CS 444 (344)
Computer Networks
Spring, 2017

Homework #1

Due: Sunday, February 5, at 10 pm, via Blackboard

Show all your work. Partial credit will be given.

Textbook (parenthetical numbers are from K&H 6th edition):

Review problems:

- **Review 1 (R4)**. List six access technologies. Classify each one as home access, enterprise access, or wide-area wireless access.
- **Review 2 (R10).** Describe the most popular wireless Internet access technologies today. Com- pare and contrast them.
- **Review 3 (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?
- **Review 4 (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.)

  a. When circuit switching is used, how many users can be supported?

  b. 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?

  c. Find the probability that a given user is transmitting.

  d. 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.

- **Review 5 (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 $R1$ = 500 kbps, $R2$ = 2 Mbps, and $R3$ = 1 Mbps.

  a. Assuming no other traffic in the network, what is the throughput for the file transfer?
  b. Suppose the file is 4million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?
  c. Repeat (a) and (b), but now with $R2$ reduced to 100 kbps.

- **Review 6 (R20).** Suppose end system A wants to send a large file to end system B. At a very high level, describe how end system A creates packets from the file. When one of these packets arrives to a packet switch, what information in the packet does the switch use to determine the link onto which the packet is forwarded? Why is packet switching in the Internet analogous to driving from one city to another and asking directions along the way?

- **Review 7 (R23).** What are the five layers in the Internet protocol stack? What are the principal responsibilities of each of these layers?

Problems:

- **Problem 1 (P1).** 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 diagram similar to that in Figure 1.2. Explicitly state the assumptions made by your protocol about the underlying end-to-end transport service.

- **Problem 2 (P3).** 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:

  - Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why?

- Suppose that a packet-switched network is used and the only traffic in this network comes from such applications as described above. Further- more, 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?

- **Problem 3 (P12).** A packet switch receives a packet and determines the outbound link to which the packet should be forwarded. When the packet arrives, one other packet is halfway done being transmitted on this outbound link and four other packets are waiting to be transmitted. Packets are transmitted in order of arrival. Suppose all packets are 1,500 bytes and the link rate is 2 Mbps. What is the queuing delay for the packet? More generally, what is the queuing delay when all packets have length L, the transmission rate is R, x bits of the currently-being-transmitted packet have been transmitted, and n packets are already in the queue?

- **Problem 4 (P18).** 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.