Answer for EE3315 Test 2 2015-2016 Semester B

Question 1. **(14 marks)**

A TCP source opens a connection and uses slow-start with an initial window size 2. 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 20 and 36 segments, (i.e. window size = 20 and 36), respectively? [8 marks]

ii) What does TCP respond for congestion control if a segment is lost due to timeout at the 16th round-trip time? [6 marks]

i) It takes 2 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 20–8=12 more round trips to reach window size equal to 20. Adding the number of round trips needed in slow start mode, it takes totally 2+12= **14 round-trips** before TCP can send 20 segments. In addition, it takes another 16 round trips or totally **30 round-trips** before TCP can send 36 segments.

(ii) At round trip times equal to 16, TCP's window size has reached 22. When a segment is lost due to timeout, the window threshold will be set to half of the current window size, i.e. 22/2=11 and the congestion window size will be set to one and TCP will enter the slow start mode.

Question 2. **(24 marks)**

Assuming TCP Reno is the protocol displaying the behavior shown in Table 1, answer the following questions. In all cases, you should provide a short explanation to justify 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	28	29	30	31	32	1	2	4	8	16	8	9	10	5	6	7

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, how segment loss is detected?
iv. After the 10th transmission round, how segment loss is detected?
v. What is the minimum 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 11th transmission round?
viii. What will be the congestion window size and the value of Threshold at the 17th transmission round if a segment is lost after the 18th 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 [10,16]: 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 were a timeout, the congestion window size would have dropped to 1.
v. The minimum possible initial value of the threshold at the first transmission round is 1 since this is the smallest window size for TCP congestion control.
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 8 during the 11th transmission round since packet loss is detected. When loss is detected during transmission round 10, the congestion windows size is 16. Hence the threshold is 8 during the 11th transmission round.
viii. The congestion window size is 8 and the threshold value is 5 since there is no loss at the 17th transmission round.

Question 3. **(20 marks)**

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

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

i) $2RTT + 10 \times 2\, RTT + 10L/R = 22RTT + 10L/R$.
ii) $2RTT + 4 \times 2\, RTT + 4L/R = 10RTT + 4L/R$.
iii) $2RTT + 3 \times 2\, RTT + 3L/R = 8RTT + 3L/R$.
iv) $2RTT + 10RTT + 10L/R = 12RTT + 10L/R$.
v) $2RTT + RTT + 10L/R = 3RTT + 10L/R$.

Question 4. **(26 marks)**

Consider Figure Q.4, in which there is an institutional network connected to the Internet. Suppose that the average request rate from the institution's browsers to the origin servers is 2000 requests per hour and that the traffic intensity on the access link, which is generated by the web traffic from the institution's browsers to the origin servers, is 0.08 Erlang. 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 five seconds and the time for coming back is five 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 $T/(1-I)$, where T is the average time required to send an object over the access link and I is the traffic intensity on the access link. Note that that the average request rate from the institution's browsers to the origin servers is equal to I/T.

i. Find the total average response time. [10 marks]

ii. Now suppose a cache is installed in the institutional LAN. Suppose that the miss rate is 0.8. Find the total average response time. [8 marks]

iii. What is the total average response time if we upgrade the access link with three parallel links, each with 10 Mbps, instead of installing a cache in the institutional LAN? Assume that the traffic is evenly distributed over the three links. [8 marks]

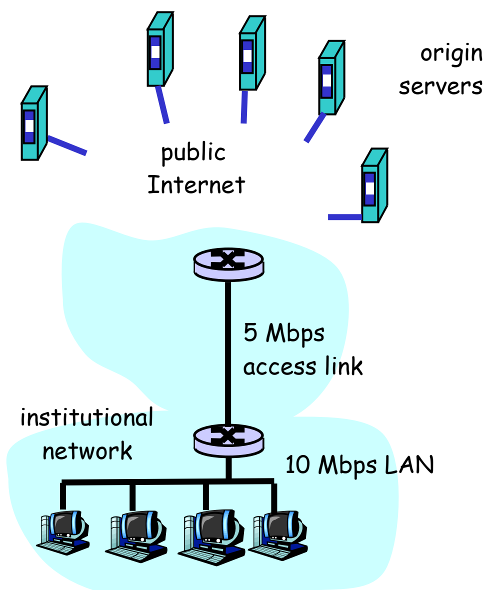

Figure Q.4

i. The average time required to send an object over the access link is
$T = I/B = 0.08/(2000/60^2) = 0.144$ sec where B is the arrival rate of objects to the access link.
Thus, the average access delay is $T/(1-I) = (0.144 \text{ sec})/(1-0.08) = 0.1565$ seconds. The total average response time is therefore 0.1565 sec + 10 sec = 10.1565 sec.

ii. The traffic intensity on the access link is reduced by 20% since the 20% of the requests are satisfied within the institutional network. Thus the average access delay is $T/(1-I)=(0.144 \text{ sec})/[1 - (0.8)(0.08)] = 0.1538$ seconds. The response time is approximately zero if the request is satisfied by the cache (which happens with probability 0.2); the average response time is 0.1538 sec + 10 sec = 10.1538 sec for cache misses (which happens 80% of the time). So the average response time is (0.2)(0 sec) + (0.8)(10.1538 sec) = 8.1230 seconds. Thus the average response time is reduced from 10.1565 sec to 8.1230 sec.

iii. Now, the access link is updated with four three links, each with 10 Mbps, instead of installing a cache in the institutional LAN.

T= 0.144/2 = 0.072sec

The traffic intensity on the link is I = 0.08/3/2 = 0.01333. Thus, the average access delay is $T/(1-I)$ = (0.072 sec)/(1– 0.01333) = 0.07297 seconds. The total average response time is therefore 0.07297 sec + 10 sec = 10.07297 sec.

Question 5. **(4 marks)**

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 2013 9:00pm”, what is the condition that the cache does not get the updated object.

The cached object has not been updated in the Web server since 1 May 2013 9:00pm.

Question 6. **(12 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 16S, where S is the maximum segment size (MSS). Denote the round-trip time between client and server as RTT (assumed to be constant). Ignoring protocol headers, determine the time to retrieve the object (**excluding** TCP connection establishment) when 9 S/R > S/R + RTT > 6 S/R.

i) If 7 S/R > RTT > 5 S/R, the total delay is

RTT + S/R + RTT + S/R + RTT + S/R + RTT + 9 S/R = 4 RTT + 12 S/R

ii) If 8 S/R > RTT ≥ 7 S/R, the total delay is

RTT + S/R + RTT + S/R + RTT + S/R + RTT + S/R + RTT + S/R = 5 RTT + 5 S/R

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