Athens University of Economics and Business
Master of Science in "Computer Science"

Fall Semester 2016-17

Course: "Computer Networks"
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1st Assignment of Exercises (v.2)

Assignment: November 22, 2016
Deadline: December 13, 2016 (Part A)
December 20, 2016 (Part B)

The assignment can be carried out by teams of two students.

Part A

1. You should solve exercise P19 from Chapter 3 of Kurose-Ross book, 6th edition, pp. 317-318 of English version. (Design of a stop-and-wait protocol for a broadcast channel.)

2. You should solve exercise P40 from Chapter 3 of Kurose-Ross book, 6th edition, pp. 322-323 of English version (Study of the curve of TCP congestion window.)

3. Study the effect of parameters α and β in the TCP's TimeoutInterval estimation algorithm: In this exercise you should implement a program (in whatever format convenient) that employs random numbers to generate samples of RTT, as follows.

   We initially set: *SampleRTT(1)=100*.
   New consecutive RTT samples are derived from formula:

   $$SampleRTT(n+1) = x(n+1) * SampleRTT(n) + y(n+1), \text{ for } n=1,2,\ldots \qquad (**)$$

   where x(n+1) is a uniformly distributed random number in (0.7,1.3) and y(n+1) is a uniformly distributed random number in (-10,35). Note that these random numbers are selected fresh every time where the formula is applied.

   From step 20 and on, every 5 samples, there is the option instead of using formula (**) to randomly select one of the following abrupt "jumps" to estimate the value of the next RTT sample. In particular, samples 20, 25, 30, 35, … are generated as follows:

   - With probability 0.25: *SampleRTT(n+1)=1.85*SampleRTT(n)*, and then we continue to apply formula (**) until the next "jump".
   - With probability 0.25: *SampleRTT(n+1)=0.65*SampleRTT(n)*, and then we continue to apply formula (**) until the next "jump".
   - With probability 0.25: *SampleRTT(n+1)=1.6*SampleRTT(n)* and *SampleRTT(n+2)=0.7*SampleRTT(n+1)*, (i.e. there is an abrupt increment and immediately after an abrupt decrement that eventually leads to a value that is relatively close to the one before the "jump") and then we continue to apply formula (**).
   - With probability 0.25: No "jump" takes place and formula (**) is applied.

In any of the above cases, if the value of *SampleRTT(n+1)* is less than 40, then this value is replaced by 40. In each step, we assume that the transmission of a segment takes place.

- If *Timeoutinterval(n-1)* > *SampleRTT(n)*, then the transmission of the segment at step n is considered as successful, and thus in the next step a segment will be transmitted.
- If *Timeoutinterval(n-1)* $\leq$ *SampleRTT(n)*, then the transmission of the segment at step n is repeated in the next step n+1 (retransmission).

For simplicity, we assume that all the SampleRTT samples are taken into account in the estimation of EstimatedRTT and DevRTT, without ignoring the samples that correspond to retransmissions.Also, again for simplicity, in this exercise we ignore the variations of CongWin, which is assumed to be constant and equal to 1 MSS.

First, you should generate 5 different (independent) sets of 200 samples of RTT. For each such set you should count the total number of retransmissions from step 20 until the end, for the following values of α and β:

- For $\alpha = 0.125$, $\beta = \{0.125, 0.25, 0.375\}$
- For $\beta = 0.25$, $\alpha = \{0.4, 0.125, 0.25\}$.

and then compare the different pairs of α and β with respect to the total number of retransmissions.

Next, for each pair (α, β), a table of detailed results should be presented for the first set of samples only, i.e. quadruples of the form
[n, *Timeoutinterval(n-1)*, *SampleRTT(n)*,
1 or 0 (successful or not transmission in step n)], only for 101$\leq$ n $\leq$ 200,

together with comments on the difference of the Timeoutinterval value from that of SampleRTT. Explain which of the above values of β is the best (i.e. leads to less retransmissions compared to others) when $\alpha = 0.125$, and respectively which value of α is the best when $\beta = 0.25$. For each of two cases present a diagram with the curves of *Timeoutinterval(n-1)* and *SampleRTT(n)*.

Finally, you should give a qualitative assessment for the differences you observe in the performance attained with different values of α, β. You should present your conclusion with respect to the incentives of a user to maintain the default $\alpha = 0.125$ and $\beta = 0.25$, or to select different values.

4. Study of the effect of AIMD mechanism in the throughput achieved with the usage of TCP protocol: As a continuation of the previous exercise and by assigning the default values in parameters α and β ($\alpha = 0.125$, $\beta = 0.25$), we assume that now the CongWin changes. For simplicity, we take that we can exhaust the entire window each time by transmitting a large segment of size CongWin each time instead of transmitting multiple segments of 1 MSS size each. The value of CongWin starts to evolve (please see below) and be taken into account at step 10 and on. Thus, we start to check for possible timeout events and to observe the adjustments of CongWin from step 10 and on. The normalized initial value of CongWin is set to 10. For simplicity, we ignore the "slow start" phase and the 3 duplicate ACKs, and consider only additive increase multiplicative decrease phases; see slide 3-99 of the presentation on transport layer by Kurose and Ross. Thus when no timeouts occur we only

consider the additive increase phase that is approximated as follows: CongWin is increased by 5 every time where no timeout occur. Upon a timeout, CongWin is decreased by 50%.

To model the effect of large value of CongWin to the congestion of the network we assume that the probability of loss of a segment (which leads to timeout) is correlated with the size of CongWin. This is modelled by adjusting the process of "generating" SampleRTT of Exercise 3, as follows:
In every step, we first "flip a coin" (by using a random number), and with probability:

0.6(1-exp{- CongWin/25})

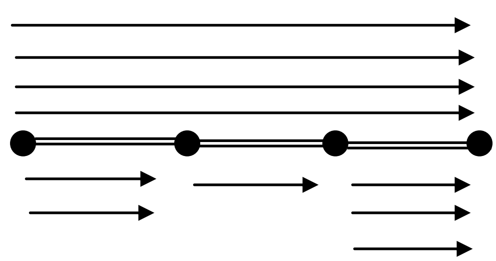
a segment loss takes place; that is, the transmitted segment is assumed to be lost due to its contribution to the network congestion. Note that based on the above rule the losses are more likely to happen when SampleRTT is larger, since such a larger value also tend to increase the level of congestion in the network. When such a loss event occur, the lost segment will be retransmitted regardless if *Timeoutinterval(n-1)≤SampleRTT(n)* or not. If, in a certain step, no loss occurs, then we check if Timeoutinterval(n-1)≤SampleRTT(n): If the condition holds, then a retransmission occurs (which in fact is not needed since there is no loss) due to premature timeout. Note that each retransmission is done in two segments (because the size of CongWin has been decreased to the half), with the second segment containing also some additional new data since it is slightly larger (by 5) from the first segment.

First, you should count the total amount of data transmitted successfully from step 10 and on (until step 200). Note that the bytes that are retransmitted as duplicates (due to a premature timeout) should not be considered as "success".

Then, propose another algorithm for the increase of CongWin that is restricted by the maximum increment of 5 per step in the additive increase phase and is combined with a decrease of 50% when a timeout occur. This algorithm should maintain high values of the size of CongWin for longer time and thus achieve higher throughput.

Part B

5. In the following network, all three links have unit capacity. Find the bandwidth distribution over the different flows, such that:
   A) Max-min fairness condition is satisfied
   B) Proportional fairness condition is satisfied



Compare the bandwidth distribution of two approaches with respect to total throughput achieved in the network, and comment on the result.

6. You should solve exercise P17 from Chapter 4 of Kurose-Ross book, 6th edition, pg. 447. (Assignment of CIDR addresses to a network.)