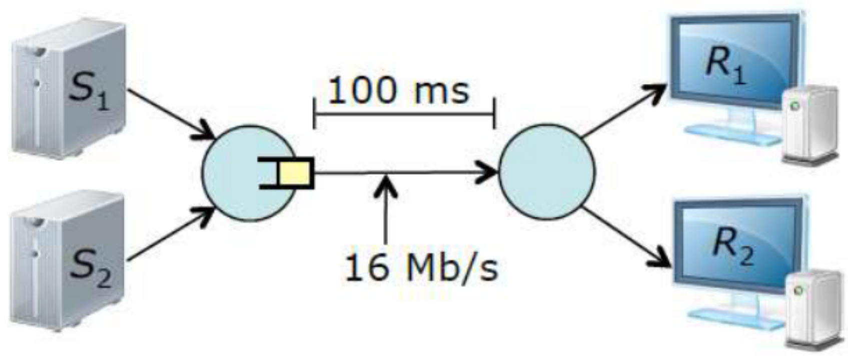
EE450: Sample Set #6: TCP Congestion Control

No Solutions. Will be glad to check your work

1. The diagram below shows two TCP senders at left and the corresponding receivers at right. Both senders use TCP Tahoe. Assume that the MSS is 1 KB, that the one-way propagation delay for both connections is 100 msec and that the link joining the two routers has a bandwidth of 16Mb/s. Let $cwnd_1$ and $cwnd_2$ be the values of the senders' congestion windows. What is the smallest value of $cwnd_1 + cwnd_2$ for which the link joining the two routers stays busy all the time?



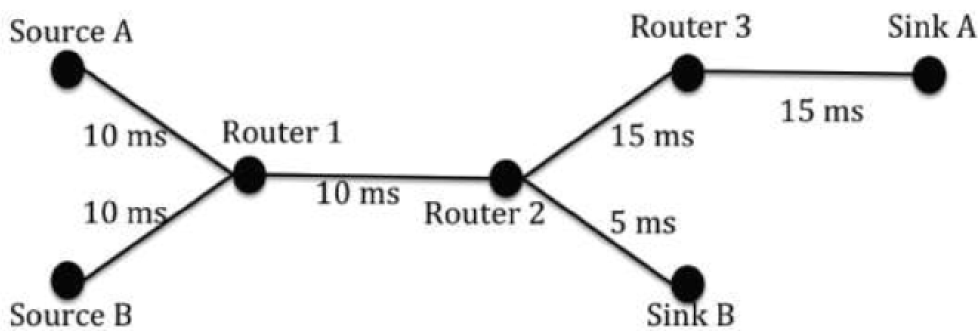
   a. Assume that the link buffer overflows whenever $cwnd_1 + cwnd_2 \geq 600$ KB and that at time 0, $cwnd_1 = 500$KB and $cwnd_2 = 100$ KB. Approximately, what are the values of $cwnd_1$ and $cwnd_2$ one RTT later? Also, what are the values of ss-thresh for each of the two connections? Assume that all losses are detected by triple duplicate ACKs.
   b. After 20more RTTs, approximately what are the values of $cwnd_1$ and $cwnd_2$?
   c. Approximately, how many more RTTs before $cwnd_1+cwnd_2 \geq 600$KB again? What is difference of their congestion windows at this point?

2. Consider the effect of using slow start on a line with a 10 msec RTT and no congestion. The receiver window is 24 KB, and the maximum segment size is 2 KB. How long does it take before the first full window can be sent? Assume that the slow start threshold is set to ½ the receiver window size.

3. Assume that in the network shown there are two parallel TCP transmissions taking place. TCP1 is a transmission between Source A and Sink A that uses TCP Tahoe. TCP2 is a transmission between Source B and Sink B that uses TCP Reno. The Initial *ssthresh* for both TCP transmissions is set to 32. There are no additional delays other than propagation delays listed above each link.

a. For TCP1 transmission, draw the resulting congestion window assuming that a packet loss is detected via 3 duplicate Acks at t = 900 msec

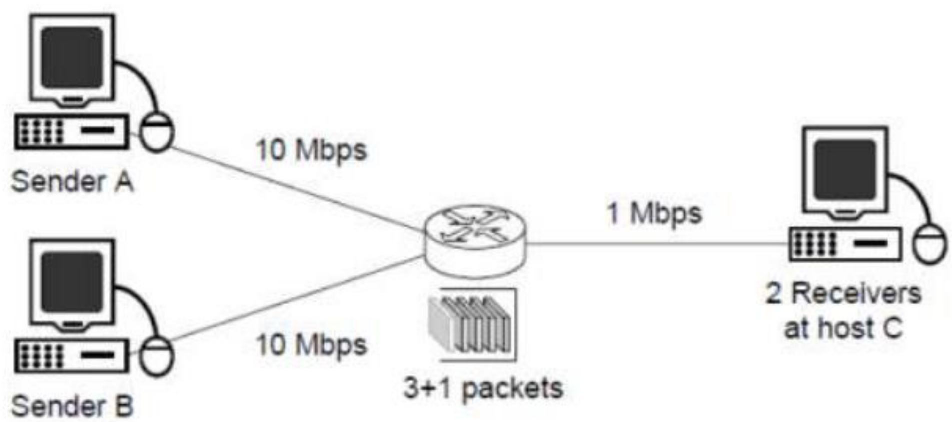
b. For TCP2 transmission, draw the resulting congestion window assuming that a packet loss is detected via 3 duplicate Acks at t = 650 msec



4. Consider a TCP Reno flow that has exactly 50 segments to send. Assume that during the transmission, exactly five segments are lost: the 4th, 5th, 6th and 48th (due to time out expiration) and segment 22nd (due to 3-duplicate acknowledgements); no other losses occur. Plot the evolution of the congestion window as each segment is sent. Assume the RTO is set to 2RTT and assume that the RTT is 1 sec. Only lost segments are retransmitted. What is the throughput of the TCP session? Assume each segment is 1KByte long.

5.

1. Consider the following network. TCP senders at hosts A and B have 3.6 KB of data each to send to their corresponding TCP receivers, both running at host C. Assume MSS = 512 bytes and the RTO = 2×RTT = 2×1 sec. Router buffer size is 3 packets in addition to the packet currently being transmitted; The drop strategy is as follows: drop the last packet that arrived from the host which currently sent more packets. Sender A runs TCP Tahoe and sender B runs TCP Reno and assume that sender B starts transmission 2×RTTs after sender A.



a. Sketch the congestion window sizes on both senders until all segments are successfully transmitted.
b. Now assume the timeout is changed to 3×RTT = 3×1 sec? What will change?

In both cases, assume a large Receiver Window (i.e. No flow control problem) and error-free transmission on all the links. Also assume that all ACK arrivals occur exactly at unit increments of RTT and that the associated Congestion Window update occurs exactly at that time, too.

6. Consider a TCP CC algorithm where the window size at the start of slow start phase is 2 MSS and the threshold at the start of first transmission is 8 MSS. Assume that a time out occurs during the fifth transmission. Find the congestion window size at the end of tenth transmission.

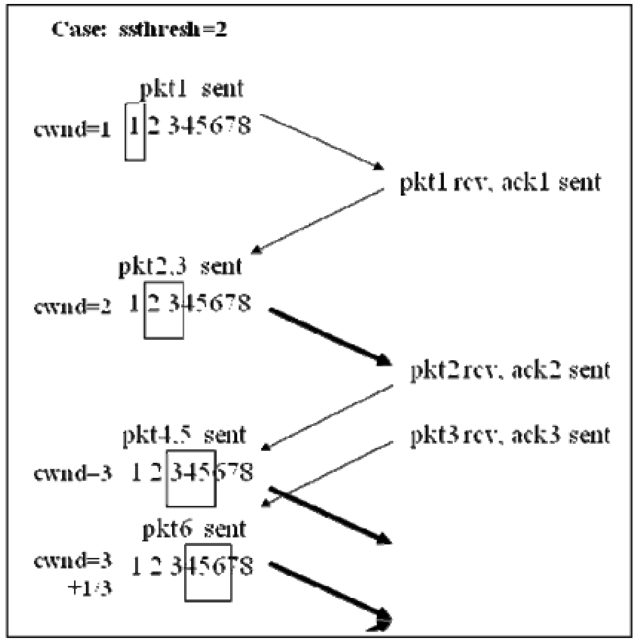
7.

Given the following forwarding table, complete the table below by specifying on which of the outgoing interfaces each destination address will be forwarded.

Destination Address Range	Link Interface
11001000 00010111 00010*** *********	0
11001000 00010111 00011000 *********	1
11001000 00010111 00011*** *********	2
otherwise	3

Destination Address	Link Interface
11001000 00010111 00010110 10100001	
11001000 00010111 00011000 10101010	
11001000 00010111 00011100 10101010	
11001000 00010111 10010110 10100001	

Suppose there is a connection with initial cwnd = 1 and ssthress = 2, as shown in the figure on the right. There are only 8 packets to send. The cwnd will become 2 when the source node receives the acknowledgement for packet 1. As a result, the source will send packet 2 and 3 at once. When the source receives the acknowledgement for packet 2, the cwnd will be 3. The source, in turn, sends packet 4 and 5. When it receives the acknowledgement for packet 3, the cwnd will be 3+1/3. The source then sends packet 6.



(1) Suppose the initial cwnd = 1 and ssthresh = 4. Can you tell us what the cwnd will be when the acknowledgement for packet 3 is received at the source and which packet(s) will be sent next? (10%)

(2) Following question (1), if packet 6 is lost, Can you tell us what the cwnd will be after the loss is detected and which packet(s) will be sent next? Assume that TCP receiver does not buffer packets out of order and retransmits with 3 duplicate acks. (10%)

(3) Following question (1), if packet 4 is lost, Can you tell us what the cwnd will be after the loss is detected and which packet(s) will be sent next? Assume that TCP receiver does not buffer packets out of order and retransmits with 3 duplicate acks. (10%)

9.

[3pts] (d) Suppose two TCP connections share a path through a router R. The router's queue size is 6 segments; each connection has a stable congestion window of 3 segments. No congestion control is used by these connections. A third TCP connection now is attempted, also through R. The third connection does not use congestion control either. Describe a scenario in which, for at least a while, the third connection gets none of the available bandwidth, and the first two connections proceed with 50% each. Does it matter if the third connection uses slow start? How does congestion avoidance by the first two connections help solve this?