University of Pittsburgh
TelCom 2310 – Computer Networks

Exam II

Name: ______________________________

Please, work out five problems. For each problem you need to show your work. Collaboration is not allowed on this take home exam, neither with current students nor with individuals who are not in the class. All work should be **your** own. Failure to observe this rule will result in a failing grade.

Problem 1	**/20**
Problem 2	**/20**
Problem 3	**/20**
Problem 4	**/20**
Problem 5	**/20**
Total	**/100**

Problem 1 (20 pts)

The TCP in station A sends a SYN segment with the initial segment number (ISN) set to 1000 and the maximum segment size (MSS) to 1000 to station B. Station B replies with a SYN segment in which the ISN is set to 5000 and the MSS to 500. Suppose station A has 10, 000 bytes to transfer to B. Assume the link between stations A and B is 8 Mbps and the distance between then is 200 meters. Neglect the header overheads to keep arithmetic simple. Station B has 3000 bytes of buffer available to receive data from A.

(1) Sketch the sequence of segment exchanges, including the relevant parameter values in the segment headers and the state of as a function of time at the two stations under the following situations:

   a. Station A sends its first data segment at t = 0. Station B has no data to send and sends an ACK segment every other frame.
   b. Station A sends its first data segment at t = 0. Station B has 6000 bytes data to send and sends its first data segment at t = 2 ms.

Suppose that the TCP in station A sends information to the TCP in station B over two-hop path. The data link in the first hop operates at a speed of 8 Mpbs, and the data link in the second hop operates at a speed of 400 Kbps. Station B has a 3 Kbyte of buffer to receive data from A, and the application at station B reads information from the receive buffer at a rate of 800 Kbps. The TCP in station A sends a SYN segment with the initial segment number (ISN) set to 1000 and the maximum segment size (MSS) to 1000 to station B. Station B replies with a SYN segment in which the ISN is set to 5000 and the MSS to 500. Suppose station A has 10, 000 bytes to transfer to B. Neglect the header overheads to keep arithmetic simple.

(2) Sketch the sequence of segment exchanges, including the relevant parameter values in the segment headers and the state of as a function of time at the two stations. Show the contents of the buffers at the intermediate switch as well as at the source and destination stations.

Problem 2 (20 pts)

Suppose that the delays experienced by TCP segments traversing the network is equally likely to be any value in the interval $50ms, 75ms]$.

(1) Find the mean and standard deviation of the delay

(2) Most computer languages have a function generating uniformly distributed random variables. Use this function in a short program to generate random times in the above interval and calculate the exponential weighted moving average, **`EstimatedRTT,`** and its deviation**`, DevRTT,`** assuming that $\alpha = 0.875$ and $\beta = 0.25$ **.** Compare to part (1) and discuss the results.

Problem 3 (20 pts).

Consider a client station A establishes a TCP connection with a server B. During the three-way handshake process station A and B agree on a sequence number.

(1) Suppose that the advertised window is 1 Mbyte long. If a sequence number is selected at random from the entire sequence number space, what is the probability that the sequence number falls inside the advertised window?

(2) Suppose that an old SYN segment from station A arrives at station B, requesting a TCP connection. Explain how the three-way handshake ensures that the connection is rejected.

(3) Now suppose that an old SYN segment from station A arrives at station B, followed a bit later by an old ACK segment from A to a SYN segment from B. Will this connection request be accepted or rejected. (Explain your answer for full credit)

(4) Suppose that the Initial Sequence Number (ISN) for the TCP connection is selected by taking the 32 low order bits from a clock. Plot the ISN versus time assuming that the clock ticks forward once every 1/Rc seconds. Expand the plot so that the sequence numbers wrap around.

Problem 4 (20 pts)

Suppose that a site has two communication lines connecting it to a central site, as depicted in Figure 1. One line has a speed of 64 Kbps, and the other line has a speed of 384 Kbps. Suppose each line is modeled by an M/M/1 queuing system with average packet delay given by $E[D] = E[X\}/(1-\rho)$, where $E[X]$ is the average time required to transmit a packet, λ is the arrival rate in packets per second to the site, and $\rho = \lambda E[X]$ is the load. Assume packets have an average length of 8000 bits. Suppose that a fraction, α, of the packet are routed to the first line (Line 1) and the remaining $(1-\alpha)$ are routed to the second line (Line 2).

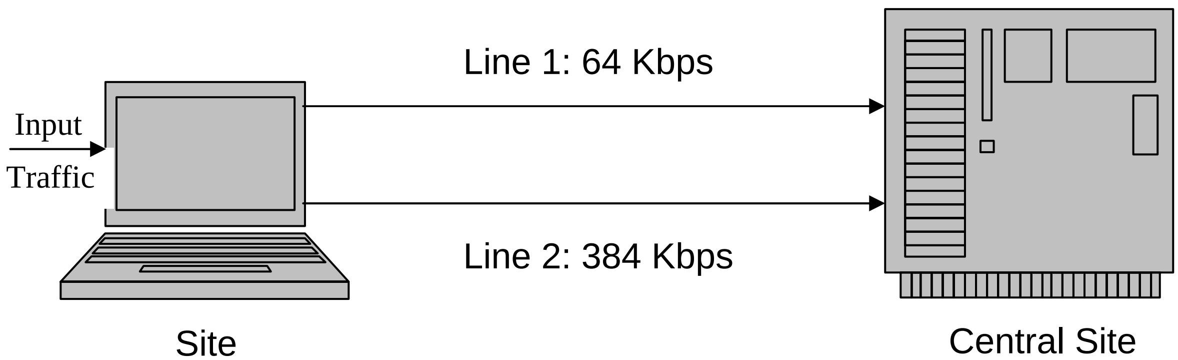

Figure 1 – Network Configuration

(1) Find the value of α that maximizes the average delay.
(2) What is the best routing strategy when the input traffic rate, λ, is very low. Use your answer to question (1) to justify your answer.
(3) Compare the average delay derived in question (1) to the average delay in a single multiplexer that combines the two transmission line into a single transmission line with an equivalent transmission rate.
(4) Suppose that a datagram packet-switching network has a routing algorithm that generates routing tables so that there are two disjoint paths between every source and destination that is attached to the network. Identify the benefits of this strategy. What problems are introduced with this approach?

Problem 5 (20 pts)

Consider the following six-node network. Assume all links have the same bit rate R.

(1) Suppose the network uses datagram routing. Find the routing able for each node, using minimum hop routing.

(2) Explain why the routing tables in part (1) lead to inefficient use of network bandwidth.

(3) Can the use of virtual circuit routing lead to better efficiency in the use of network bandwidth? (Explain why or why not for full credit)

(4) Suggest an approach in which the routing tables in datagram network are modified to lead to better efficiency. Show the modified routing tables.

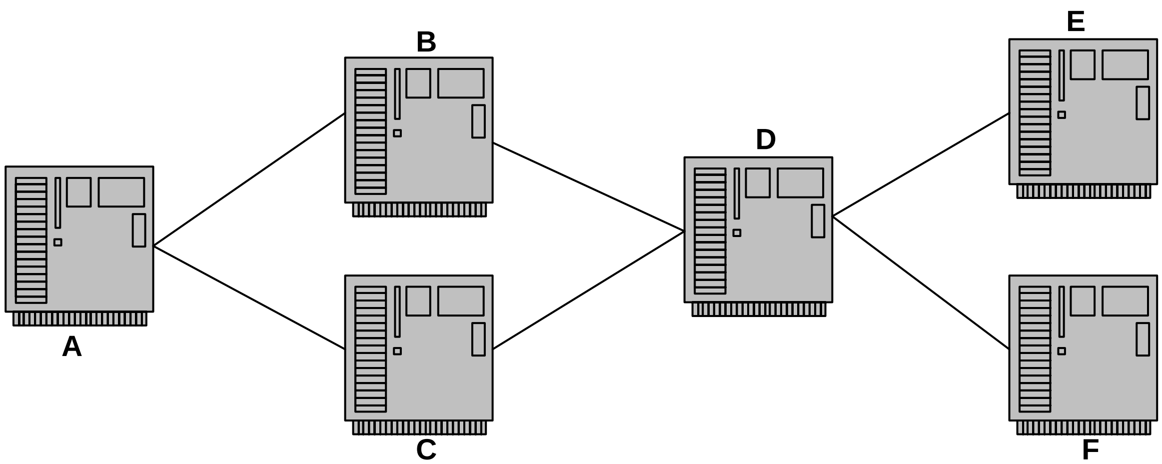

Figure 2 – Network Topology