Answer for EE3315 Test 2 2013-2014 Semester B

Question 1. **(20 marks)**

A TCP opens a connection and uses slow start. Assume that the maximum window size is 50 and the window threshold is 8.

i) Approximately how many round-trip times are required before TCP can send 16 and 32 segments, (i.e. window size = 16 and 32), respectively? [14 marks]

ii) What does TCP respond for congestion control if a segment is lost at the round-trip times equal to 25? [6 marks]

i) TCP initializes the congestion window to 1, sends an initial segment, and waits. When the ACK arrives, it increases the congestion window to 2, sends 2 segments, and waits. When the 2 ACKs arrive, they each increase the congestion window by one, so that it can send 4 segments. It takes $\log_2 8 = 3$ round trips before TCP can send 8 segments.

After the congestion window size reach 8, TCP enter congestion avoidance mode. TCP will increase its window size by one when all Acks for a full congestion window of packets are received. It takes 16−8=8 more round trips to reach window size equal to 16. Adding the number of round trips needed in slow start mode, it takes totally 3+8= **11 round-trips** before TCP can send 16 segments.

In addition, it takes another 16 round trips or totally **27 round-trips** before TCP can send 32 segments.

(ii) At round trip times equal to 25, TCP's window size has reached 30. When a segment is lost, the window threshold will be set to half of the current window size, i.e 30/2=15. If the lost is caused by time out, then the congestion window size will be set to one and TCP will enter the slow start mode. If the lost is caused by triple duplicate ACKs, then the congestion window size will be set to 15 and TCP will enter the congestion avoidance mode.

Question 2. **(24 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
CWS	28	29	30	31	32	1	2	4	8	16	8	9	10	11	12

NTR – number of transmission round (note that transmission round has been renumbered)
CWS – congestion window size

i. Identify the intervals of time when TCP slow start is operating.
ii. Identify the intervals of time when TCP congestion avoidance is operating.
iii. After the 5th transmission round, by which way is segment loss detected?

iv. After the 10th transmission round, by which way is segment loss 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 6th transmission round?
vii. What is the value of Threshold at the 10th 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 17^{th} transmission round due to a triple duplicate ACK?

i. TCP slowstart is operating in the interval [6,9]: double the previous window size
ii. TCP congestion avoidance is operating in the intervals [1,5], and [10,15]: linearly increase the window size
iii. After the 5th transmission round, packet loss is detected due to timeout, and hence the congestion window size is set to 1.
iv. After the 10th transmission round, segment loss is recognized by a triple duplicate ACK. If there was a timeout, the congestion window size would have dropped to 1.
v. The maximum possible initial value of the threshold at the first transmission round is 28 since when the congestion window size is 28, TCP congestion avoidance is operating.
vi. The threshold is set to half the value of the congestion window when packet loss is detected. When loss is detected during transmission round 5, the congestion windows size is 32. Hence the threshold is 16 during the 6th transmission round.
vii. The threshold is 16 during the 10th transmission round since there is no packet loss since transmission round 5 so the threshold remains the same as that during transmission round 5.
viii. The congestion window size is 13 and the threshold value is 8 since there is no loss at the 15th transmission round.

Question 3. **(26 marks)**

i. Suppose Alice, with a Web-based Hotmail e-mail account, sends a message to Bob, who accesses his mail from his mail server using a Web-based Outlook e-mail account. And, suppose Bob, with a non-Web-based Outlook e-mail account, returns a message to Alice, who accesses her mail from her mail server using IMAP. Discuss how the message gets from Alice's host to Bob's host. Be sure to list the series of application-layer protocols that are used to move the message between the two hosts. ` [6 marks]

Message is sent from Alice's host to her mail server over HTTP.
Alice's mail server then sends the message to Bob's mail server over SMTP.
Bob then transfers the message from his mail server to his host over HTTP.

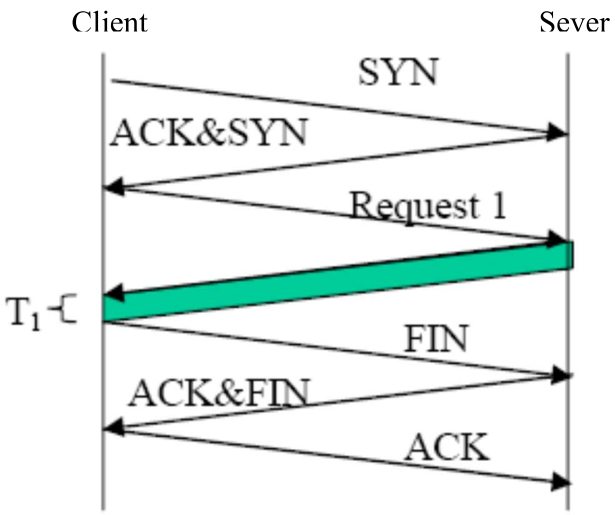
ii. In Web caching, "conditional GET" is used to update the cached object. If the cache sends an HTTP request with "If-modified-since: 1 May 2012 10:00pm", what is the condition that the cache does not get the updated object. [4 marks]

The cached object has not been updated in the Web server since 1 May 2012 10:00pm.

iii. Suppose an HTTP client wants to download three objects from a server. The sizes of the three objects are all smaller than the MSS (maximum segment size). The transmission times for the three objects are T_1, T_2, and T_3, respectively, and those of the control packets are negligible. Assume that the transmission is error free and loss free, and pipelining is not used. Let RTT be the round-trip time. Assume that the client opens a new TCP connection only after the last ACK is transmitted. [16 marks]

a. Draw a transmission figure to show how the client opens a connection, downloads the first object from the server, and closes the connection, assuming that HTTP with non-persistent connection is used. Indicate the exchange of all packets (including control packets) in the figure.
b. How much time is involved from the beginning of the download to the return of the last ACK, using HTTP with non-persistent connection to download the three objects?
c. How much time is involved from the beginning of the download to the return of the last ACK, using HTTP with persistent connection to download the three objects? Draw a figure to justify your answer.
d. How much time is involved from the beginning of the download to the return of the last ACK, using HTTP with persistent connection and pipelining to download the three objects?

a.

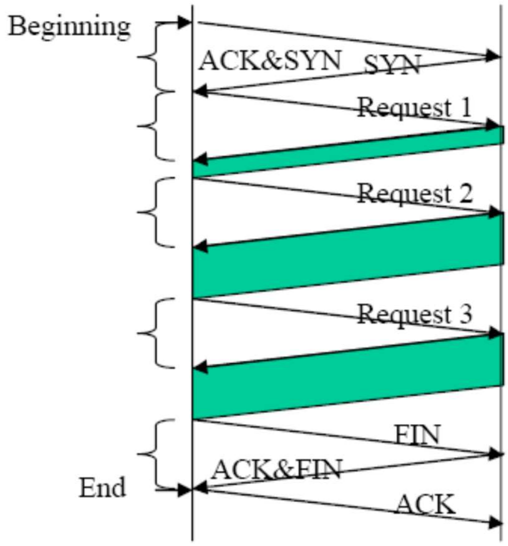


b.

As can be seen from the above figure, transferring the first objects takes $3RTT + T1$. Hence, the total transfer delay is $9RTT + T_1 + T_2 + T_3$.

c.

Transferring the three objects takes: $5RTT + T_1 + T_2 + T_3$.



d.

Transferring the three objects takes: $3RTT + T_1 + T_2 + T_3$

<u>Question 4.</u> **(24 marks)**

Consider Figure Q.4, in which there is an institutional network connected to the Internet. Suppose that the average object size is 600,000 bits and that the average request rate from the institution's browsers to the origin servers is 3200 requests per hour. 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 and coming back is three seconds on average. 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. 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.

i. Find the total average response time. [8 marks]

ii. Now suppose a cache is installed in the institutional LAN. Suppose that the hit rate is 0.35. 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, each with 5 Mbps, instead of installing a cache in the institutional LAN? Assume that the traffic is evenly distributed on the two links. [8 marks]

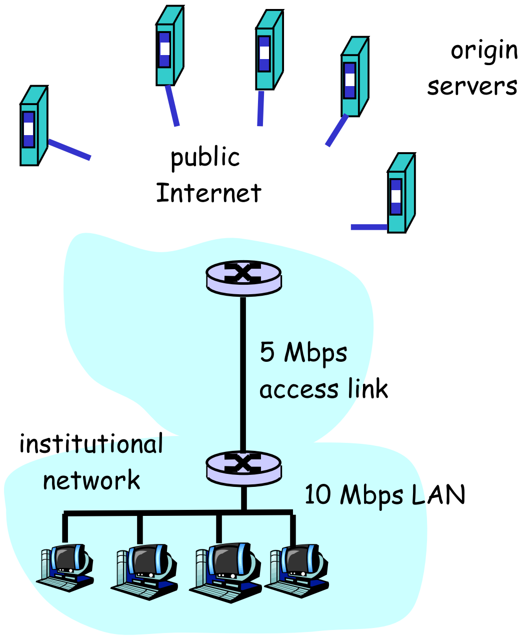


Figure Q.4

i. The time to transmit an object of size L over a link or rate R is L/R. The average time is the average size of the object divided by R:
T= (600,000 bits)/(5,000,000 bits/sec) = 0.12 sec
The traffic intensity on the link is TB = $(3200/60^2)(0.12)$ = 0.1067. Thus, the average access delay is $T/(1-TB)$ = (0.12 sec)/(1− 0.1067) = 0.1343 seconds. The total average response time is therefore 0.1343 sec + 3 sec = 3.1343 sec.

ii. The traffic intensity on the access link is reduced by 35% since the 35% of the requests are satisfied within the institutional network. Thus the average access delay is $T/(1-TB)$=(0.12 sec)/[1 – (0.65)(0.1067)] = 0.1289 seconds. The response time is approximately zero if the request is satisfied by the cache (which happens with probability 0.35); the average response time is 0.1289 sec + 3 sec = 3.1289 sec for cache misses (which happens 65% of the time). So the average response time is (0.35)(0 sec) + (0.65)(3.1289 sec) = 2.0338 seconds. Thus the average response time is reduced from 3.1343 sec to 2.0338 sec.

iii. Now, the access link is updated with two parallel links, each with 5 Mbps, instead of installing a cache in the institutional LAN.

T= (600,000 bits)/(5,000,000 bits/sec) = 0.12 sec
The traffic intensity on the link is TB = $(1600/60^2)(0.12)$ = 0.0533. Thus, the average access delay is $T/(1-TB)$ = (0.12 sec)/(1− 0.0533) = 0.1268 seconds. The total average response time is therefore 0.1268 sec + 3 sec = 3.1268 sec.

<u>Question 5.</u> **(6 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. Suppose the client wants to retrieve an object whose size is exactly equal to $13S$, 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 (**excluding** TCP connection establishment) when

i) $4 S/R > RTT > 3 S/R$, [3 marks]
ii) $5 S/R > RTT > 4 S/R$. [3 marks]

i) The total delay is

$$RTT + S/R + RTT + S/R + RTT + S/R + RTT + 6S/R = 4RTT + 9 S/R$$

ii) The total delay is

$$RTT + S/R + RTT + S/R + RTT + S/R + RTT + 6S/R = 4RTT + 9 S/R$$

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