Here we select some exercises from the textbook, and they may be helpful for you to prepare for the midterm exam. Note that you don't need to hand in these exercises, and we **WILL NOT** provide the answer.

P5.

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

a. Suppose the caravan travels 175 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 $s = 2.5 \times 10^8$, $L = 1500$ bytes, and $R = 10$ Mbps. Find the distance m so that d_{prop} equals d_{trans}.

P8.

Suppose users share a 10 Mbps link. Also suppose each user requires 200 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 51 or more users transmitting simultaneously.

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?

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

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 illustrates the end-to-end transport of a message with and without message segmentation. Consider a message that is 10^6 bits long that is to be sent from source to destination in Figure 1. Suppose each link in the figure is 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 100 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.

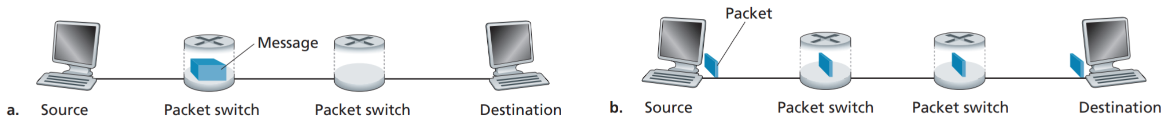

Figure 1: End-to-end message transport: (a) without message segmentation; (b) with message segmentation

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.

R10.

Describe the different wireless technologies you use during the day and their characteristics. If you have a choice between multiple technologies, why do you prefer one over another?

R12.

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?

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?

R23.

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

Here we select some exercises from the textbook, and they may be helpful for you to prepare for the midterm exam. Note that you don't need to hand in these exercises, and we **WILL NOT** provide the answer.

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.

P9.

Consider Figure 2, for which there is an institutional network connected to the Internet. Moreover, assume the access link has been upgraded to 54 Mbps and the institutional LAN is upgraded to 10 Gbps. Suppose that the average object size is $1,600,000$ bits and that the average request rate from the institution's browsers to the origin servers is 24 requests per second. Also suppose that the amount of time it takes from when the router on the Internet side of the access link forwards an HTTP request until it receives the response is three seconds on average (see Section 2.2.5). Model the total average response time as the sum of the average access delay (that is, the delay from Internet router to institution router) and the average Internet delay. For the average access delay, use $\Delta/(1-\Delta\beta)$, where Δ is the average time required to send an object over the access link and β is the arrival rate of objects to the access link.

a. Find the total average response time.

b. Now suppose a cache is installed in the institutional LAN. Suppose the miss rate is 0.3. Find the total response time.

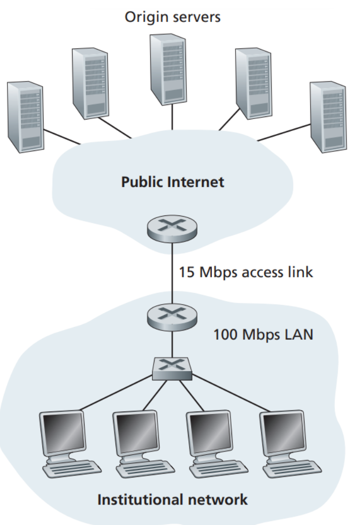

Figure 2: Bottleneck between an institutional network and the Internet

P10.

Consider a short, 30-meter link, over which a sender can transmit at a rate of 300 bits/sec in both directions. Suppose that packets containing data are $100,000$ bits long, and packets containing only control (e.g., ACK or handshaking) are 200 bits long. Assume that N parallel connections each get $1/N$ of the link bandwidth. Now consider the HTTP protocol, and suppose that each downloaded object is 100 Kbits long, and that the initial downloaded object contains 10 referenced objects from the same sender. Would parallel downloads via parallel instances of non-persistent HTTP make sense in this case? Now consider persistent HTTP. Do you expect significant gains over the non-persistent case? Justify and explain your answer.

P11.

Consider the scenario introduced in **P10**. Now suppose that the link is shared by Alice with Bob. Alice does not use parallel instances of non-persistent HTTP while Bob uses non-persistent HTTP with five parallel downloads each.

a. Does Alice have any advantage over Bob? Why or why not?

b. If Alice opens five parallel instances of non-persistent HTTP, then would her parallel connections be beneficial? Why or why not?

P22.

Consider distributing a file of $F = 10$ Gbits to N peers. The server has an upload rate of $u_s = 1$ Gbps, and each peer has a download rate of $d_i = 200$ Mbps and an upload rate of u. For $N = 10$, 100, and $1,000$ and $u = 2$ Mbps, 10 Mbps, and 100 Mbps, prepare a chart giving the minimum distribution time for each of the combinations of N and u for both client-server distribution and P2P distribution.

P26.

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

a. Alice who has been using BitTorrent tells Bob that he cannot receive a complete copy of the file that is shared by the swarm. Is Alice correct or not? Why?

b. Charlie claims that Alice is wrong and that he has even been using a collection of multiple computers (with distinct IP addresses) in the computer lab in his department to make his downloads faster, using some additional coordination scripting. What could his script have done?

P30.

Can you configure your browser to open multiple simultaneous connections to a Web site? What are the advantages and disadvantages of having a large number of simultaneous TCP connections?

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?

R18.

What is the HOL blocking issue in HTTP/1.1? How does HTTP/2 attempt to solve it?

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?