Homework 3

Handed Out: November 20th, 2023 ***Due: December 4th, 2023***

- Homework assignments must be submitted online through Blackboard. Hard copies are not accepted. Please submit a pdf file to Blackboard. 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. It is also your responsibility to ensure that your partner obeys the academic integrity rules as well.
- This assignment has a total of 100 points.
- **Please write your answer in the white space to the right of the corresponding problem**.

1 Choose all that Apply - 3 × 3 points

Each question may have more than one correct answer. You will only get points if you identify all the correct answers.

1. A TCP socket is an end to end connection between two_.

   (a) processes

   (b) threads

   (c) hosts

   (d) devices

Answer: a

2. Suppose Host A sends one segment with sequence number 40 and 8 bytes of data over a TCP connection to Host B. In this same segment the acknowledgement number is necessarily 48.

   (a) True

   (b) False

Answer: b

3. Consider Selective ACK protocol. Choose all that apply

   (a) Receiver's base sequence number can be smaller than transmitter's base sequence number

   (b) Receiver's base sequence number can be smaller than transmitter's tail sequence number

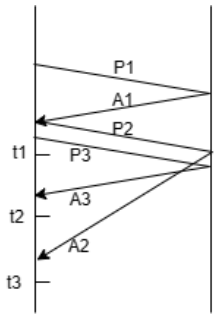
   (c) Receiver's base sequence number can be larger than transmitter's tail sequence number.

   (d) Receiver's base sequence number can be larger than transmitter's tail sequence number plus one.

Answer: bc

2 TCP examples 1 - 2 × 3 + 3 points

Assume TCP is at slow start phase from CW = 1



1. CW at time t1 =
Answer: 2

2. CW at time t2 =
Answer: 4

3. CW at time t3 =
Answer: 4

4. How should the TCP transmitter react after receiving A3? 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.

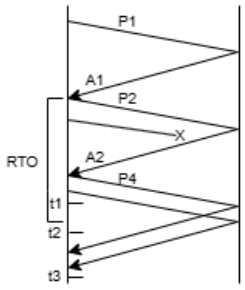
A sequence of numbers. When the transmitter has no packets to send, write [].

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

5. How should the TCP transmitter react after receiving A2? Please give CW_head, CW_tail, and Send
Answer: CW_head = 4, CW_tail = 7, Send = []

3 TCP example 2 - 2 x 3 + 4 x 3 points

Assume TCP is at slow start phase from CW = 1



1. CW at time t1 =
Answer: 3

2. CW at time t2 =
Answer: 1

3. CW at time t3 = Answer: 1

4. How should the TCP transmitter react after receiving packet P3's timeout? Please give CW_head, CW_tail, SSthresh and Send

Answer: CW_head = 3, CW_tail = 3, SSthresh = 1, Send = [3]

5. How should the TCP transmitter react after receiving the penultimate ACK shown in graph? Please give CW_head, CW_tail, SSthresh and Send

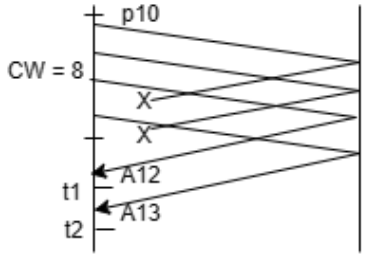
Answer: CW_head = 3, CW_tail = 3, SSthresh = 1, Send = []

6. How should the TCP transmitter react after receiving the last shown ACK? Please give CW_head, CW_tail, SSthresh and Send

Answer: CW_head = 3, CW_tail = 3, SSthresh = 1, Send = []

4 TCP example 3 - 2 x 2 + 3 points

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



1. CW at time t1 =
Answer: 11

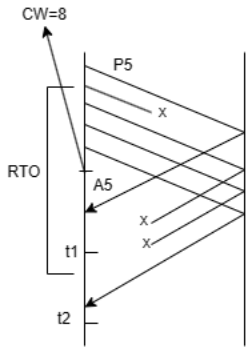
2. CW at time t2 =
Answer: 12

3. How should the TCP transmitter react after receiving A13? Please give CW_head, CW_tail, and Send

Answer: Answer: CW_head = 14, CW_tail = 25, Send =[24,25]

5 TCP example 4 - 2 x 2 + 3 + 4 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 t1 =
Answer: 9

2. CW at time t2 =
Answer: 1

3. How should the TCP transmitter react after receiving A5? Please give CW_head, CW_tail, and Send

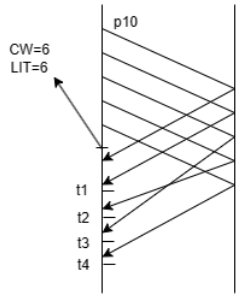
Answer: Answer: CW_head = 6, CW_tail = 14, Send =[10, 11, 12, 13, 14]

4. How should the TCP transmitter react after timeout? Please give CW_head, CW_tail, SSthresh and Send

Answer: CW_head = 6, CW_tail = 6, SSthresh = 4.5, Send =[6]

6 TCP example 5 - 4 × 6 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 t1, t2, t3, and t4? (Round to 1 decimal place)
Answer: 6.3, 6.7, 6.7, 6.8

2. How should the TCP transmitter react upon receiving A10? Please give CW_head, CW_tail, SSthresh, and Send
Answer: CW_head = 11, CW_tail = 16, SSthresh = 6, Send =[15, 16]

3. How should the TCP transmitter react upon receiving A11? Please give CW_head, CW_tail, SSthresh, and Send
Answer: CW_head = 12, CW_tail = 17, SSthresh = 6, Send =[17]

4. How should the TCP transmitter react upon receiving A13? Please give CW_head, CW_tail, SSthresh, and Send
Answer: CW_head = 14, CW_tail = 19, SSthresh = 6, Send =[18, 19]

5. How should the TCP transmitter react upon receiving A12? Please give CW_head, CW_tail, SSthresh, and Send
Answer: CW_head = 14, CW_tail = 19, SSthresh = 6, Send =[]

6. How should the TCP transmitter react upon receiving A14? Please give CW_head, CW_tail, SSthresh, and Send
Answer: CW_head = 15, CW_tail = 20, SSthresh = 6, Send =[20]

7 T/F Question - 5 + 5 points

Answer true or false of the following questions and briefly justify your answer:

1. With SR protocol, it is possible for the sender to receive an ACK for a packet that falls outside of its current window.
Answer: True. Suppose the sender has a window size of 3 and sends packets 1, 2, 3 at t0. At t1 (t1 > t0) the receiver ACKS 1, 2, 3. At t2 (t2 > t1) the sender times out and resends 1, 2, 3. At t3 the receiver receives the duplicates and re-acknowledges 1, 2, 3. At t4 the sender receives the ACKs that the receiver sent at t1 and advances its window to 4, 5, 6. At t5 the sender receives the ACKs 1, 2, 3 the receiver sent at t2 . These ACKs are outside its window.

2. With GBN, it is possible for the sender to receive an ACK for a packet that falls outside of its current window.
Answer: True. By essentially the same scenario as in (a).

8 GBN Question - 6 x 2 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 are the possible set of sequence number inside the sender's window at time t? Justify your answer.
Here we have a window size of N. Suppose the receiver has received packet k-1, and has ACKed that and all other preceding packets. If all of these ACK's have been received by sender, then sender's window is [k, k+N-1]. Suppose next that none of the ACKs have been received at the sender. In this second case, the sender's window contains k-1 and the N packets up to and including k-1. The sender's window is thus [k-N,k-1]. By these arguments, the senders window is of size N and begins somewhere in the range [k-N,k].

2. What are all possible values of ACK field in all possible message currently propagting back to the sender at time t? Justify your answer.
If the receiver is waiting for packet k, then it has received (and ACKed) packet k-1 and the N-1 packets before that. If none of those N ACKs have been yet received by the sender, then ACK messages with values of [k-N,k-1] may still be propagating back.Because the sender has sent packets [k-N, k-1], it must be the case that the sender has already received an ACK for k-N-1. Once the receiver has sent an ACK for k-N-1 it will never send an ACK that is less that k-N-1. Thus the range of in-flight ACK values can range from k-N-1 to k-1.