Computer Networks
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Homework 5

Problem 5.1

Solution:

a) SEQ = 1030, ACK= 3848, F=ACK, WIN=4000. This segment carried 1200 bytes of data (payload).

b) The server sends two almost identical acknowledgments in order to inform the other side of the connection that the window size has changed since the data that was stored in the buffer has been consumed. We see that in segment 12, the window size is 200, which means that at this point the client is informed that the sender is willing to receive only 200 bytes. Then, in segment 13, the window size is increased back to 4000 from the server since it needs to store the payload, and meanwhile it it did not receive any acknowledgement from the client.

c) Selective acknowledgements extensions enable a receiver to send the received segment range to the sender in the duplicate acknowledgement. It is used when the packet is lost even though the duplicate data may have arrived, in order to inform the sender concerning the data that was not lost during the transmission, so that it can send only the missing part of the segment. The two numbers in the SACK extensions stand for the left edge and the right edge of the received segment. This option is very useful in the case of lost packets and duplicate acknowledgement numbers, because, since the missing data cannot be found, it makes possible to specify what was received, such that the sender can retransmit and track the packets accordingly.

d) The server could have used selective acknowledgements in the 8^{th} segment in order to indicate the received packets. The Left Edge and Right Edge numbers of the selective acknowledgments in this case would be 3430 and 4630 respectively.

e) We can see that in segment 14, the client sends the flags F=ACK,FIN, which means that it is trying to end its communication with the server. After that, in segment 15, the server receives the flags from the client and sends F=ACK,FIN too. In segment 16, the client sends the ACK flag and at this moment, the client enters the `TIME_WAIT` state, in case ACK got lost in the flight. This means that the client will not receive data from the server for some time, and after the server enters the `CLOSED` state, the client also goes in the `CLOSED` state.

Problem 5.2

Solution:

a) Considering the fact that there are 1300000 bytes (max ACK from the server) in the specified time interval and 12.5 - 0.5 = 12 is the interval, the average data rate during the entire data transfer is: $\frac{1300000}{12} \approx 108333$ B/s.

b) We check for this part the ACK line and the receive window line. We find the minimum and maximum value of the difference between these lines, which gives the respective minimum and maximum receive window size:
* Min: 30000 bytes.
* Max: 300000 bytes.

c) Considering the dark red lines from the graph that show the stacked TCP segments, we can observe that at t = 12, there are 6 segments in total that are lost and not yet successfully retransmitted.

d) At the beginning of a data transfer, a TCP connection is formed and from t=0.5 to t=1.4, many TCP segments are transferred. However, a lot of them are lost and retransmitted during the interval t=[1.6, 3.3]. After that, a normal TCP communication continues.