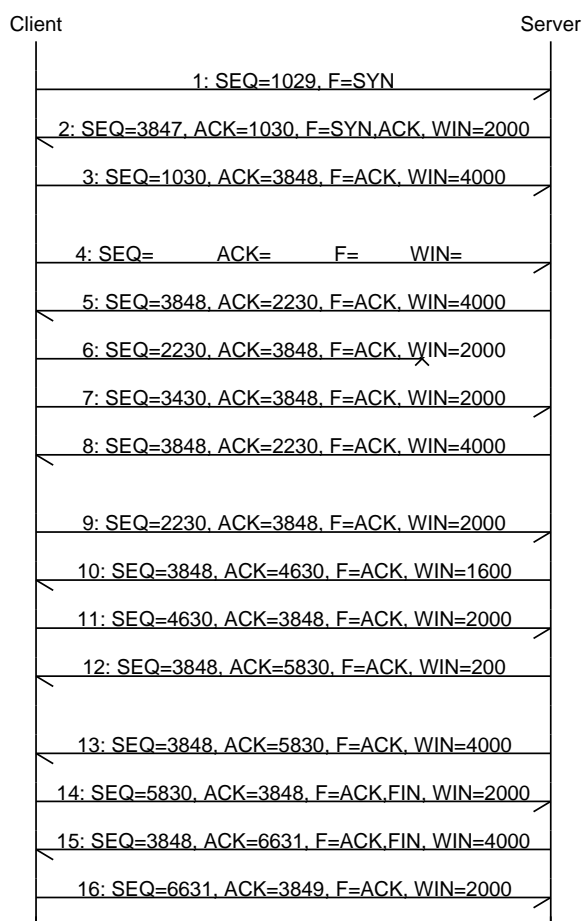


CN 2019 Problem Sheet #5

Problem 5.1: *tcp selective acknowledgements*

(1+1+2+1+1 = 6 points)

A TCP client connects to a TCP server. Once the connection has been established, the client pushes data to the server. The following time sequence graph describes the exchange of TCP segments between the client and the server. For each TCP segment, the sequence number, the acknowledgment number, the flags, and the receive window size are shown in the label.

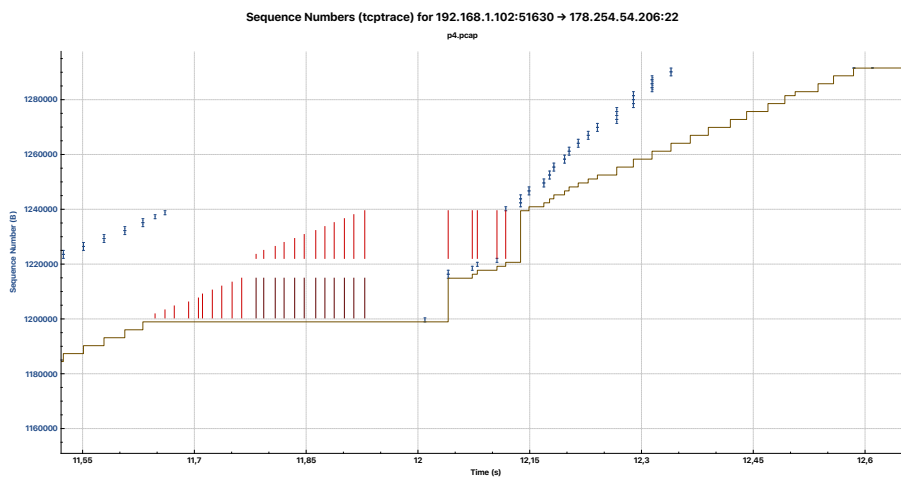
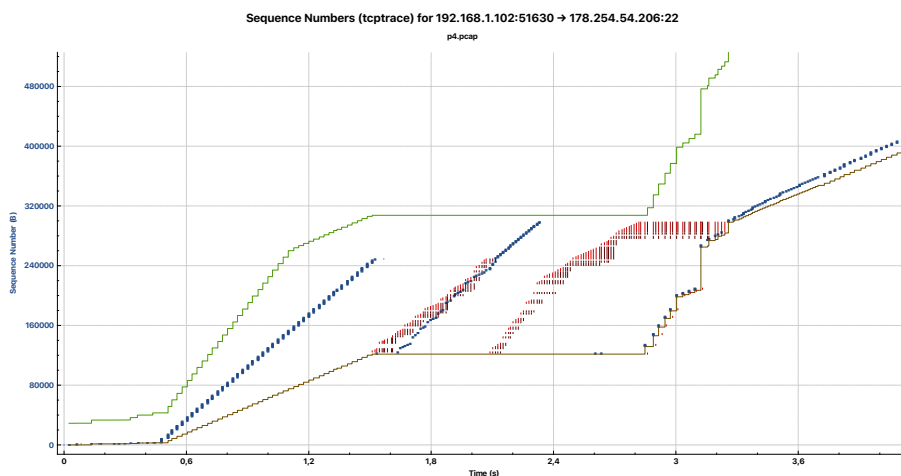
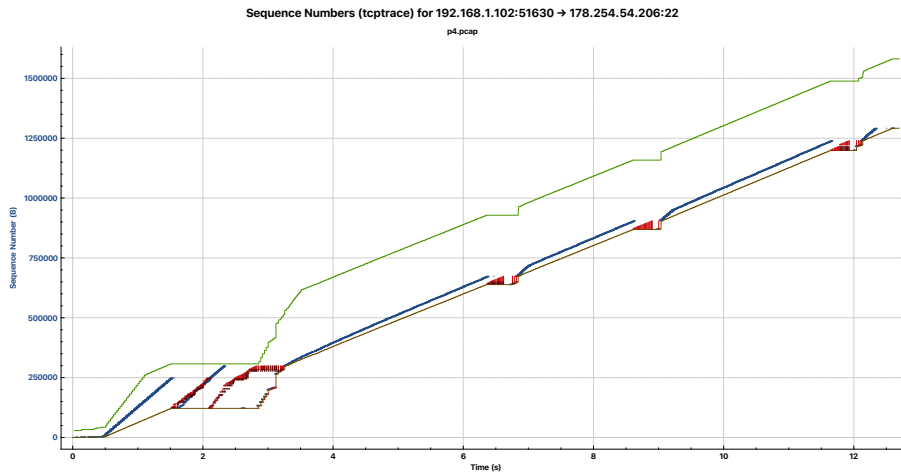


- What are the sequence number, the acknowledgment number, the flags, and the receive window in TCP segment 4? How much data (payload) did this segment carry?
- Why does the server send two almost identical acknowledgments (segments 12 and 13)? What has likely happened on the server between the sending of segment 12 and the sending of segment 13?
- RFC 2018 introduced a TCP extension to carry selective acknowledgments (SACK) in TCP header options. Explain *in your own words* how selective acknowledgments work and why they are useful. What exactly do the two numbers carried in the SACK option for each block indicate?
- In which TCP segment could the server have used selective acknowledgments? What are the Left Edge and Right Edge numbers of the selective acknowledgments?
- Does the client's or the server's TCP state machine go into the TIME_WAIT state? Explain.

Problem 5.2: tcp trace analysis

(1+1+1+1 = 4 points)

A file has been copied to a remote server and a 'tcptrace diagram' has been produced using wireshark. The following plots are using vector graphics and hence they are zoomable so you can look into the details. A good description of tcptrace diagrams can be found on the blog post [Understanding the tcptrace Time-Sequence Graph in Wireshark](#).



- a) What was the average data rate during the entire data transfer (time interval $[0.5, 12.5]$)?
- b) What was the minimum and the maximum receive window size during the data transfer?
- c) How many segments were lost and not yet successfully retransmitted at $t = 12$?
- d) Describe what is happening at the beginning of the data transfer (time interval $[0.5, 3.5]$)?