R_1 = 500$ kbps, $R_2 = 2$ Mbps, and $R_3 = 1$ Mbps.

- Assuming no other traffic in the network, what is the throughput for the file transfer?
- Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?
- Repeat (a) and (b), but now with R_2 reduced to 100 kbps.

R23. What are the five layers in the Internet protocol stack? What are the principal responsibilities of each of these layers?

R25. Which layers in the Internet protocol stack does a router process? Which layers does a link-layer switch process? Which layers does a host process?

P5. Review the car-caravan analogy in Section 1.4. Assume a propagation speed of 100 km/hour.

- a. Suppose the caravan travels 150 km, beginning in front of one tollbooth, passing through a second tollbooth, and finishing just after a third tollbooth. What is the end-to-end delay?
- b. Repeat (a), now assuming that there are eight cars in the caravan instead of ten.

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 $t = d_{\text{trans}}$, where is the last bit of the packet?
- e. Suppose d_{prop} is greater than d_{trans} . At time $t = d_{\text{trans}}$, where is the first bit of the packet?
- f. Suppose d_{prop} is less than d_{trans} . At time $t = d_{\text{trans}}$, where is the first bit of the packet?
- g. 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} .

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.
- c. Suppose there are 120 users. Find the probability that at any given time, exactly n users are transmitting simultaneously. (Hint : Use the binomial distribution.)
- d. Find the probability that there are 21 or more users transmitting simultaneously.

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 overnight 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 2.5×10^8 meters/sec.
- Calculate the bandwidth-delay product, $R \cdot d_{\text{prop}}$.
 - 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?
 - Provide an interpretation of the bandwidth-delay product.
 - What is the width (in meters) of a bit in the link? Is it longer than a football field?
 - 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 .

Chapter 2

- R3. For a communication session between a pair of processes, which process is the client and which is the server?
- R5. What information is used by a process running on one host to identify a process running on another host?
- R6. Suppose you wanted to do a transaction from a remote client to a server as fast as possible. Would you use UDP or TCP? Why?
- R11. Why do HTTP, FTP, SMTP, and POP3 run on top of TCP rather than on UDP?
- R13. 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?
- R19. Is it possible for an organization's Web server and mail server to have exactly the same alias for a hostname (for example, `foo.com`)? What would be the type for the RR that contains the hostname of the mail server?
- R21. In BitTorrent, suppose Alice provides chunks to Bob throughout a 30-second interval. Will Bob necessarily return the favor and provide chunks to Alice in this same interval? Why or why not?
- R22. Consider a new peer Alice that joins BitTorrent without possessing any chunks. Without any chunks, she cannot become a top-four uploader for any of the other peers, since she has nothing to upload. How then will Alice get her first chunk?
- R23. What is an overlay network? Does it include routers? What are the edges in the overlay network?
- R26. In Section 2.7, the UDP server described needed only one socket, whereas the

TCP server needed two sockets. Why? If the TCP server were to support n simultaneous connections, each from a different client host, how many sockets would the TCP server need?

R27. For the client-server application over TCP described in Section 2.7, why must the server program be executed before the client program? For the client-server application over UDP, why may the client program be executed before the server program?

P1. True or false?

- a. A user requests a Web page that consists of some text and three images. For this page, the client will send one request message and receive four response messages.
- b. Two distinct Web pages (for example, www.mit.edu/research.html and www.mit.edu/students.html) can be sent over the same persistent connection.
- c. With nonpersistent connections between browser and origin server, it is possible for a single TCP segment to carry two distinct HTTP request messages.
- d. The Date: header in the HTTP response message indicates when the object in the response was last modified.
- e. HTTP response messages never have an empty message body.

P8. Referring to Problem P7, suppose the HTML file references eight very small objects on the same server. Neglecting transmission times, how much time elapses with

- a. Non-persistent HTTP with no parallel TCP connections?
- b. Non-persistent HTTP with the browser configured for 5 parallel connections?
- c. Persistent HTTP?

P25. Consider an overlay network with N active peers, with each pair of peers having an active TCP connection. Additionally, suppose that the TCP connections pass through a total of M routers. How many nodes and edges are there in the corresponding overlay network?

P26. Suppose Bob joins a BitTorrent torrent, but he does not want to upload any data to any other peers (so called free-riding).

- a. Bob claims that he can receive a complete copy of the file that is shared by the swarm. Is Bob's claim possible? Why or why not?
- b. Bob further claims that he can further make his "free-riding" more efficient by using a collection of multiple computers (with distinct IP addresses) in the computer lab in his department. How can he do that?