Answer for EE3315 Test 2 2016-2017 SemB

Question 1. [16 marks]

A TCP source opens a connection and uses congestion avoidance with an initial window size 4. Assume that the maximum window size is 50 and the window threshold is less than 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 round-trip times equal to 18? [8 marks]

i) It takes **16 round trips** to reach window size equal to 20. In addition, it takes another 16 round trips or totally **32 round-trips** before TCP can send 36 segments.

(ii) At round trip times equal to 18, 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. [32 marks]

Assuming TCP Reno is the protocol experiencing the behavior shown in Table 1, answer the following questions.

Table 1: TCP congestion control

NTR	1	2	3	4	5	6	7	8	9	10	11	12
CWS	28	29	30	31	32	1	2	4	8	16	8	9

NTR – number of transmission round (note that transmission round has been renumbered)

CWS – congestion window size

i. Revise Table 1 if there is a time-out segment loss after 3rd transmission round, assuming that other conditions remain the same.

NTR	1	2	3	4	5	6	7	8	9	10	11	12
CWS	28	29	30	1	2	1	2	3	4	5	2	3

ii. Revise Table 1 if there is a triple-duplicate-ACK segment loss after 3rd transmission round, assuming that other conditions remain the same.

NTR	1	2	3	4	5	6	7	8	9	10	11	12
CWS	28	29	30	15	16	1	2	4	8	9	4	5

iii. Revise Table 1 if there is a triple-duplicate-ACK segment loss after 5th transmission round, assuming that other conditions remain the same.

NTR	1	2	3	4	5	6	7	8	9	10	11	12
CWS	28	29	30	31	32	16	17	18	19	20	10	11

iv. Revise Table 1 if there is triple-duplicate-ACK segment losses after 5th transmission round and after 8th transmission round, assuming that other conditions remain the same.

NTR	1	2	3	4	5	6	7	8	9	10	11	12
CWS	28	29	30	31	32	16	17	18	9	10	5	6

<u>Question 3.</u> [14 marks]

Using TCP EA-RTT estimator (Exponential Average Round-Trip Time estimator), we have the following equation:

$$\text{EA-RTT}(K + 1) = (1 - \alpha) \times \text{EA-RTT}(K) + \alpha \times \text{RTT}(K).$$

(i) Assume that all the RTT(K) are the same and equal to RTT. Write down the expression for EA-RTT(n) in terms of EA-RTT(2) and RTT. *Hint:* The equation for calculating EA-RTT can be rewritten to simplify the calculation, using the equation $(1 + \ldots + \beta^{n-2} + \beta^{n-1}) = (1 - \beta^{n})/(1- \beta)$. [8 marks]

(ii) Choose $\alpha = 0.2$ and EA-RTT(1) = 2 seconds, and assume all measured RTT values = 5 second and no packet loss. What is EA-RTT(30) using the expression written in (i)? [6 marks]

(i) $\text{EA-RTT}(n) = (1 - \alpha)^{n-2}\, \text{EA-RTT}(2) + \alpha \times \text{RTT}\, ((1 - \alpha)^{n-3} + (1 - \alpha)^{n-4} + \ldots + 1)$
$= (1 - \alpha)^{n-2}\, \text{EA-RTT}(2) + \text{RTT}\, [1 - (1 - \alpha)^{n-2}]$

(ii) $\text{EA-RTT}(2) = (1\text{-}0.2) \times \text{EA-RTT}(1) + 0.2 \times \text{RTT}(1) = 0.8\times2+0.2\times5= 2.6$ sec
$\text{EA-RTT}(30) = (1-0.2)^{28} \times 2.6 + 5\, [1 - (1-0.2)^{28}]= 4.995$ sec

<u>Question 4.</u> [26 marks]

Consider Figure Q.4b, 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 1000 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 0.06. 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 five seconds for the round-trip time 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 0.6. Find the total average response time. [8 marks]
iii. What is the total average response time if we upgrade the access link with four parallel links, each with 20 Mbps, instead of installing a cache in the institutional LAN? Assume that the traffic is evenly distributed on the four links. [8 marks]

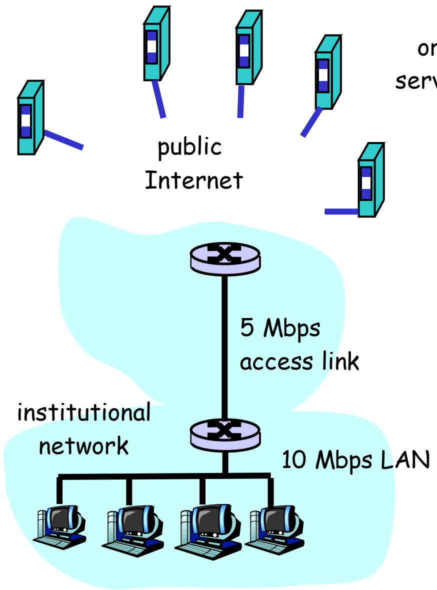

Figure Q.4b

i. The average time required to send an object over the access link is
T= I/B = 0.06/(1000/602) = 0.216 sec where B is the arrival rate of objects to the access link.
Thus, the average access delay is T/(1–I) = (0.216 sec)/(1– 0.06) = 0.2298 seconds. The total average response time is therefore 0.2298 sec + 5 sec = 5.2298 sec.

ii. The traffic intensity on the access link is reduced by 40% since the 40% of the requests are satisfied within the institutional network. Thus the average access delay is T/(1–I)=(0.216 sec)/[1 – (0.6)(0.06)] = 0.2241 seconds. The response time is approximately zero if the request is satisfied by the cache (which happens with probability 0.4); the average response time is 0.2241 sec + 5 sec = 5.2241 sec for cache misses (which happens 60% of the time). So the average response time is (0.4)(0 sec) + (0.6)(5.2241 sec) = 3.13284 seconds. Thus the average response time is reduced from 5.2298 sec to 3.13284 sec.

iii. Now, the access link is updated with four links, each with 20 Mbps, instead of installing a cache in the institutional LAN.
T= 0.216/4 = 0.0054sec
The traffic intensity on the link is I = 0.06/4/4 = 0.00375. Thus, the average access delay is T/(1–I) = (0.0054 sec)/(1– 0.00375) = 0.0054 seconds. The total average response time is therefore 0.0054 sec + 5 sec = 5.0054 sec.

Question 5. [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 17*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 5 S/R < RTT < 8 S/R.

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

RTT + RTT + S/R + RTT + S/R + RTT + S/R + RTT + 10 S/R = 5 RTT + 13 S/R

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

RTT+ RTT + S/R + RTT + S/R + RTT + S/R + RTT + S/R + RTT + 2S/R
= 6 RTT + 6 S/R

- END -