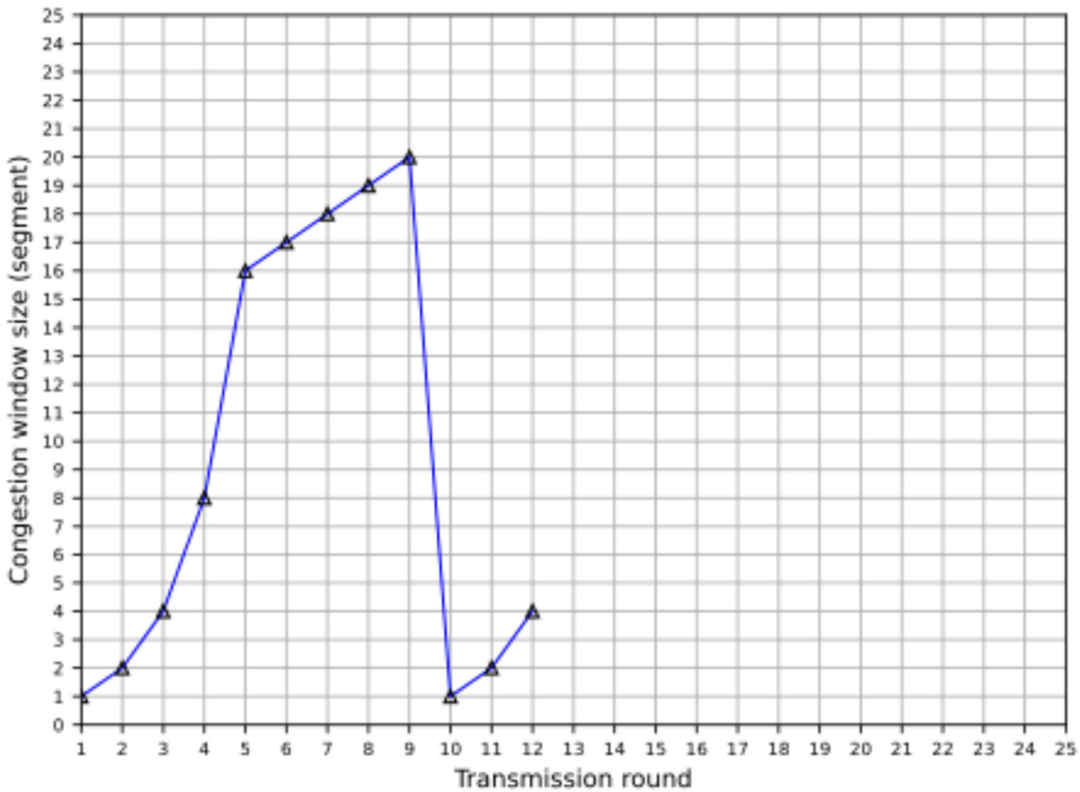
2. TCP

Consider the figure below. Assume TCP Reno is the protocol experiencing the behaviour, and the TCP session has a large number of packets to send. Answer the following questions (1)—(3). There is only one single TCP session in this figure.

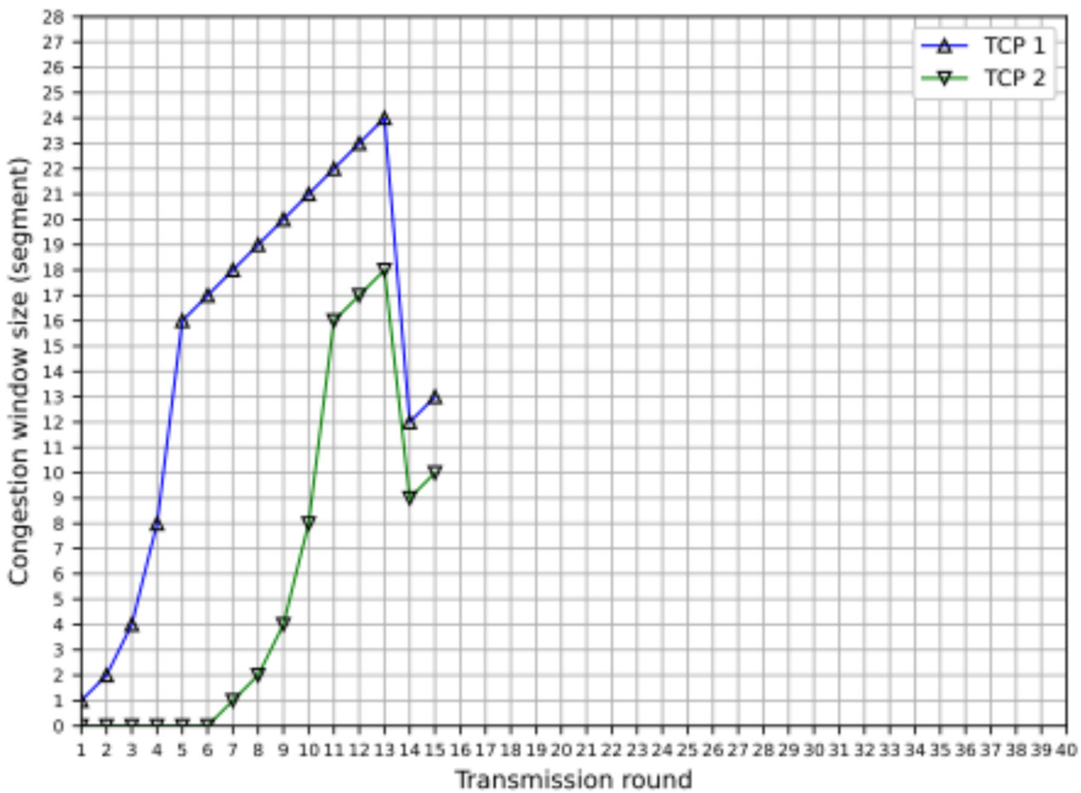
(1) The congestion window size is decreased to 1 (segment) at round 10. Is it caused by three duplicate ACKs or timeout? Why?

(2) What is ssthresh at round 1? Why?

(3) Suppose there is no packet loss after round 10. In the figure, what are the congestion window sizes from round 12 to round 25?



(4) In Figure below. Two TCP (Reno) sessions are sharing the same link and the link capacity is limited by 42 segments. Whenever the sum of the congestion window sizes reaches (or exceeds) 42, a packet is lost for each TCP session and the packet loss is detected by three duplicate ACKs. TCP session 2 starts later than TCP session 1. What are the congestion window sizes of the two sessions from round 15 to round 40? If the congestion window size is not an integer (in segment), you need to round it down.



3. Estimated RTT.

Consider the TCP procedure for estimating RTT. Let $EstimatedRTT_0 = 100$ ms be the estimated RTT when a TCP is initialised. Then, the TCP sender receives 5 ACKs and sample RTTs are measured as $SampleRTT_1$, $SampleRTT_2$, $SampleRTT_3$, $SampleRTT_4$, and $SampleRTT_5$. All of them are 110 ms. Let $EstimatedRTT_i$ denote the estimated RTT right after the ith ACK. We assume $\alpha = 0.125$ in this question.

(1) Calculate $EstimatedRTT_4$ and $EstimatedRTT_5$.

(2) Generalise your solution to n sample RTTs. The TCP sender receives n ACKs, with ith sample RTT $SampleRTT_i$. We assume all $SampleRTT_i$ are 110 ms. Express $EstimatedRTT_n$ as a function of n.

(3) For the formula in part (2), let n approach infinity. What is $EstimatedRTT_n$? Comment on why this averaging procedure is called an exponential moving average.