Lecture 12-13 Congestion Control Exercises

Q1 TCP Congestion Control (15 points)
Assumptions: all TCP values are measured in packets, the sender always has new data to send, RWND is very large, and ACK numbers carry the **next expected packet sequence number**. (Note: explanations are optional, but they may earn you partial credit even if you gave an incorrect answer key.)

Q1.1 (1 point) Immediately after the TCP handshake, suppose you set CWND = 5 packets. In general, not necessarily for this specific flow, why might senders initialize CWND to 5 instead of 1?

ANS:

Q1.2 (2 points) Immediately after the TCP handshake, you are in Slow Start mode, with CWND = 5, SSTHRESH = ∞, and the sender's first data packet has sequence number 20. Suppose you receive an ACK with acknowledgment number 21. At this point, which packets are allowed to be in flight?

ANS:

Q1.3 (2 points) Suppose you then receive an ACK with acknowledgment number 22. At this point, which packets are allowed to be in flight?

ANS:

The rest of this question is independent of earlier subparts, and each subpart continues from the previous one.

Some time later, you are in Slow Start mode, with CWND = 14, SSTHRESH = ∞, all packets up to and including 30 sent and acknowledged, packets 31 through 44 sent but not acknowledged, and all packets 45 and later not yet sent. Suppose packet 31 is dropped in transit, while later packets are successfully delivered and cause duplicate ACKs for the missing packet.

Q1.4 (1 point) In this scenario, TCP switches from Slow Start mode to Fast Recovery mode immediately after receiving which ACK?

ANS:

Q1.5 (2 points) What is the value of CWND the instant after TCP switches from Slow Start mode to Fast Recovery mode?

ANS:

Q1.6 (2 points) The receiver receives packets in this order: 32, 33, 34, …, 43, 44, 31 retransmitted. The sender receives the resulting ACKs in the same order, with no timeouts. What is the value of CWND the instant before TCP switches out of Fast Recovery mode?

ANS:

Q1.7 (2 points) What is the value of CWND the instant after TCP switches out of Fast Recovery mode?

ANS:

Q1.8 (2 points) At the instant before TCP switches out of Fast Recovery mode, which packets have been sent out? State the largest packet sequence number that has been sent.

ANS:

Q1.9 (1 point) After TCP switches out of Fast Recovery mode, what congestion-control mode is TCP in?

ANS:

Q2 TCP (10 points) **(Note: This question uses Byte numbers instead of packet sequence numbers.)** Assume a TCP sender has an **MSS of 100 B** and a **window size of 400 B**. **There is no congestion control, so the window size is constant.** The sender has just received ACK 1000, meaning the receiver has received all bytes up to byte 999 and is now expecting byte 1000. The timeout interval is constant and is denoted by RTO. Unless otherwise stated, all transmitted segments experience an RTT. Assume segments are never fragmented or reordered, and that losses occur only when explicitly stated. Each segment carries 100 bytes and is identified by the sequence number equal to the number of its first byte. Thus, the sender may transmit segments starting at bytes 1000, 1100, 1200, and so on. Assume TCP keeps a single timer for the segment containing the first unacknowledged byte, and when the first unacknowledged byte advances, the timer becomes associated with the new left edge of the window. All subparts are independent.

Q2.1 (1 point) Immediately after the sender processes **ACK 1000**, which byte is the first unacknowledged byte?

ANS:

Q2.2 (2 points) At the moment the sender transmits the segment whose first byte is **1600**, what is the highest ACK number the sender must already have received?

ANS:

Q2.3 (4 points) Assume that the only lost segment is the one whose first byte is **1400**.

(a) How does the sender detect the loss?

- Timeout
- 3 duplicate ACKs
- The sender does not detect the loss

ANS:

(b) After the retransmitted segment starting at byte **1400** is received successfully, what ACK number does the receiver send?

ANS:

Q8.4 (3 points) Assume every segment whose first byte is **1400 or larger** is dropped. When does the timer for byte 1400 start, and when does it expire?

ANS: