Fundamentals of Computer Networking	**Homework 4**
CS4700/CS5700 Fall 2009	**10 November 2009**

This homework is due at the beginning of class on November 19th, 2009.

Name: _____

Problem	**Possible**	**Score**
1	30	
2	25	
3	30	
4	25	
5	40	
Total	150	

1a. Host A is transferring a file of size S to host B using TCP. A sends the file data in fixed size packets equal to the Maximum Segment Size (MSS), a predetermined value. B sends an acknowledgement immediately upon receiving a data segment. Let R be the round trip delay between A and B. The advertised receiver window size of host B is W. In this problem, we assume the TCP connection is already established and that the transmission time is negligable. TCP performs the slow start and congestion avoidance mechanisms, and there is no error or packet loss during transmission.

Given $W = 3 * \text{MSS}$, $L = 10 * \text{MSS}$, how long does it take for the file to be sent and acknowledged? Show your work. (15 points)

1b. (continuation of 1a) Given $W = 5 * \text{MSS}$, $L = 15 * \text{MSS}$, how long does it take for the file to be sent and acknowledged? Show your work. (15 points)

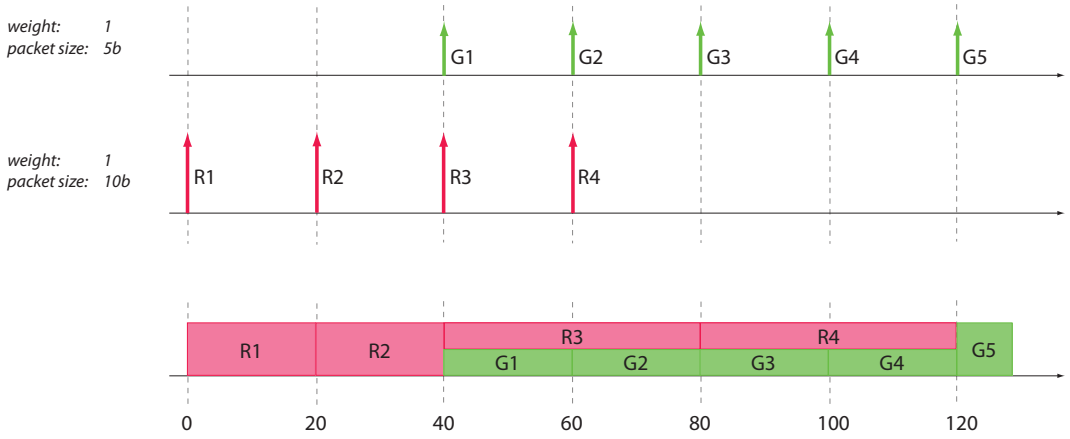
2a. TCP packets are being sent from a client to a server. The MSS is equal to 1480 bytes, and each TCP packet is sent with the maximum capacity. How many TCP packets can be sent before the sequence number field in the TCP header will wrap around? (10 points)

2b. (continuation of 2a) How much time (in seconds) will this take on a 1 Mbit/s link? (5 points)

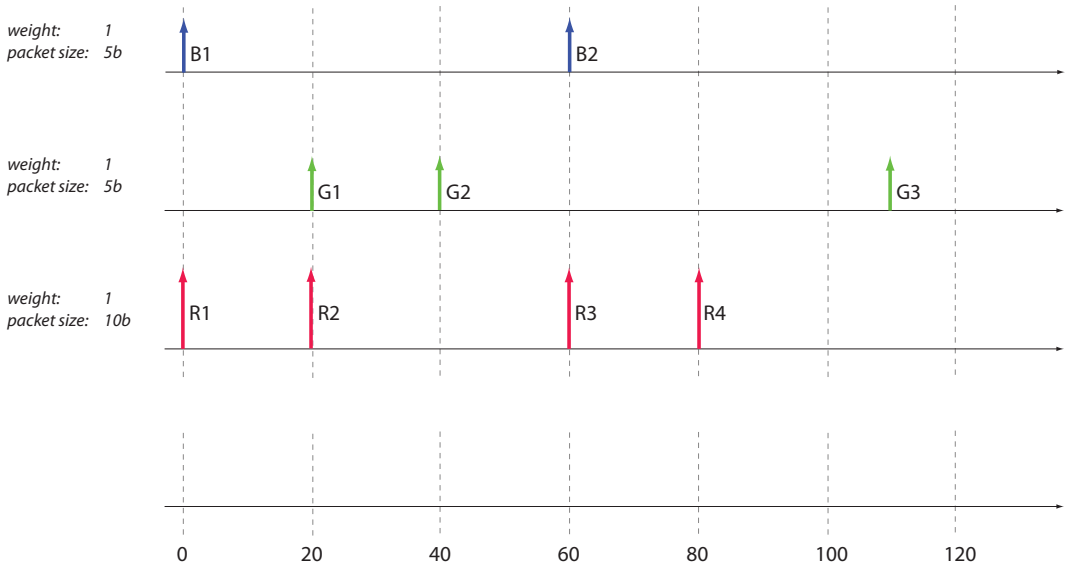
2c. (continuation of 2b) How much time (in seconds) will this take on a 1 Gbit/s link? (5 points)

2d. (continuation of 2c) How much time (in seconds) will this take on a 100 Gbit/s link? (5 points)

3a. Below shows the packet arrivals of two flows G and R at a weighted fair queuing scheduler. The two flows have equal weight, flow Rs packets are twice as big as flow Gs packets. The service provided in the corresponding fluid flow system is shown.



Now, suppose the packet arrival is changed to the following pattern, draw the service in the corresponding fluid flow system for this new arrival pattern. (20 points)



3b. (continuation of 3a) Using this fluid system as the ideal reference for weighted fair queuing scheduling, what is the transmission order in the corresponding packet system? (10 points)

4a. A router using weighted fair queuing has 10 flows waiting to go out over a 1 Mbit/s link. The weight w_i of flow $i \in \{1, 2, ..., 10\}$ is defined as $w_i = i$. How much bandwidth is guaranteed to flows 2, 6, and 9? (10 points)

4b. (continuation of 4a) Now suppose that there are only packets waiting for flows 3, 4, and 10. How much bandwidth is allocated to each one of these three flows? (10 points)

4c. (continuation of 4b) Finally, suppose that there are only packets waiting for flow 1. How much bandwidth is allocated to this flow? (5 points)

5a. Suppose two flows A and B are arriving at a weighted fair queuing scheduler. For simplicity, the link capacity is 10 bits per second. The two flows have equal weight, $w_A = 1$ and $w_B = 4$. The arrival times, and packet sizes are shown in the tables below.

Flow A

Packet	Arrival time (s)	Size (b)
1	0	7
2	2	4
3	2.5	2
4	2.5	20

Flow B

Packet	Arrival time (s)	Size (b)
1	0	4
2	0.5	4
3	2	8
4	3	8
5	3	8

Compute the start time and the finish time of every packet in the fluid flow system. You may draw a fluid flow system picture to help illustrate your answers. (10 points)

5b. (continuation of 5a) Write down the packet transmission order in the real packet system. Use $A1$ to denote the first packet of flow A. (10 points)

5c. (continuation of 5b) Recall that the system virtual time $V(t)$ is the number of rounds of service the WFQ server has given at time t. $V(t = 0) = 0$. One round of service is provided when every flow x that has traffic to send has received w_x bits of service. When a packet of flow A arrives at the system at time t, its virtual start time is either the current system virtual time $V(t)$ or the virtual finish time of the previous packet in flow A, whichever is larger.

Compute the virtual start time and the virtual finish time of every packet in the system. (20 points)