EE3315 Assignment 2 2021-2022

Question 1. **[20 marks]**

Suppose that within your web browser you click on a link to obtain a web page. Suppose that web page associated with the link contains some HTML text. Let *RTT* denote the round trip time between the local host and the server containing the HTML file with size 2*L*. Further suppose that the page references nine objects each with size 3*L* and the transmission rate *R*/2. Assuming the queueing time is 2*Q* for each object and zero for other messages, how much time is needed from when the client clicks on the link until the client receives all the nine referenced objects with

i) persistent HTTP with pipelining? [4 mark]
ii) persistent HTTP without pipelining? [4 mark]
iii) non-persistent HTTP with no parallel connections? [4 mark]
iv) non-persistent HTTP with parallel TCP connections but the maximum number of parallel connections is set to two? [4 mark]
v) non-persistent HTTP with parallel TCP connections but the maximum number of parallel connections is set to four? [4 mark]

Question 2. **[24 marks]**

Consider Figure Q.2, in which there is an institutional network connected to the Internet. Suppose that the average object size is 375,000 bits and that the average request rate from the institution's browsers to the origin servers is 120 requests per minute. Also suppose that the amount of time it takes for the signal traveling from the router on the Internet side of the access link to the origin servers is two seconds on average and it takes four seconds for the signal coming back. Model the total average response time as the sum of the average access delay (that is, the delay from the Internet router to the institution router), and the average Internet delay, ignoring the delay in the LAN. For the average access delay, use $T/(1-TB)$, where T is the average time required to send an object over the access link and B is the arrival rate of objects to the access link. Note that the number of significant digits after the decimal point should be limited to four during the calculation.

i. Find the average total response time. **[8 marks]**
ii. Now suppose a cache is installed in the institutional LAN. Suppose that the miss rate is 0.4. Find the total average response time. **[8 marks]**
iii. What is the total average response time if we upgrade the access link with two parallel links, one with 5 Mbps and another with 10 Mbps, instead of installing a cache in the institutional LAN? Assume that 30% of the traffic is distributed on the 5 Mbps link and the remaining 70% of the traffic is on the 10 Mbps link. **[8 marks]**

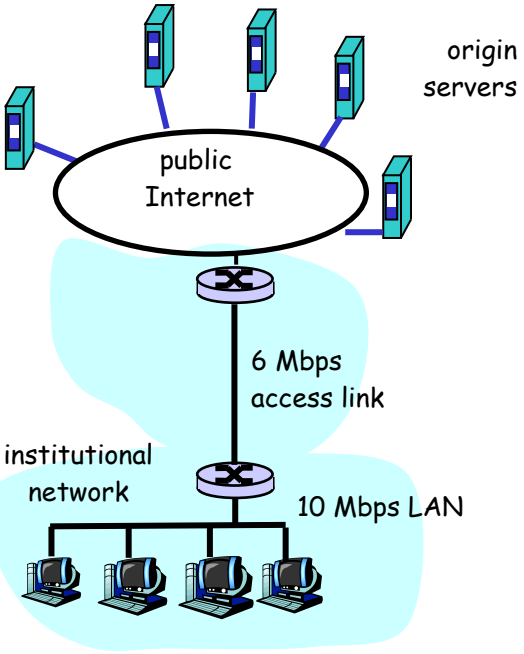


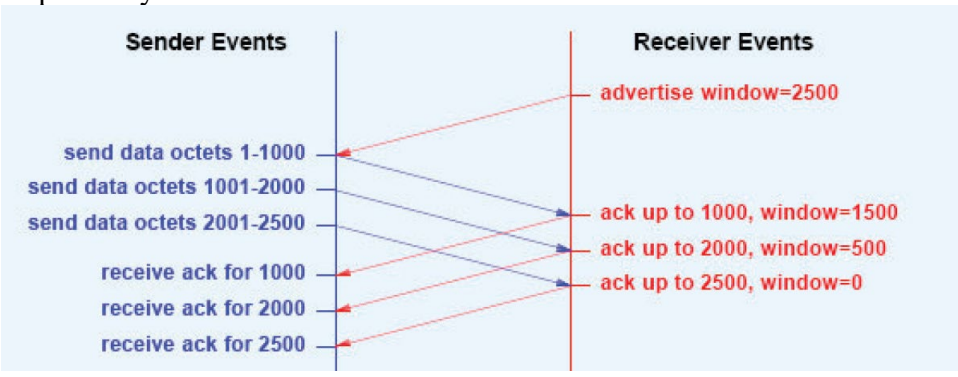
Figure Q.2

Question 3. **[20 marks]**

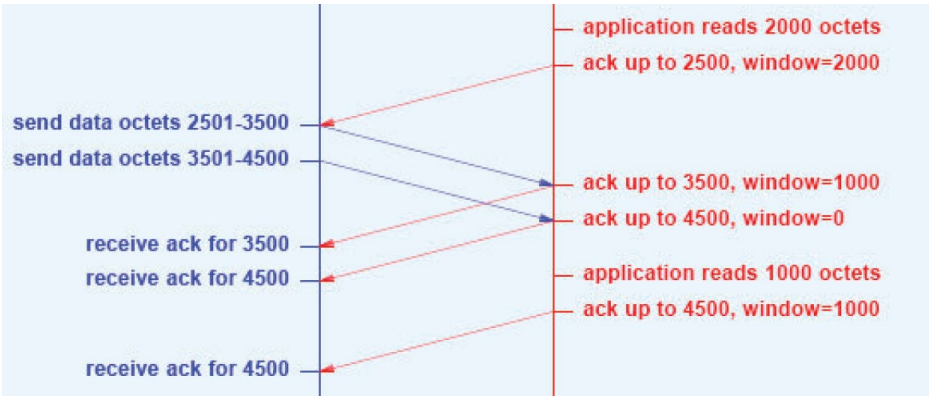
In this problem we consider the delay introduced by the TCP slow-start phase. Consider a client and a Web server directly connected by one link of rate *R*/4. Suppose the client wants to retrieve an object whose size is exactly equal to 14*S*, where *S* is the maximum segment size (MSS). Denote the round-trip time between client and server as RTT (assume to be constant). Ignoring protocol headers, determine the time to retrieve the object (**including** TCP connection establishment) when 12 S/R > RTT > 4 S/R and RTT ≥ 12 S/R, respectively.

Question 4. TCP flow control: **[20 marks]**

(i) According to the figure below, if advertise window is changed from 2500 to 2300, list out in sequence the modified Sender Events and the modified Receiver Events, respectively.



(ii) According to the figure below, if the application reads 1800 octets instead of 2000 octets, list out in sequence the modified Sender Events and the modified Receiver Events, respectively.



<u>Question 5</u>. **[16 marks]**

Assuming TCP Reno is the protocol experiencing the behavior shown in Table 1, answer the following questions. In all cases, you should provide a short explanation justifying your answer.

Table 1: TCP congestion control

NTR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CWS	30	31	32	1	2	4	8	16	17	18	9	10	11	12	6	7

NTR – number of transmission round
CWS – congestion window size

i. Identify the one/two interval(s) of time when TCP slow start is operating.
ii. Identify the one/two interval(s) of time when TCP congestion avoidance is operating.
iii. After the 3th transmission round, how segment loss is detected?
iv. After the 10th transmission round, how segment loss is detected?
v. What is the maximum possible initial value of Threshold at the first transmission round?
vi. What is the value of Threshold at the 4th transmission round?
vii. What is the value of Threshold at the 11th transmission round?
viii. What will be the congestion window size and the value of Threshold at the 16^{th} transmission round if a segment is lost after the 15^{th} transmission round due to a triple duplicate ACK?