CSE434 Computer Networks (Fall, 2009)
Homework 2
Due: Monday, September 14, 2009

Submission Procedure: No late submissions will be accepted. Submit a hardcopy of your answers before the class.

Note: Please note that not all questions will be graded. Be clear and technically precise arguments for your answers. Answers without proper justification will not get full credit even thought the final result is correct.

1. Compare a packet-switched network and a circuit-switched network. What are the relative advantages and disadvantages of each?

2. Explain three types of addressing; unicast, multicast, and broadcast. Give an example of a situation in which each of multicast and broadcast addressing might be beneficial.

3. Explain why statistical multiplexing is cost-effective for a general-purpose computer network (compared to STDM and FDM)? Give an example of a network in which each of STDM (Synchronous Time-Division Multiplexing and FDM (Frequency-Division Multiplexing) might be beneficial. Why?

4. Design and describe an application-level protocol to be used between an automatic teller machine and a bank’s centralized computer. Your protocol should allow a user’s card and password to be verified, the account balance (which is maintained at the centralized computer) to be queried, and an account withdrawal to be made (that is, money disbursed to the user). Your protocol entities should be able to handle the all-too-common case in which there is not enough money in the account to cover the withdrawal. Specify your protocol by listing the messages exchanged and the action taken by the automatic teller machine or the bank’s centralized computer on transmission and receipt of messages. Sketch the operation of your protocol for the case of a simple withdrawal with no errors, using a sequence diagram. Explicitly state the assumptions made by your protocol about the underlying end-to-end transport service.

5. Suppose a 100-Mbps point-to-point link is being set up between Earth and a new lunar colony. The distance from the moon to Earth is approximately 385,000 km, and data travels over the link at the speed of light—$3 \times 10^8$ m/s.
   a. Calculate the minimum RTT for the link.
   b. Using the RTT as the delay, calculate the delay × bandwidth product for the link.
   c. What is the significance of the delay × bandwidth product computed in (b)?
   d. A camera on the lunar base takes pictures of Earth and saves them in digital format to disk. Suppose Mission Control on Earth wishes to download the most current image, which is 25 MB. What is the minimum amount of time that will elapse between when the request for the data goes out and the transfer is finished?

6. 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 rate is less than the capacities of each and every link. Is some form of congestion control needed? Why?

7. 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 intra-continent and inter-continent results.

8. 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 illustrates the end-to-end transport of a message with and without message segmentation. Consider a message that is $8 \times 10^6$ bits long that is to be sent from source to destination in Figure 1. Suppose each link in the figure is 2 Mbps. Ignore propagation, queuing, and processing delays.

![Figure 1. End-to-end message transport: (a) without message segmentation; (b) with message segmentation](image)

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 4,000 packets, with each packet being 2,000 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. Discuss the drawbacks of message segmentation.