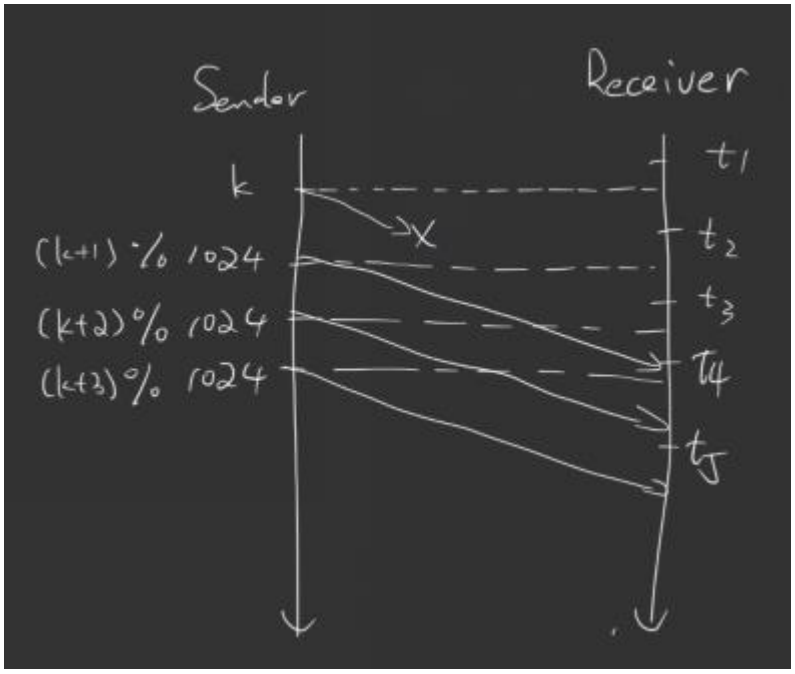
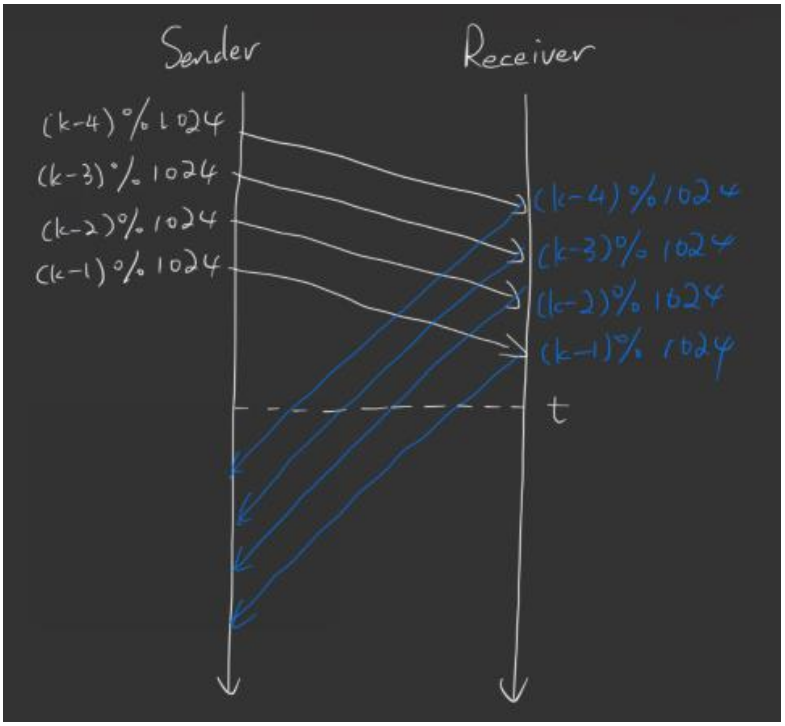
## Q1:

**a.**




As we can see in the picture. At time t1, t2, t3, t4, t5, the next in-order packet that the receiver is expecting all has a sequence number of k. However, at time t1, the send base of the sender is k, the next sequence number is k. At time t2, the send base of the sender is k, the next sequence number is (k +1) % 1024. At time t3, the send base of the sender is k, the next sequence number is (k +2) % 1024. At time t4, the send base of the sender is k, the next sequence number is (k +3) % 1024. At time t5, the send base of the sender is k, the next sequence number is (k +4) % 1024.

**b.**



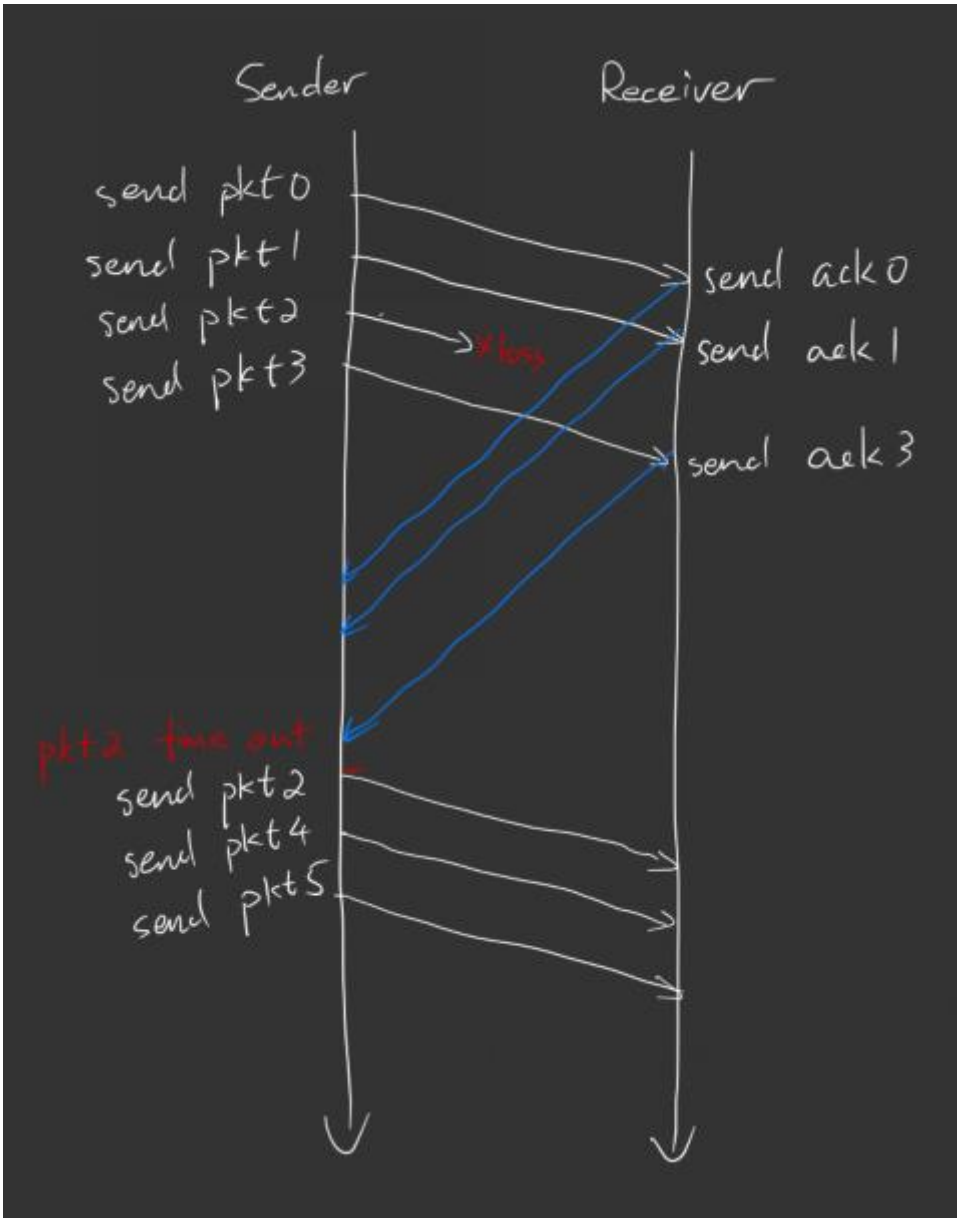
As we can see in the picture. At time t, the next in-order packet that the receiver is expecting all has a sequence number of k. In this situation, there are four ACK messages are currently being propagating back to the sender which are ACK message for (k - 4) % 1024, (k - 3) % 1024, (k - 2) % 1024, (k - 1) % 1024. These are all possible values of the ACK field in all possible messages currently propagating back to the sender at time t.

## Q2:

The selective repeat protocol is used because the ack3 is sent when receiver receives pkt3. If it is Go-Back-N protocol, the receiver will send ack1 instead of ack3.

**a.** The position of sender window is 0 to 3. The position of receiver window is 2 to 5.

**b.**

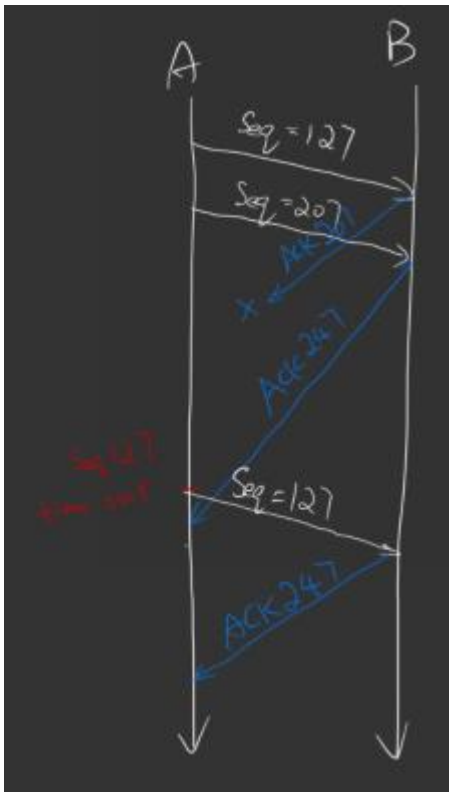


## Q3:

**a.** 110 – 90 = 20 bytes
**b.** It will be acknowledgment 110.

## Q4:

**a.** The sequence number is 127 + 80 = 207
The source port is 302 and the destination port is 80.
**b.** The acknowledgment number is 127 + 80 = 207
The source port is 80 and the destination port is 302.
**c.** The acknowledgment number is 127, the source port is 80 and the destination port is 302.
**d.**




## Q5:

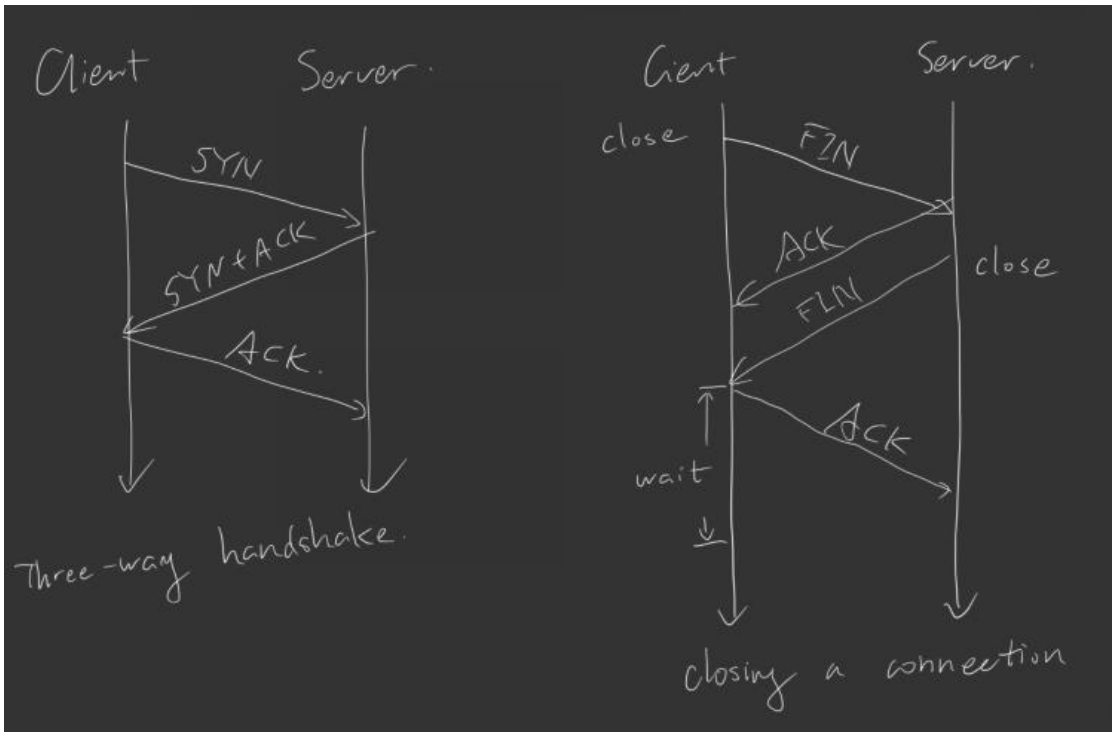
**a.** from 1st to 6th and 23rd to 26th transmission round
**b.** from 6th to 23rd transmission round
**c.** A triple duplicate ACK.
**d.** A timeout.
**e.** 32
**f.** 21
**g.** 14
**h.** 7th transmission round
**i.** congestion window size = 8 / 2 + 3 = 7
ssthresh = 8 / 2 = 4

**j.** ssthresh = 42 / 2 = 21
congestion window = 1 * 2 * 2 = 4 segments
**k.** 1 + 2 + 4 + 8 + 16 + 32 = 63 packets

## Q6:

**a.** 2 ^ (4 * 8) * 536 = 2Tb
**b.** 2 ^ (4 * 8) * (536 + 66) * 8 / (155 * 1024 * 1024) = 127266 s = 2121 min = 35 h

## Q7:




## Q8:

Sequence number = 65530
Acknowledgement number = 81920 + 10240 = 92160

## Q9:

Since rwnd is bigger than cwnd, the number of bytes that can be sent is determined by cwnd.
So 3000 – 2000 = 1000 more bytes can be sent.

## Q10:

| Transmission# | Congestion Window | Threshold | Receive Window |
|---|---|---|---|
| 1 | 4Kb | 12Kb | 32Kb |
| 2 | 8Kb | 12Kb | 32Kb |
| 3 | 16Kb | 12Kb | 32Kb |
| 4 | 20Kb | 12Kb | 32Kb |
| 5 | 24Kb | 12Kb | 32Kb |
| 6 | 28Kb | 12Kb | 32Kb |
| 7 | 32Kb | 12Kb | 32Kb |
| 8 | 4Kb | 16Kb | 32Kb |
| 9 | 8Kb | 16Kb | 32Kb |
| 10 | 16Kb | 16Kb | 32Kb |
| 11 | 20Kb | 16Kb | 32Kb |
| 12 | 24Kb | 16Kb | 32Kb |
| 13 | 28Kb | 16Kb | 32Kb |
| 14 | 32Kb | 16Kb | 32Kb |
| 15 | 36Kb | 16Kb | 32Kb |
| 16 | 30Kb | 18Kb | 32Kb |
| 17 | 34Kb | 18Kb | 32Kb |
| 18 | 4Kb | 17Kb | 32Kb |
| 19 | 8Kb | 17Kb | 32Kb |
| 20 | 16Kb | 17Kb | 32Kb |
| 21 | 32Kb | 17Kb | 32Kb |
| 22 | 36Kb | 17Kb | 32Kb |
| 23 | 4Kb | 18Kb | 32Kb |
| 24 | 8Kb | 18Kb | 32Kb |

The sender attempts to send 8Kb data on the 24th transmission.