

Homework 3

Handed Out: October 2nd, 2023

Due: 11:59pm, October 18th, 2023

Students Name:

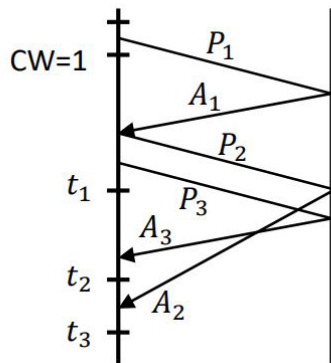
- Homework assignments must be submitted online through **Gradescope**. Hard copies are not accepted. Please submit a **pdf file** to Gradescope (<https://www.gradescope.com/courses/581425>). You can either type your solution or scan a **legible** hand-written copy. We will not correct anything we do not understand. Contact the TAs via email if you face technical difficulties in submitting the assignment.
- While we encourage discussion within and outside of the class, cheating and copying is strictly prohibited. Copied solutions will result in the entire assignment being discarded from grading at the very least and a report filed in the FAIR system. It is also your responsibility to ensure that your partner obeys the academic integrity rules as well.
- This assignment has a total of 110 points. The grade will be capped at 100 points.
- **Please write your answer in the white space to the right of the corresponding problem.**
- **We only allow at most 2-day late submission (either from requested exemption, or penalized) for this assignment.** All the submissions after **11:59pm, October 21st, 2023 WILL BE REJECTED (0 points)**.

1 Choose all the correct answers - 3×4 points

1. Assume TCP is in the Slow Start phase, with SSThreshold as 32. At some time instant, the congestion window is 16. When the congestion window increases the next time, it becomes 32. Assume TCP is ACKing all packets and that no ACKs are getting lost
 - (a) True
 - (b) False
2. A TCP socket is an end to end connection between two _____.
 - (a) threads
 - (b) processes
 - (c) devices
 - (d) hosts
3. Flow control regulates the congestion window, i.e., the congestion window is not increased when the receiver does not have adequate buffer space.
 - (a) True
 - (b) False
4. In Selective Repeat, the lower end of the transmitter's window can be _____ the lower end of the receiver's window.
 - (a) greater than
 - (b) equal to
 - (c) smaller than

2 TCP example 1 - 2×5 points

Assume TCP is at slow start phase.



1. CW at time $t_1 =$
2. CW at time $t_2 =$
3. CW at time $t_3 =$
4. How should the TCP transmitter react after receiving A_3 ? Please give CW_head , CW_tail , and $Send$

NOTE: For questions that ask how TCP reacts, the following fields are defined as:

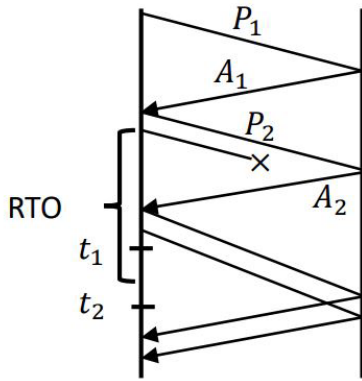
- CW_head : Congestion Window Head (also called Base); An integer
- CW_tail : Congestion Window Tail; An integer
- $SSthresh$: Slow Start Threshold; Numerical answers round to 1 decimal place.
- $Send$: The packets that need to be transmitted by the TCP transmitter. A sequence of numbers. When the transmitter has no packets to send, write [].

Example: If $CW=[4,5,6,7,8]$, then you should answer CW_head as 4 and CW_tail as 8.

5. How should the TCP transmitter react after receiving A_2 ? Please give CW_head , CW_tail , and $Send$

3 TCP example 2 - 2×5 points

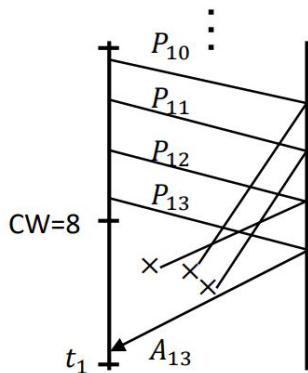
Assume TCP is at slow start phase from $CW=1$.



1. CW at time $t_1 =$
2. CW at time $t_2 =$
3. How should the TCP transmitter react after packet P3's timeout (shown in the figure)? Please give CW_head, CW_tail, SStresh, and Send
4. How should the TCP transmitter react when each of the last two ACKs (shown in the figure) arrive? Please give CW_head, CW_tail, SStresh, and Send

4 TCP example 3 - 3×2 points

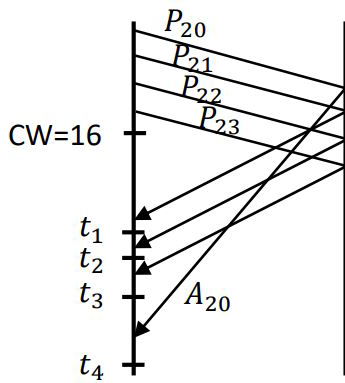
Assume packets before P10 have already been acknowledged in the past and TCP is in slow start.



1. CW at time $t_1 =$
2. How should the TCP transmitter react upon receiving A13? Please give CW_head, CW_tail, and Send

5 TCP example 4 - 2×8 points

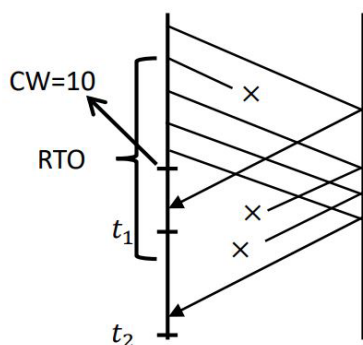
Assume packets before P20 have already been acknowledged in the past and TCP is in slow start.



1. CW at time $t_1 =$
2. CW at time $t_2 =$
3. CW at time $t_3 =$
4. CW at time $t_4 =$
5. How should the TCP transmitter react upon receiving A21? Please give CW_head, CW_tail, and Send
6. How should the TCP transmitter react upon receiving A22? Please give CW_head, CW_tail, and Send
7. How should the TCP transmitter react upon receiving A23? Please give CW_head, CW_tail, and Send
8. How should the TCP transmitter react upon receiving A20? Please give CW_head, CW_tail, and Send

6 TCP example 5 - 2×5 points

Assume that the first ACK that is shown to arrive at the TCP transmitter is A5 and TCP is in slow start. Also assume packets before P5 have already been acknowledged in the past.

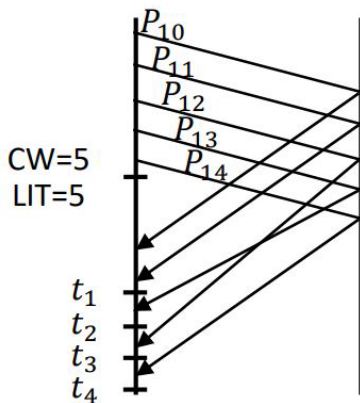


1. CW at time $t_1 =$

2. CW at time $t_2 =$
3. How should the TCP transmitter react upon receiving A5, when the timeout occurs, and upon receiving the last shown ACK (just before t_2)? Please give CW_head, CW_tail, and Send
4. How should the TCP transmitter react after timeout: ? Please give CW_head, CW_tail, **SSthresh**, and Send
5. How should the TCP transmitter react after receiving last shown ACK: Please give CW_head, CW_tail, **SSthresh**, and Send

7 TCP example 6 - $5 + 2 * 5$ points

SSthresh is also sometimes known as "linear increase threshold (LIT)". The LIT shown in the figure means SSthresh. Assume packets before P10 have already been acknowledged in the past.



1. What should the values of CW be at times t_1 , t_2 , t_3 , and t_4 ? (Round to 1 decimal place)
2. How should the TCP transmitter react upon receiving A10? Please give CW_head, CW_tail, **SSthresh**, and Send
3. How should the TCP transmitter react upon receiving A11? Please give CW_head, CW_tail, **SSthresh**, and Send
4. How should the TCP transmitter react upon receiving A13? Please give CW_head, CW_tail, **SSthresh**, and Send
5. How should the TCP transmitter react upon receiving A12? Please give CW_head, CW_tail, **SSthresh**, and Send
6. How should the TCP transmitter react upon receiving A14? Please give CW_head, CW_tail, **SSthresh**, and Send

8 T/F Question - 4×4 points

Considering the Selective ACK protocol, please answer following question and justify your answer.

1. Can Receiver's base sequence number be smaller than transmitter's base sequence number?
2. Receiver's base sequence number can be smaller than transmitter's tail sequence number?
3. Receiver's base sequence number can be larger than transmitter's tail sequence number.
4. Receiver's base sequence number can be larger than transmitter's tail sequence number plus one.

9 Sequence Number Space - 3×5 points

Consider the Go-Back-N protocol with a send window size of N and a large sequence number range. Suppose that at time t , the next in-order packet that the receiver is expecting has a sequence number of k . Assume that, the medium may drop packets but does not reorder messages. Also, "window-base" as taught in class is also called the "window-head".

1. What is the lower bound of sequence number (inclusive) for the head of the sender's window at time t ?
2. What is the upper bound of sequence number (inclusive) for the head of the sender's window at time t ?
3. What is the lower bound of the ACK sequence number field (inclusive) in the message currently propagating back to the sender at time t ?
4. What is the upper bound of the ACK sequence number field (inclusive) in the message currently propagating back to the sender at time t ?
5. With the Go-Back-N protocol, is it possible for the sender to receive an ACK for a packet that falls outside of its current window?

10 Self-practice Question (0 points) - 0 points

These questions are for you to think and answer but has no points associated to them. The solutions to these questions will be released with the HW solutions.

Please identify if each statement is true or false, and use one sentence within 20 words to justify your reason.

1. Although small, the TCP ACKs still consume some bandwidth. It would be better if the TCP receiver only sends NACKs upon receiving out of order (or

corrupted) packets. (T/F)

2. The TCP sender has packets 20 to 30 in its congestion window (CW), all waiting for ACKs, when a timeout occurs. The sender will cut down CW to 1 and will have to gradually retransmit each of these packets (from 20 to 30).
3. TCP can cope with any amount of losses, and hence, TCP should work without modifications on lossy wireless networks.
4. The Selective Repeat receiver need not send an ACK if the received packet is less than its lower end of the (current) receive window.