Internet Infrastructure and Protocols (COMP5311)

Solution to Assignment Two

Each question carries 8 marks, unless stated otherwise.

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1) Consider that an IP packet of 1500 bytes (with destination address as D and a 20-byte IP header) entering into a router R, and the packet will be tunneled before forwarding. The tunnel MTU is assumed to be 1480 bytes. Therefore, IP fragmentation is required for this packet. In this question, we explore a fragment-first-and-then-tunnel approach. Using this approach, the IP packet will be first fragmented in packets not exceeding the tunnel MTU, and then each fragment is tunneled by encapsulating the fragment with a 20-byte IP header.
   a) (3 marks) What is the size of the second fragment?
   b) (3 marks) If there is no further fragmentation, where will the fragments be reassembled? The exit tunnel endpoint or D?
   c) (2 marks) If the fragments are further fragmented in the path between the two tunnel endpoints, where will these fragments of fragments be reassembled? Assume that there is no other IP tunnel in the path.

   Solutions:
   a) (3 marks) The size is 60 bytes: 20 bytes for the tunnel header, 20 bytes for the original IP header, and 20 bytes for the IP payload.
   b) (3 marks) The fragments will be reassembled at D, because the inner IP headers contain the fragmentation information.
   c) (2 marks) The fragments of fragments will be reassembled at the tunnel exit endpoint, because the the outer IP headers contain the fragmentation information.
2) When a TCP node receives a valid TCP data segment from the other side of a TCP connection, it has to check, among others, whether the data sent in the segment has been received before. If positive, it will discard the duplicate data. Let SEQ be the sequence number in the TCP data packet and LEN be the length of the TCP packet's payload.
   a) (2 marks) Give the condition in terms of the state variables kept by the receiver (e.g., `rcv_nxt` and `rcv_wnd`) that at least some data in the TCP packet are duplicate.
   b) (3 marks) Give the condition in terms of the state variables kept by the receiver (e.g., `rcv_nxt` and `rcv_wnd`) and LEN that the entire payload of the TCP packet is duplicate.
   c) (3 marks) If the entire payload is a duplicate, it is essential for the receiver to send an ACK to the sender before dropping the data. Explain why this is necessary.

   Solutions:
   a) (2 marks) The condition is $SEQ <$ `rcv_nxt`.
   b) (3 marks) The condition is `rcv_nxt` $- SEQ \geq LEN$.

c) (3 marks) A possible reason for the sender to send multiple copies is that it does not receive the receiver's ACK. By not responding with an ACK, the sender will continue to interpret that the data segment concerned is lost and will retransmit it again.

3) Figure 1 shows a Wireshark trace of a web session: from a client with port 65416 to a server with port 80. Assume that both sides use an initial sequence number (SN) of 0. Therefore, the SN and the acknowledgment number (AN) in the SYN-ACK packet are 0 and 1, respectively. The SN and AN in the third hand-shaking packet are both 1.

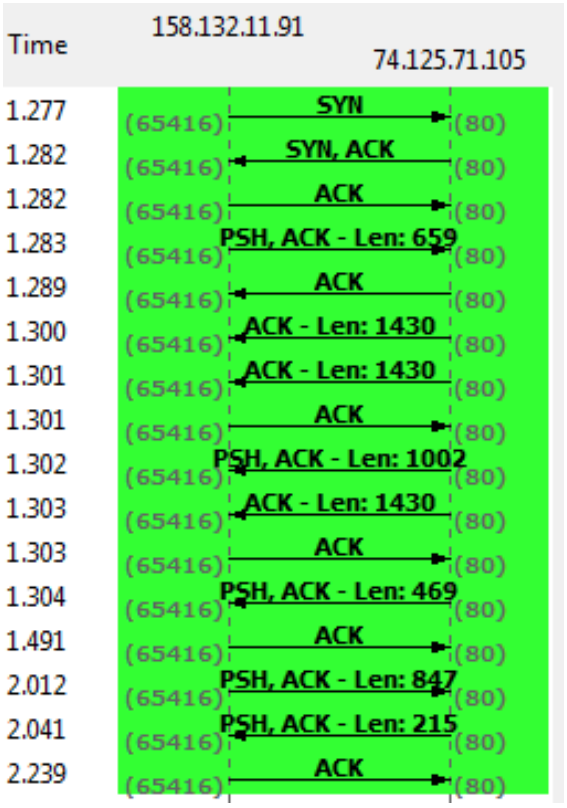

Fig. 1. TCP transmissions in a web session.

Answer the following questions concerning Figure 1 with succinct explanation.

a) (2 marks) What is the server's `snd_nxt` just after sending the SYN-ACK packet at time 1.282?

b) (2 marks) What is the client's `snd_nxt` just after sending the data packet at time 1.283 (i.e., the fourth packet in Figure 1)?

c) (2 marks) What is the client's `rcv_nxt` just after receiving the data packet from the server at time 1.301 (i.e., the seventh packet in Figure 1)?

d) (2 marks) What is the AN in the last packet in Figure 1?

Solutions: Referring the packet sequence in Figure 2, we have

a) (2 marks) The server's `snd_nxt` is 1, because the SYN packet takes up a sequence number.

b) (2 marks) The client's `snd_nxt` is 660, because it just sent out 659 bytes of data.

c) (2 marks) The client's `rcv_nxt` is 2861, because it has received a total of 2860 bytes of data from the server.

d) (2 marks) The AN is 5977, because a total of 5976 bytes of data have been received from the server.

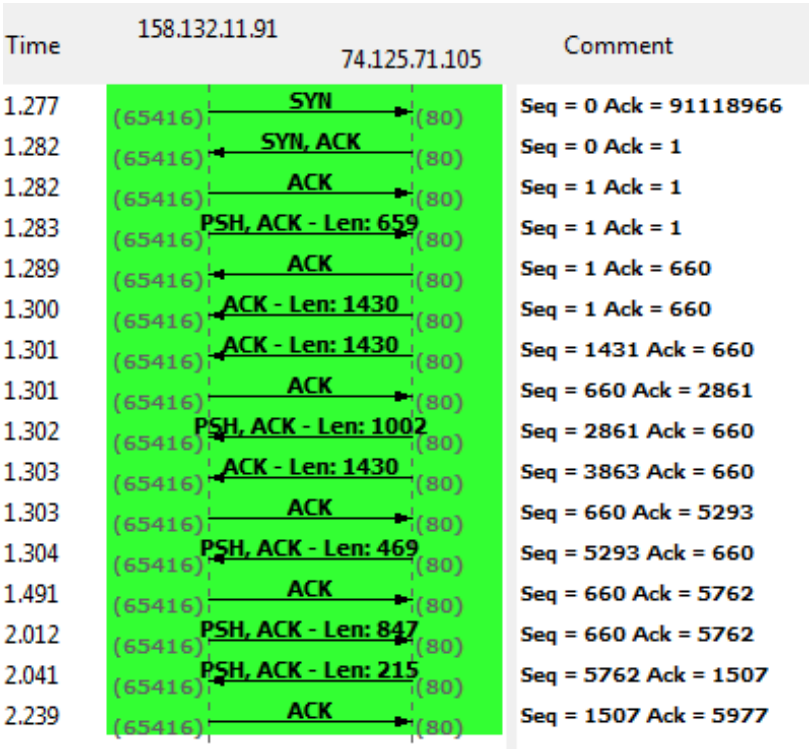

Fig. 2. The TCP transmissions in a web session with the SNs and ANs.