TCP Review

CS 640, Spring 2017

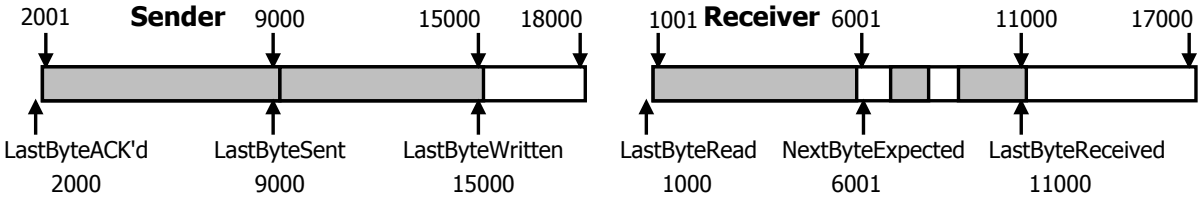
Connection establishment and termination

1. Draw a timeline diagram showing the packets a client and server exchange to establish a TCP connection. For each packet, specify the TCP flags, sequence number, and acknowledgement number. Assume the client and server choose 100 and 500, respectively, as their initial sequence numbers.

2. Draw a timeline diagram showing the packets a client and server exchange to terminate a TCP connection. For each packet, specify the TCP flags, sequence number, and acknowledgement number. Assume the client sends 500 bytes and then initiates a connection close operation. After the client half of the connection has been closed, the server sends 7000 bytes and then initiates a connection close operation. Assume the client and server each use 0 for their initial sequence numbers.

Flow control

3. The figure below shows sender and receiver buffers at a specific point during a TCP connection. Important buffer slots are labeled with the sequence number currently associated with that slot; assume the sequence number for the first byte of data was 1. Shaded buffer regions contain data.

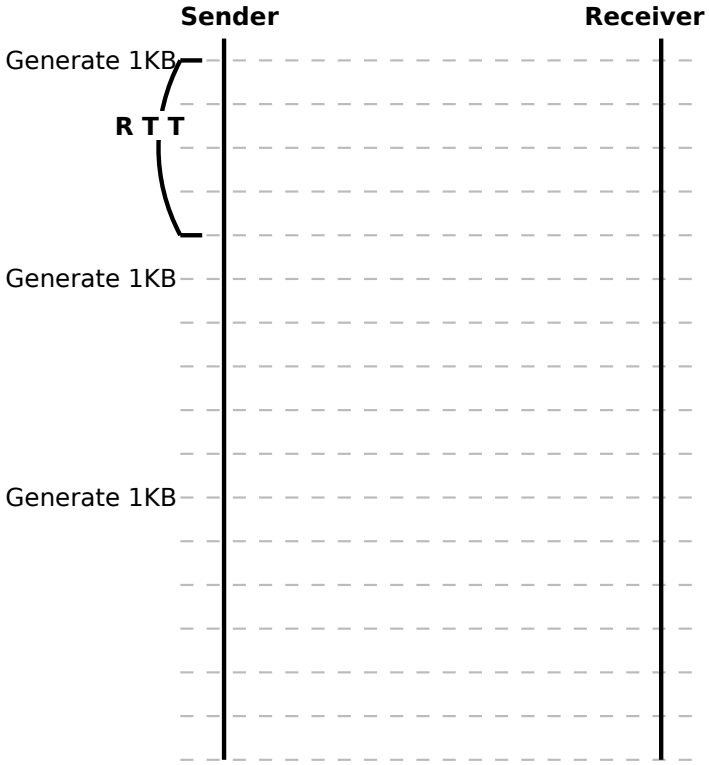


(a) What is the receiver's *advertised window*? Show the equation you used to calculate this.

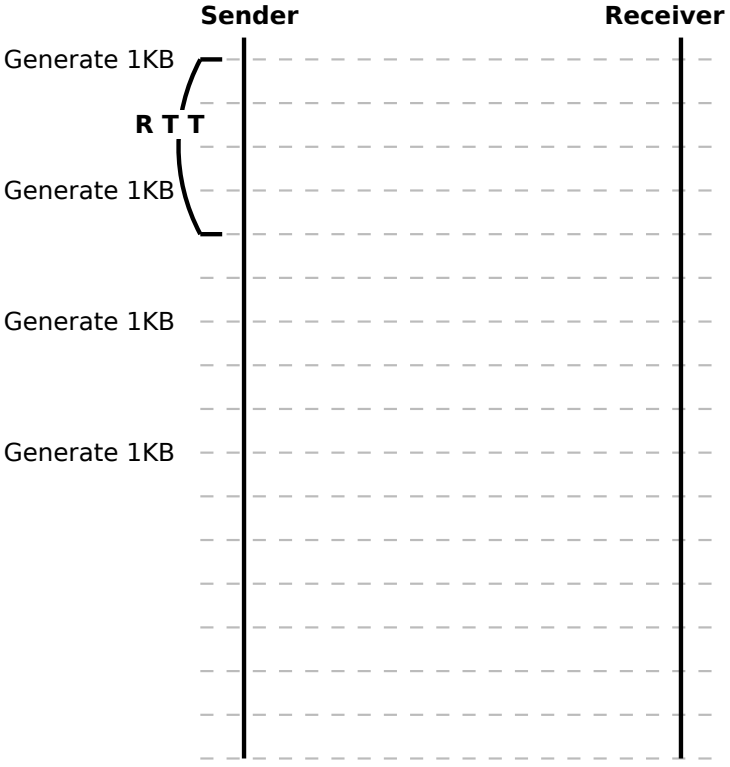
(b) Assume the last advertised window the sender received was 14000 and there is no congestion control. What is the sender's *effective window*? Show the equation you used to calculate this.

(c) If this connection used congestion control and the current congestion window was 10000 bytes, then what would be the sender's *effective window*? Show the equation you used to calculate this.

4. (a) Assume a sender generates 1KB of data every 50ms and a receiver consumes 1KB of data in 10ms. Furthermore, assume the maximum segment size (MSS) is 1KB, the round trip time (RTT) is 40ms, the sequence number for the first byte of data is 1, and the receiver's buffer size is 2.5KB. Draw a timeline diagram showing the data and acknowledgement packets that are exchanged to transmit the first 3KB of data. (The gap between each dashed line is 10ms.) For each data packet, specify the sequence number and data length. For each acknowledgement packet, specify the acknowledgement number and advertised window.

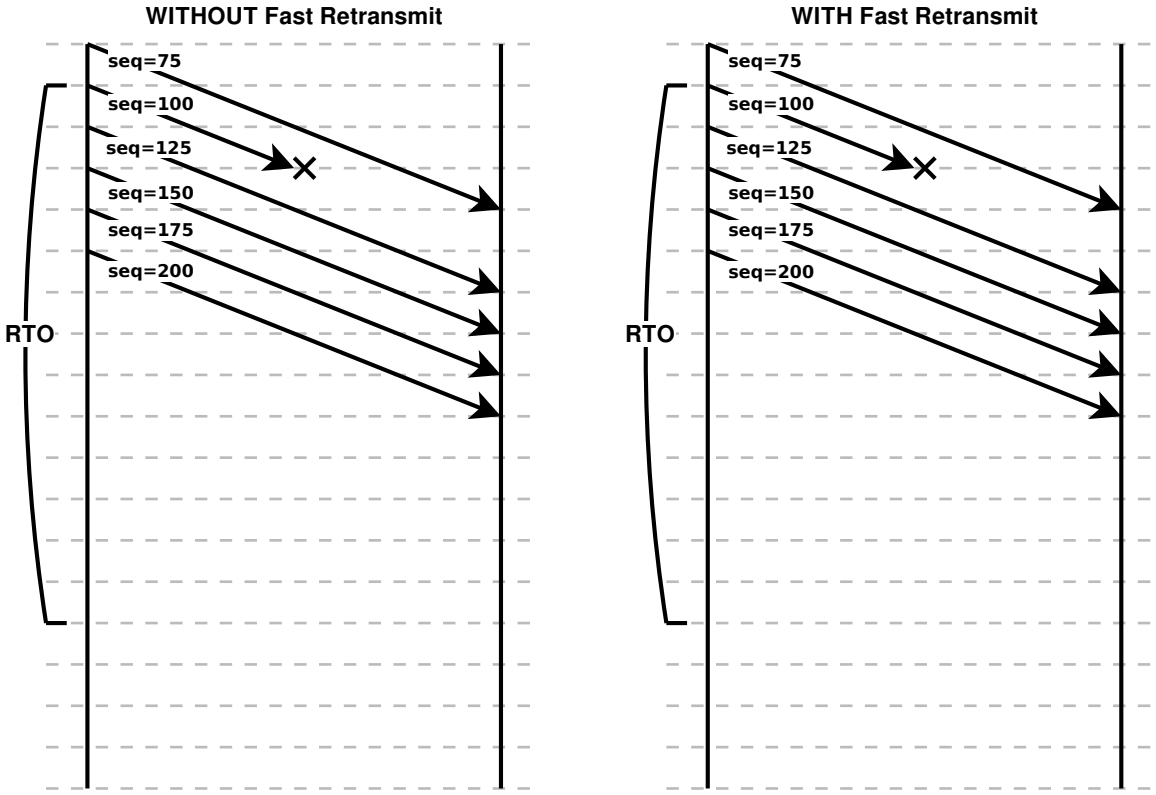


(b) Now, assume the same scenario as above *except* the sender generates 1KB of data every 30ms and the receiver consumes only 0.2KB of data in 10ms. Draw a timeline diagram showing the data packets and acknowledgement packets that are exchanged to transmit the first 4KB of data using TCP. Remember to apply *Nagle's algorithm* when deciding when to transmit.

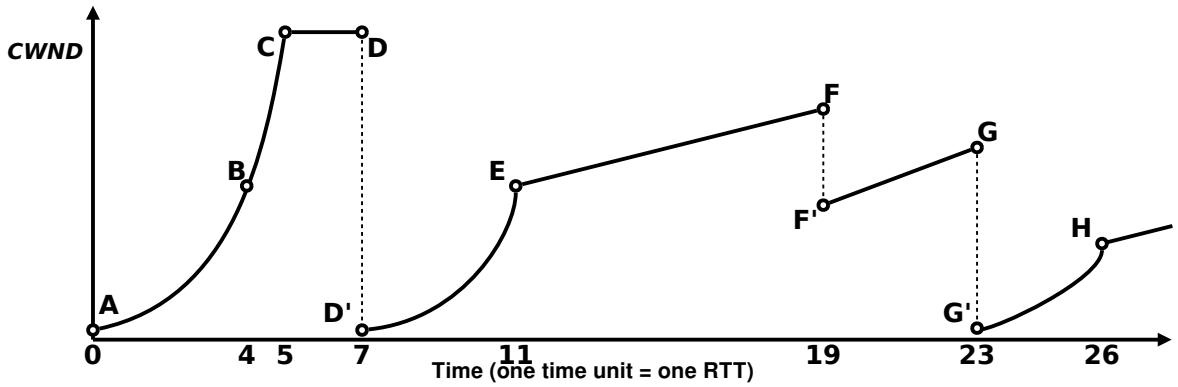


Congestion control

5. Assume a TCP sender transmits 5 packets, each 25 bytes in length, and the 2nd packet is dropped, as shown in the timelines below. Furthermore, assume the RTT is 80ms, the retransmissions timeout for each packet is 130ms, and the gap between each dashed line is 10ms. Add lines to the timeline diagrams for ACKs **and** retransmitted data packets; be sure to note the acknowledgement # contained in each ACK packet. The left timeline should reflect the behavior of TCP **without** fast retransmit and the right timeline should reflect the behavior of TCP **with** fast retransmit.



6. The figure below shows the size of the congestion window over the lifetime of a connection.

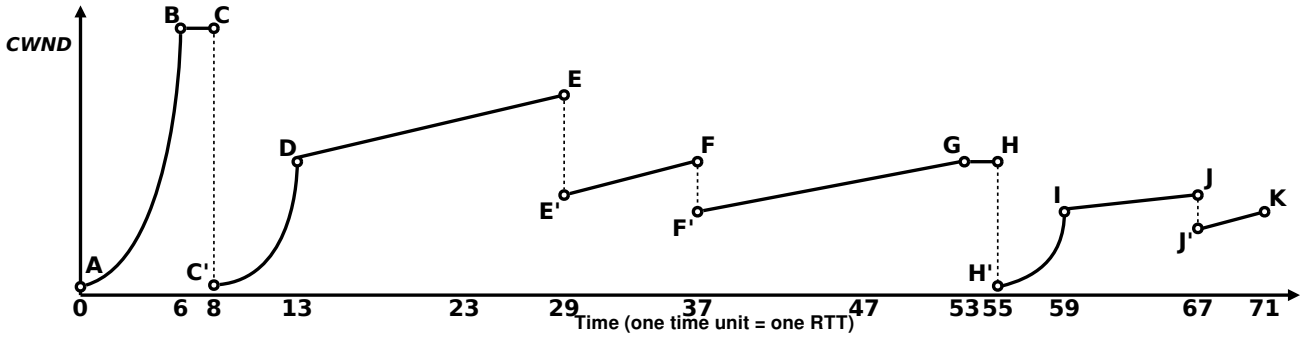


(a) During what time periods does slow start occur?

(b) At what time points does fast recovery occur?

(c) Label each letter in the figure with the value of the congestion window at that point.

7. The figure below shows the size of the congestion window over the lifetime of a connection.



(a) Identify all time intervals when the TCP flow is undergoing slow start.

(b) Identify all points where a timeout occurs.

(c) Identify all points where fast recovery occurs.

(d) Label each letter in the figure with the value of CWND at that point.

(e) Label each letter in the figure with the value of SSTHRESH at that point.