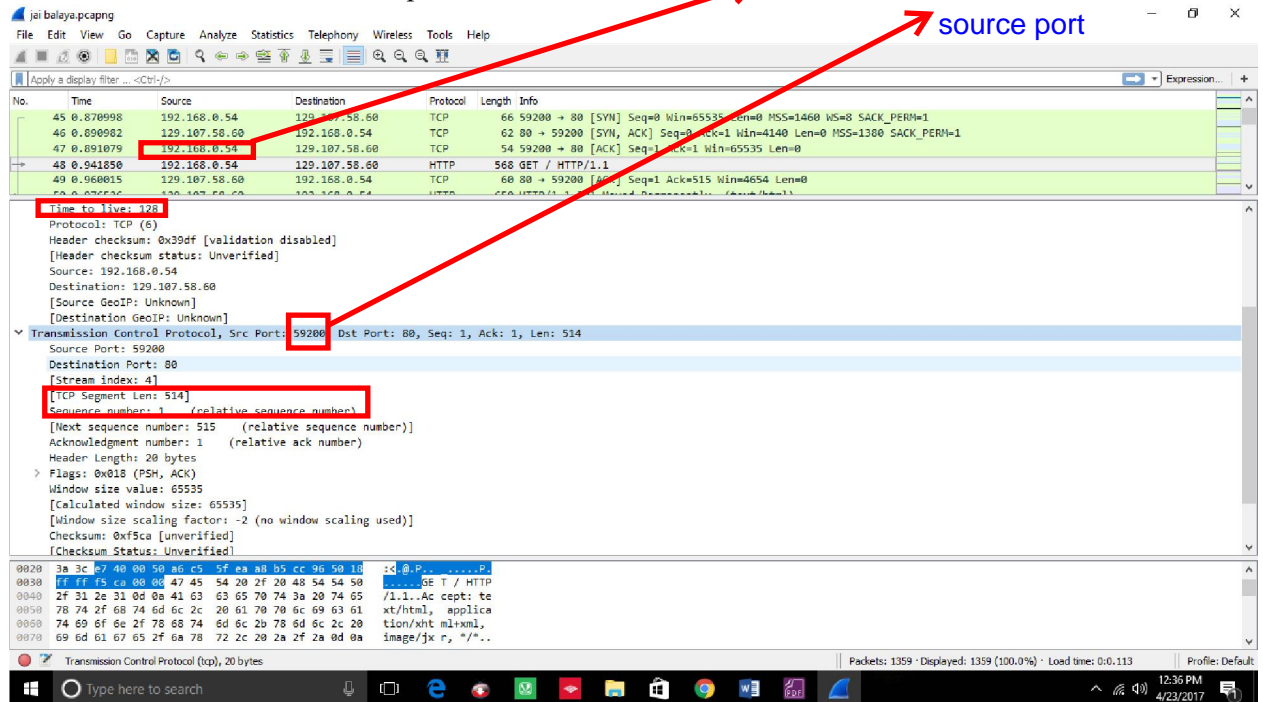


Problem set-1

- Source IP address:-192.168.0.54, port number:-59200

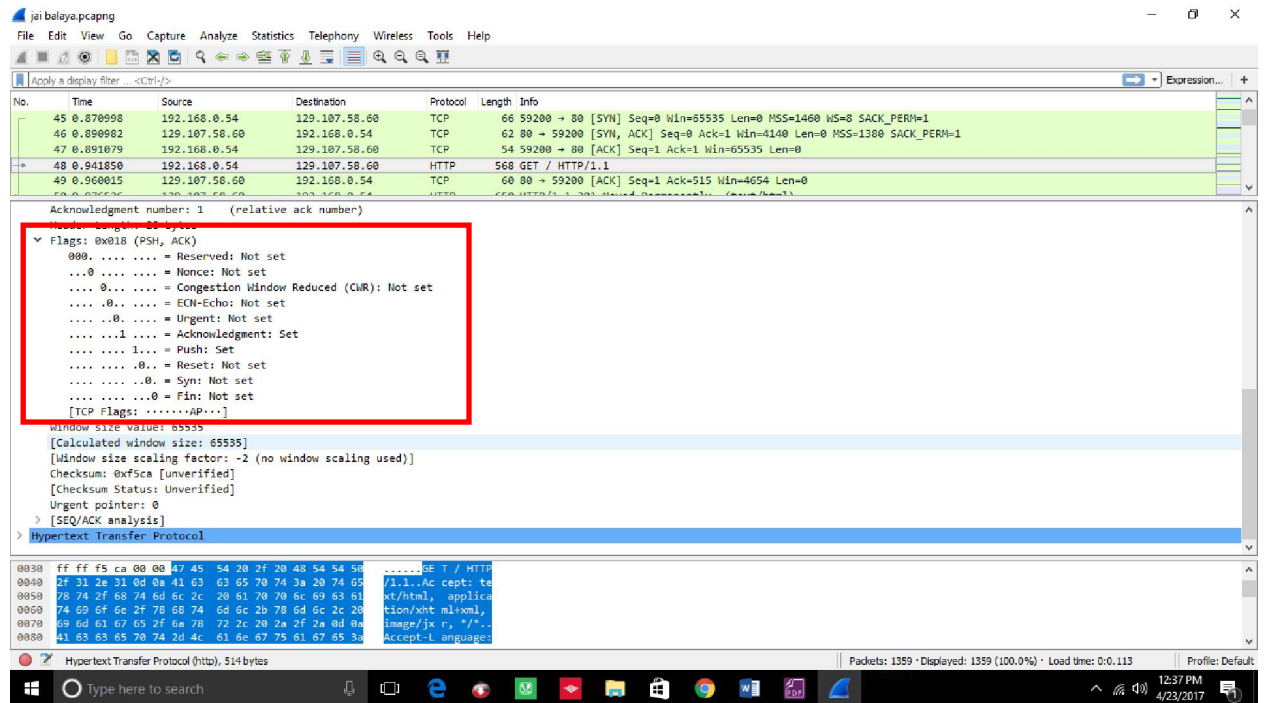
source ip address

source port



- 128
- IPv4
- No information is present.
- No, the packet is not fragmented.
- TCP segment length: 514
- Sequence number: 1
- Acknowledgement number: 515
- Reserved, Nonce, Congestion Window Reduced(CWR), ECN-Echo, Urgent, Acknowledgement, Push, Reset, Syn, Fin.

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10. Destination IP address:- 129.107.58.60 destination port number:-80

Problem set-2

11.2.630757	2605:6800:8bd7:d000::2607:f800:4000:80c1::	TCP	52 53104 → 443 [SYN] Seq=0 Win=55535 Len=0 MSS=1460 SACK_PERM=1
12.2.630757	2605:6800:8bd7:d000::2607:f800:4000:80c1::	QUIT	752 Payload (Encrypted), PKT= 2, CID: 3632444332087452424
12.2.630640	209.18.47.61	DNS	125 Standard query response 0xab63 A www.youtube.com CHAVE youtube-ui.l.google.com A 216.58.218.110
13.2.638407	192.168.0.54	DNS	79 Standard query 0x2b65 A fls.doubleclick.net
14.2.646244	2605:6800:8bd7:d000::2607:f800:4000:814::	OUT	1412 Client Hello, PKT= 1, CID: 2402660847150938031
15.2.647579	2607:f800:4000:80c1::2605:6800:8bd7:d000::	TCP	52 443 → 53104 [SYN, ACK] Seq=0 Ack=1 Win=27200 Len=0 MSS=1360 SACK_PERM=1
16.2.648091	2605:6800:8bd7:d000::2607:f800:4000:80c1::	TCP	74 53104 → 443 [ACK] Seq=1 Ack=1 Win=65280 Len=0

1. The sequence number is 0.
2. the SYN flag for this segment has been set to 1, implying that this segment is a SYN segment.
3. The sequence number is 0, Acknowledgement number is 1.
4. The SYNACK packet is acknowledging the previously received SYN packet with the sequence number 0 and since this SYN segment does not contain any data, the TCP receiver on the web server simply increments this value by 1 and copies it to the acknowledgement field. The server is thus indicating to the client that the next segment, which it expects from the client, should contain the sequence number 1. The ACK flag is set to 1 indicating that this is an ACK segment.

Problem set-3

140.4.081562	172.20.10.2	23.235.44.231	TCP	1454 [TCP segment of a reassembled PDU]
141.4.081562	172.20.10.2	23.235.44.231	TCP	201 [TCP segment of a reassembled PDU]
142.4.081563	172.20.10.2	23.235.44.231	HTTP	75 POST /vjs/page/hotel/results HTTP/1.1 (application/x-www-form-urlencoded)
143.4.082853	172.20.10.2	209.105.248.3	TLSv1	583 Client Hello
144.4.135363	23.235.44.231	172.20.10.2	TCP	66 80 → 55790 [ACK] Seq=56130 Ack=2803 Win=72 Len=0 TSval=51237230 TSecr=105870899
145.4.135713	23.235.44.231	172.20.10.2	TCP	66 80 → 55790 [ACK] Seq=56130 Ack=2938 Win=77 Len=0 TSval=51237230 TSecr=105870899
146.4.135716	23.235.44.231	172.20.10.2	TCP	66 80 → 55790 [ACK] Seq=56130 Ack=2947 Win=77 Len=0 TSval=51237230 TSecr=105870899
147.4.136062	209.105.248.3	172.20.10.2	TLSv1	211 Server Hello, Change Cipher Spec, Encrypted Handshake Message
148.4.136121	172.20.10.2	209.105.248.3	TCP	66 55806 → 443 [ACK] Seq=518 Ack=146 Win=131712 Len=0 TSval=1058708952 TSecr=98461204
149.4.136418	172.20.10.2	209.105.248.3	TLSv1	72 Change Cipher Spec
150.4.136474	172.20.10.2	209.105.248.3	TLSv1	119 Encrypted Handshake Message
151.4.137150	172.20.10.2	209.105.248.3	TLSv1	503 Application Data
152.4.151176	23.235.44.231	172.20.10.2	TCP	1016 [TCP segment of a reassembled PDU]
153.4.151188	23.235.44.231	172.20.10.2	HTTP	88 HTTP/1.1 302 Found (text/plain) (text/plain)
154.4.151247	172.20.10.2	23.235.44.231	TCP	66 55789 → 80 [ACK] Seq=3138 Ack=6102 Win=4066 Len=0 TSval=105870967 TSecr=917517947
155.4.151240	172.20.10.2	23.235.44.231	TCP	66 55789 → 80 [ACK] Seq=3138 Ack=6122 Win=4065 Len=0 TSval=105870967 TSecr=917517947
156.4.162321	172.20.10.2	23.235.44.231	TCP	1454 [TCP segment of a reassembled PDU]

1. 1415
2. i) sequence number of packet 1: 1415

- sequence number of packet 2: 2803
 - sequence number of packet 3: 5152
 - sequence number of packet 4: 3138.
 - ii) Time for the packet 1: 4.081502
 Time for the packet 2: 4.081503
 Time for the packet 3: 4.151176
 Time for the packet 4: 4.162321.
 - iii) Acknowledge time for packet 1: 4.135363
 Acknowledge time for packet 2: 4.135713
 Acknowledge time for packet 3: 4.151247
 Acknowledge time for packet 4: 4.210628.
 - iv) 0.053861, 0.54210, 0.00071, 0.048307.
 - v) RTT of packet 1: 0.053861
 RTT of packet 2: 0.054210
 RTT of packet 3: 0.000071
 RTT of packet 4: 0.048307.
 - vi) $\text{EstimatedRTT} = 0.875 * \text{EstimatedRTT} + 0.125 * \text{SampleRTT}$
 - vii) Estimated RTT of packet 1: 0.053861
 Estimated RTT of packet 2: 0.17212838
 Estimated RTT of packet 3: 0.27561233
 Estimated RTT of packet 4: 0.36616079
3. the length of the segment 1 is: 1388 bytes.
 the length of the segment 2 is: 135 bytes.
 the length of the segment 3 is: 950 bytes.
 the length of the segment 4 is: 1388 bytes.
 4. The minimum amount of available buffer space advertised at the received is 72 bytes.
 - 1) the amount of available buffer space advertised by packet 1 is: 72 bytes.
 - 2) the amount of available buffer space advertised by packet 2 is: 77 bytes.
 - 3) the amount of available buffer space advertised by packet 3 is: 4066 bytes.
 - 4) the amount of available buffer space advertised by packet 4 is: 96 bytes.
 5. The sender is never throttled due to lacking of receiver buffer space by inspecting this trace.
 6. No there is no retransmitted segments in the trace file. This can be explained by packets with same sequence number at different time is not found.
 7. The difference between the acknowledged sequence numbers of two consecutive ACKs indicates the data received by the server between these two ACKs. For example the difference between $841 - 838 = 3$ and $3617 - 838 = 2779$.

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The screenshot shows a Wireshark packet capture of a TCP segment. The packet list pane shows several packets, with packet 43 selected. The packet details pane shows the following information:

- Frame 43: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
- Ethernet II, Src: Apple_Bb:6e:80 (6c:40:08:8b:6e:80), Dst: fa:cf:9c:21:5f:64 (fa:cf:9c:21:5f:64)
- Internet Protocol Version 4, Src: 172.20.10.2, Dst: 23.235.44.231
- Transmission Control Protocol, Src Port: 55789, Dst Port: 80, Seq: 1558, Ack: 3617, Len: 0
 - Source Port: 55789
 - Destination Port: 80
 - [Stream index: 3]
 - [TCP Segment Len: 0]
 - Sequence number: 1558 (relative sequence number)
 - Acknowledgment number: 3617 (relative ack number)
 - Header Length: 32 bytes
 - Flags: 0x010 (ACK)
 - Window size value: 4052
 - [Calculated window size: 4052]
 - [Window size scaling factor: -1 (unknown)]
 - Checksum: 0xe464 [unverified]
 - [Checksum Status: Unverified]
 - Urgent pointer: 0
 - Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
 - [SEQ/ACK analysis]
 - [This is an ACK to the segment in frame: 42]
 - [The RTT to ACK the segment was: 0.000083000 seconds]

The packet number 144, 145 and 146 contains cases where the receiver is ACK-ing every other received segment.

The screenshot shows a Wireshark packet capture of a TCP segment. The packet list pane shows several packets, with packet 144 selected. The packet details pane shows the following information:

- Frame 144: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
- Ethernet II, Src: fa:cf:9c:21:5f:64 (fa:cf:9c:21:5f:64), Dst: Apple_Bb:6e:80 (6c:40:08:8b:6e:80)
- Internet Protocol Version 4, Src: 23.235.44.231, Dst: 172.20.10.2
- Transmission Control Protocol, Src Port: 80, Dst Port: 55790, Seq: 56130, Ack: 2803, Len: 0
 - Source Port: 80
 - Destination Port: 55790
 - [Stream index: 4]
 - [TCP Segment Len: 0]
 - Sequence number: 56130 (relative sequence number)
 - Acknowledgment number: 2803 (relative ack number)
 - Header Length: 32 bytes
 - Flags: 0x010 (ACK)
 - Window size value: 72
 - [Calculated window size: 72]
 - [Window size scaling factor: -1 (unknown)]
 - Checksum: 0x4548 [unverified]
 - [Checksum Status: Unverified]
 - Urgent pointer: 0
 - Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
 - [SEQ/ACK analysis]
 - [This is an ACK to the segment in frame: 140]
 - [The RTT to ACK the segment was: 0.053861000 seconds]

8. Throughput= Amount of the data transmitted/ time incurred.

9. Time incurred = 3.180420-3.005854=0.174566

Amount of data sent = 1388 bytes

Throughput = 1388/0.174566 = 7951.14742 kbytes/sec.

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Top Screenshot: Frame 24

No.	Time	Source	Destination	Protocol	Length	Info
24	3.065854	172.20.10.2	23.235.44.231	TCP	66	55805 → 80 [ACK] Seq=1 Ack=1 Win=131840 Len=0 TSval=105069840 TSecr=335022886

> Frame 24: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
 > Ethernet II, Src: Apple_B8:6e:80 (6c:40:08:8b:6e:80), Dst: fa:cf:9c:21:5f:64 (fa:cf:9c:21:5f:64)
 > Internet Protocol Version 4, Src: 172.20.10.2, Dst: 23.235.44.231
 > Transmission Control Protocol, Src Port: 55805, Dst Port: 80, Seq: 1, Ack: 1, Len: 0
 Source Port: 55805
 Destination Port: 80
 [Stream index: 2]
 [TCP Segment Len: 0]
 Sequence number: 1 (relative sequence number)
 Acknowledgment number: 1 (relative ack number)
 Header Length: 32 bytes
 > Flags: 0x010 (ACK)
 Window size value: 4120
 [Calculated window size: 131840]
 [Window size scaling factor: 32]
 Checksum: 0xf283 [Unverified]
 [Checksum Status: Unverified]
 Urgent pointer: 0
 > Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
 > [SEQ/ACK analysis]
 [This is an ACK to the segment in frame: 23]
 [The RTT to ACK the segment was: 0.000084000 seconds]
 [RTT: 0.092164000 seconds]

Bottom Screenshot: Frame 30

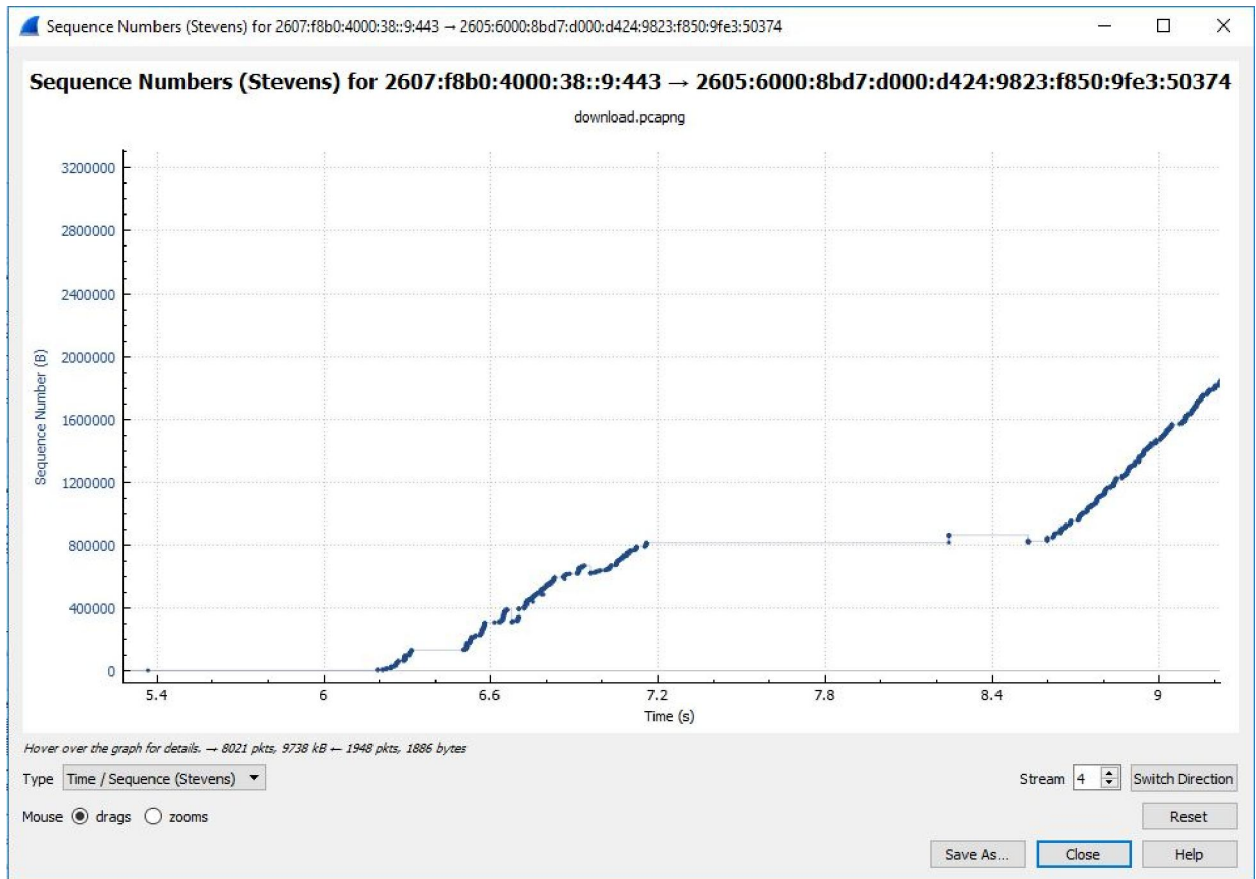
No.	Time	Source	Destination	Protocol	Length	Info
30	3.108420	172.20.10.2	23.235.44.231	HTTP	235	GET /s/compareresults/spinner?code=PRICELINEPRECHE_US_HFDCMP2 HTTP/1.1

> Frame 30: 235 bytes on wire (1880 bits), 235 bytes captured (1880 bits) on interface 0
 > Ethernet II, Src: Apple_B8:6e:80 (6c:40:08:8b:6e:80), Dst: fa:cf:9c:21:5f:64 (fa:cf:9c:21:5f:64)
 > Internet Protocol Version 4, Src: 172.20.10.2, Dst: 23.235.44.231
 > Transmission Control Protocol, Src Port: 55789, Dst Port: 80, Seq: 1389, Ack: 1, Len: 169
 Source Port: 55789
 Destination Port: 80
 [Stream index: 3]
 [TCP Segment Len: 169]
 Sequence number: 1389 (relative sequence number)
 [Next sequence number: 1558 (relative sequence number)]
 Acknowledgment number: 1 (relative ack number)
 Header Length: 32 bytes
 > Flags: 0x018 (PSH, ACK)
 Window size value: 4096
 [Calculated window size: 4096]
 [Window size scaling factor: -1 (unknown)]
 Checksum: 0x37bd [Unverified]
 [Checksum Status: Unverified]
 Urgent pointer: 0
 > Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
 > [SEQ/ACK analysis]
 [Bytes in flight: 1557]
 [Bytes sent since last PSH flag: 1557]
 TCP segment data (169 bytes)
 > [2 Reassembled TCP Segments (1557 bytes): #29(1388), #30(169)]
 > Hypertext Transfer Protocol

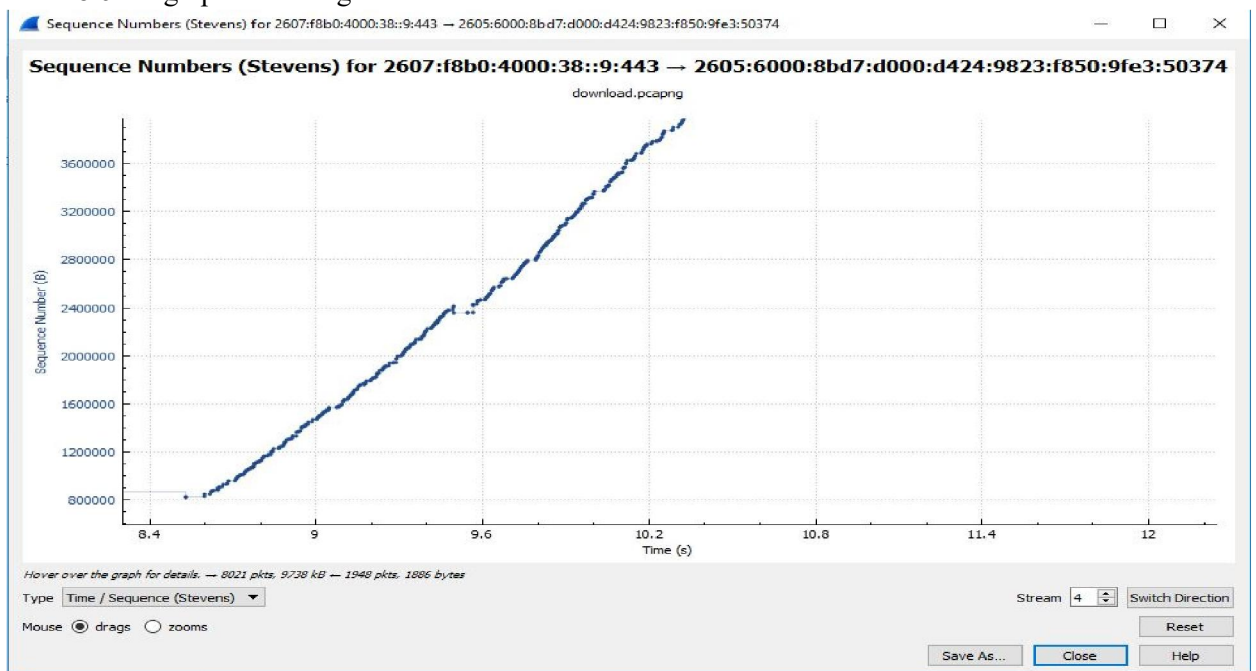
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Problem set-4

1. The slow start start at 5.38 and ends at 8.6.



2. After 8.6 the graph is in congestion avoidance state.



3. According to the behavior of TCP the transmission window should increase linearly but in the graph the TCP transmit window does not grow linearly during this phase. In fact, it appears that the sender transmits packets in uneven batches with different number of packets each time.