Homework 1 – Whirlwind Intro

Assigned: Thursday, January 20, 2011
Due: Tuesday, February 1, 2011 *at the beginning of class*
CS 455: 84 points
CS 555: 94 points

Note: All homework assignments must be done on your own, and your answers should be in your own words. The textbook and lecture notes may be used, but you should not copy verbatim from either of them. Consider the written homework as practice for the exam. *Use of previous years' assignments/solutions or the textbook's solutions manual is **not** permitted.*

Review Questions (51 pts – 3 pts each part)

1. Satellite wireless links can have a high transmission speed, but what is the disadvantage to using a satellite link?

2. Explain the idea behind statistical multiplexing.

3. How does statistical multiplexing apply to packet-switching?

4. Contrast statistical multiplexing with the multiplexing that takes place in TDM.

5. Suppose there is exactly one packet switch between a sender and a receiver. The transmission rates between the sender and the switch and between the switch and the receiver are R_1 and R_2, respectively. Assuming that the switch uses store-and-forward packet switching, what is the total end-to-end delay to deliver a packet of length L to the receiver? (Ignore queuing, propagation, and processing delays.)

6. Suppose users share a 2 Mbps link. Also suppose each user requires 1 Mbps when transmitting, but each user transmits only 20% of the time.
    a. When circuit switching is used, how many users can be supported?
    b. If packet switching is used, can more users be supported than with circuit switching? Explain.

7. Explain how packets using datagram routing over a packet-switched network can arrive to the destination in a different order than they were sent.

8. List the delay components in end-to-end delay. For each component, indicate what factors affect the amount of delay a packet would encounter.

9. 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.
    a. Assuming no other traffic in the network, what is the throughput for the file transfer?
    b. Now R_2 = 100 kbps, assuming no other traffic on the network, what is the throughput for the file transfer?

10. What is the difference between flow control and congestion control?

11. List the five Internet protocol layers (top to bottom) and briefly describe the purpose of each.

12. Consider the five Internet protocol layers.
    a. Which does a router typically process?
    b. Which does an end system typically process?

13. What is the difference between a computer virus and a computer worm?

14. In what year was TCP/IP deployed?

Problems (455: 33 pts, 555: 43 pts)

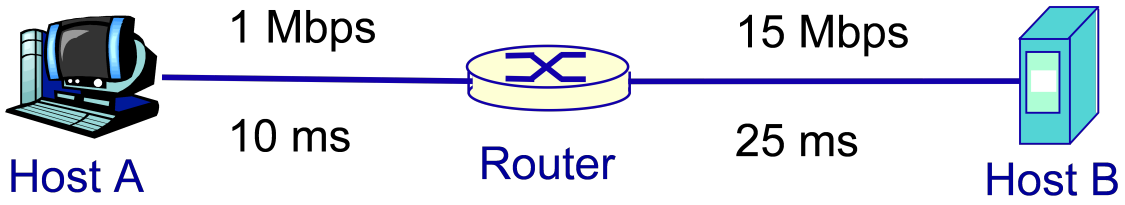
15. **[10 pts]** Consider two hosts, A and B, connected by a single link of rate R bps. Suppose that the two hosts are separated by m meters and that the propagation speed along the link is s meters/sec. Host A is to send a packet of size L bits to Host B.
    a. Express the propagation delay, d_{prop}, 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, give an expression for the end-to-end delay.
    d. Suppose Host A begins to transmit the packet at time $t = 0$. At time $t = d_{trans}$, where is the last bit of the packet?
    e. Suppose d_{prop} is greater than d_{trans}. At time $t = d_{trans}$, where is the first bit of the packet (at Host A, in the network, or at Host B)?

16. Suppose two hosts, A and B, are separated by 7,500 kilometers and are connected by a direct link of R = 10 Mbps. Suppose the propagation speed over the link is 2.5×10^8 meters/sec.
    a. **[2 pts]** Calculate the bandwidth-delay product, $R * d_{prop}$.
    b. **[2 pts]** Consider sending a file of 500,000 bits from Host A to Host B. Suppose the file is sent continuously as one big message. What is the maximum number of bits that will be in the link at any given time?
    c. **[2 pts]** Assuming the file is sent continuously, how long does it take before the receiver has received the entire 500,000-bit file?
    d. **[3 pts, CS 555 only]** Suppose the 500,000-bit file is broken up into 10 packets with each packet containing 50,000 bits (no header information is added to the packet). Suppose that each packet is acknowledged by the receiver and the transmission time of an acknowledgement packet is negligible. Finally, assume that the sender cannot send a packet until the preceding one is acknowledged. How long does it take to send the file and receive the final acknowledgement?
    e. **[2 pts, CS 555 only]** Suppose that the 500,000-bit file is broken up into packets, each with a maximum size (including the header) of 25,000 bits. The sender must append

a 500-bit header on each packet before sending. How many packets will it take to send the file?

17. Perform a `traceroute` between a source and far-away destination at three different hours of the same day. *You will not get full credit if you only submit a printout of your traceroutes (this only satisfies a portion of part a).*
    a. **[3 pts]** Give the IP address of the source and the time of day each traceroute was run. Submit a printout of the output of the three traceroutes.
    b. **[3 pts]** What is the average of the round-trip delays (between source and destination) at each of the three hours?
    c. **[3 pts]** How many routers were in the path at each of the three hours? Did the paths change between any of the hours?
    d. **[2 pts, CS 555 only]** Are link layer switches included in traceroute output? Why or why not?

18. **[8 pts]** Consider the following network. Host A sends a 1500-**byte** packet to Host B. You may assume that the transmission time for a single bit is negligible (but you must still compute transmission delays for the entire packet). **Hint:** When working this problem, don't forget to look back at your answers for Problem 15.



    a. Compute the transmission delay of the packet from Host A to the router.
    b. Compute the transmission delay of the packet from the router to Host B.
    c. Assume Host A sends the packet at time 0. When will the *first* bit arrive at Host B? **Hint:** Remember that the network is store-and-forward.
    d. Assume Host A sends the packet at time 0. When will the *last* bit arrive at Host B (*i.e.*, what is the end-to-end delay)? **Hint:** Remember that the network is store-and-forward.

19. **[3 pts, CS 555 only]** Consider sending a large file of F bits from Host A to Host B. There are two links (and one switch) 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 40 bits of header to each segment, forming packets of L = 40 + 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.