

PART-A

1.

The IP address and TCP port number used by the client computer (source) that is transferring the alice.txt file to gaia.cs.umass.edu is **192.168.0.107** and **57056** respectively. Given below the figure shows it.

33 5.643087629	192.168.0.107	23.37.247.127	TCP	66 46256 → 443 [FIN, ACK] Seq=1 Ack=1 Win=501 Len=0
34 5.643142775	192.168.0.107	69.173.158.92	TCP	66 42808 → 443 [FIN, ACK] Seq=1 Ack=1 Win=501 Len=0
35 5.643293537	192.168.0.107	128.119.245.12	TCP	74 57046 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 S
36 5.643391553	192.168.0.107	128.119.245.12	TCP	74 57056 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 S
37 5.659943301	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data
38 5.659943523	23.37.247.127	192.168.0.107	TCP	66 443 → 46256 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0
39 5.659995431	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0
40 5.660027903	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0
41 5.664744453	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data
42 5.664744814	23.37.247.127	192.168.0.107	TCP	66 443 → 46240 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0
43 5.664791011	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0
44 5.664827270	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0
45 5.695937555	69.173.158.92	192.168.0.107	TCP	66 443 → 42808 [ACK] Seq=1 Ack=2 Win=36200 Len=0 TS
46 5.695938125	69.173.158.92	192.168.0.107	TCP	66 443 → 42808 [FIN, ACK] Seq=1 Ack=2 Win=36200 Len=0
47 5.695999107	192.168.0.107	69.173.158.92	TCP	66 42808 → 443 [ACK] Seq=2 Ack=2 Win=501 Len=0 TS
48 5.964344113	128.119.245.12	192.168.0.107	TCP	66 8A → 57056 [SYN ACK] Seq=0 Ack=1 Win=29200 Len=0

Frame 35: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface wlp6s0, id 0
Ethernet II, Src: IntelCor_87:0f:87 (a0:d3:7a:87:0f:87), Dst: TP-Link_24:a8:ac (40:ed:00:24:a8:ac)
Internet Protocol Version 4, Src: 192.168.0.107, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 57046, Dst Port: 80, Seq: 0, Len: 0

0000 40 ed 00 2
0010 00 3c 30 c
0020 f5 0c de c
0030 fa f0 6d c
0040 17 0f aa f

2.

The IP address of gaia.cs.umass.edu is **128.119.245.12** and the port number it is sending and receiving TCP segments for this connection is **80**. Given below the figure shows it.

33 5.643087629	192.168.0.107	23.37.247.127	TCP	66 46256 → 443 [FIN, ACK] Seq=1 Ack=1 Win=501 Len=0
34 5.643142775	192.168.0.107	69.173.158.92	TCP	66 42808 → 443 [FIN, ACK] Seq=1 Ack=1 Win=501 Len=0
35 5.643293537	192.168.0.107	128.119.245.12	TCP	74 57046 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 S
36 5.643391553	192.168.0.107	128.119.245.12	TCP	74 57056 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 S
37 5.659943301	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data
38 5.659943523	23.37.247.127	192.168.0.107	TCP	66 443 → 46256 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0
39 5.659995431	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0
40 5.660027903	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0
41 5.664744453	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data
42 5.664744814	23.37.247.127	192.168.0.107	TCP	66 443 → 46240 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0
43 5.664791011	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0
44 5.664827270	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0
45 5.695937555	69.173.158.92	192.168.0.107	TCP	66 443 → 42808 [ACK] Seq=1 Ack=2 Win=36200 Len=0 TS
46 5.695938125	69.173.158.92	192.168.0.107	TCP	66 443 → 42808 [FIN, ACK] Seq=1 Ack=2 Win=36200 Len=0
47 5.695999107	192.168.0.107	69.173.158.92	TCP	66 42808 → 443 [ACK] Seq=2 Ack=2 Win=501 Len=0 TS
48 5.964344113	128.119.245.12	192.168.0.107	TCP	66 8A → 57056 [SYN ACK] Seq=0 Ack=1 Win=29200 Len=0

Frame 35: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface wlp6s0, id 0
Ethernet II, Src: IntelCor_87:0f:87 (a0:d3:7a:87:0f:87), Dst: TP-Link_24:a8:ac (40:ed:00:24:a8:ac)
Internet Protocol Version 4, Src: 192.168.0.107, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 57046, Dst Port: 80, Seq: 0, Len: 0

0000 40 ed 00 2
0010 00 3c 30 c
0020 f5 0c de c
0030 fa f0 6d c
0040 17 0f aa f

3.

The sequence number of the TCP SYN segment that is used to initiate the TCP connection between the client computer and gaia.cs.umass.edu is **195412907**. Given below the figure shows it.

Transmission Control Protocol, Src Port: 57046, Dst Port: 80, Seq: 0, Len: 0

Source Port: 57046
 Destination Port: 80
 [Stream index: 14]
 [Conversation completeness: Complete, NO_DATA (23)]
 [TCP Segment Len: 0]

Sequence Number: 0 (relative sequence number)
 Sequence Number (raw): 195412907
 Acknowledgment Number: 1
 Sequence Number (raw): 192868 [sequence number]]

0000	40 ed 00 24
0010	00 3c 30 d1
0020	f5 0c de d6
0030	fa f0 6d c4
0040	17 0f 00 00

The **SYN** bit is set to 1 inside the flags of the TCP header and tells us that the selected TCP segment identifies the SYN segment. Given below the figure shows it.

30	5.173250963	203.195.121.141	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 50030 [ACK] Seq=1
32	5.642998740	192.168.0.107	23.37.247.127	TCP	66 46240 → 443 [FIN, ACK] Seq=1 Ack=1 Win=1173 Len=0 TS
33	5.643087629	192.168.0.107	23.37.247.127	TCP	66 46256 → 443 [FIN, ACK] Seq=1 Ack=1 Win=501 Len=0 TS
34	5.643142775	192.168.0.107	69.173.158.92	TCP	66 42888 → 443 [FIN, ACK] Seq=1 Ack=1 Win=501 Len=0 TS
35	5.643293537	192.168.0.107	128.119.245.12	TCP	74 57046 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SAC
36	5.643391553	192.168.0.107	128.119.245.12	TCP	74 57056 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SAC
37	5.659943301	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data
38	5.659943523	23.37.247.127	192.168.0.107	TCP	66 443 → 46256 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0 TS
39	5.659995431	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0
40	5.660027903	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0
41	5.664744453	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data
42	5.664744814	23.37.247.127	192.168.0.107	TCP	66 443 → 46240 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0 TS
43	5.664791011	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0
44	5.664827270	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0
45	5.665037555	69.173.158.92	192.168.0.107	TCP	66 113 → 12800 [ACK] Seq=1 Ack=2 Win=36200 Len=0 TSval
↓					
.... 0. = Congestion Window Reduced: Not set					
.... 0. = ECN-Echo: Not set					
.... 0. = Urgent: Not set					
.... 0. = Acknowledgment: Not set					
.... 0. = Push: Not set					
.... 0. = Reset: Not set					
.... 1. = Syn: Set					
↓ Expert info (short sequence): Connection establish request (SYN): server port 80					
.... 0. = Fin: Not set					

Yes, the TCP receiver in this session will be able to **use selective acknowledgements** as the SACK Permitted option is present in the TCP options section. Given below the figure shows it.

				RECV FROM	DATA
38	5.659943523	23.37.247.127	192.168.0.107	TCP	66 443 → 46256 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0
39	5.659995431	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0
40	5.660027903	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0
41	5.664744453	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data
42	5.664744814	23.37.247.127	192.168.0.107	TCP	66 443 → 46240 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0
43	5.664791011	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0
44	5.664827270	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0
45	5.695937555	69.173.158.92	192.168.0.107	TCP	66 443 → 42808 [ACK] Seq=1 Ack=2 Win=36200 Len=0
46	5.695938125	69.173.158.92	192.168.0.107	TCP	66 443 → 42808 [FIN, ACK] Seq=1 Ack=2 Win=36200 Len=0
47	5.695999107	192.168.0.107	69.173.158.92	TCP	66 42808 → 443 [ACK] Seq=2 Ack=2 Win=501 Len=0 TSval=2
48	5.964344413	128.119.245.12	192.168.0.107	TCP	66 80 → 57056 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0
49	5.964344639	128.119.245.12	192.168.0.107	TCP	66 80 → 57046 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0
50	5.964371926	192.168.0.107	128.119.245.12	TCP	54 57056 → 80 [ACK] Seq=1 Ack=1 Win=64256 Len=0
51	5.964391322	192.168.0.107	128.119.245.12	TCP	54 57046 → 80 [ACK] Seq=1 Ack=1 Win=64256 Len=0

Details of selected TCP Option - SACK permitted:

- Kind: SACK Permitted (4)
- Length: 2

Note: My system sends two SYN requests, gets two SYNACK replies and then again sends two ACK to “gaia.cs.umass.edu”.

4.

The sequence number of the TCP SYNACK segment that was sent by gaia.cs.umass.edu to the client computer in reply to the SYN is **3152507284**. Given below the figure shows it.

				RECV FROM	DATA
36	5.643391553	192.168.0.107	128.119.245.12	TCP	74 57056 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SAC
37	5.659943301	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data
38	5.659943523	23.37.247.127	192.168.0.107	TCP	66 443 → 46256 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0 T
39	5.659995431	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0
40	5.660027903	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0
41	5.664744453	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data
42	5.664744814	23.37.247.127	192.168.0.107	TCP	66 443 → 46240 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0 T
43	5.664791011	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0
44	5.664827270	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0
45	5.695937555	69.173.158.92	192.168.0.107	TCP	66 443 → 42808 [ACK] Seq=1 Ack=2 Win=36200 Len=0 TSval
46	5.695938125	69.173.158.92	192.168.0.107	TCP	66 443 → 42808 [FIN, ACK] Seq=1 Ack=2 Win=36200 Len=0
47	5.695999107	192.168.0.107	69.173.158.92	TCP	66 42808 → 443 [ACK] Seq=2 Ack=2 Win=501 Len=0 TSval=2
48	5.964344413	128.119.245.12	192.168.0.107	TCP	66 80 → 57056 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 M
49	5.964344639	128.119.245.12	192.168.0.107	TCP	66 80 → 57046 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 M
50	5.964371926	192.168.0.107	128.119.245.12	TCP	54 57056 → 80 [ACK] Seq=1 Ack=1 Win=64256 Len=0
51	5.964391322	192.168.0.107	128.119.245.12	TCP	54 57046 → 80 [ACK] Seq=1 Ack=1 Win=64256 Len=0

Details of selected TCP Segment:

- Conversation completeness: Complete, NO_DATA (23)
- [TCP Segment Len: 0]
- Sequence Number: 3152507284 (relative sequence number)
- Sequence Number (raw): 3152507284
- Acknowledgment Number: 1 (relative ack number)
- Acknowledgment number (raw): 195412908
- 1000 = Header Length: 32 bytes (8)
- Flags: 0x012 (SYN, ACK)

The **SYN and acknowledgment bit is set to 1** inside the flags of the TCP header and tells us that the selected TCP segment identifies the SYNACK segment. Given below the figure shows it.

37 5.659943301	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data	
38 5.659943523	23.37.247.127	192.168.0.107	TCP	66 443 → 46256 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0 T	
39 5.659995431	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0	
40 5.660027903	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0	
41 5.664744453	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data	
42 5.664744814	23.37.247.127	192.168.0.107	TCP	66 443 → 46240 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0 T	
43 5.664791011	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0	
44 5.664827270	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0	
45 5.695937555	69.173.158.92	192.168.0.107	TCP	66 443 → 42808 [ACK] Seq=1 Ack=2 Win=36200 Len=0 TSval	
46 5.695938125	69.173.158.92	192.168.0.107	TCP	66 443 → 42808 [FIN, ACK] Seq=1 Ack=2 Win=36200 Len=0	
47 5.695999107	192.168.0.107	69.173.158.92	TCP	66 42808 → 443 [ACK] Seq=2 Ack=2 Win=501 Len=0 TSval=2	
48 5.964344413	128.119.245.12	192.168.0.107	TCP	66 80 → 57056 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 M	
49 5.964344639	128.119.245.12	192.168.0.107	TCP	66 80 → 57046 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 M	
50 5.964371926	192.168.0.107	128.119.245.12	TCP	54 57056 → 80 [ACK] Seq=1 Ack=1 Win=64256 Len=0	
51 5.964371926	192.168.0.107	128.119.245.12	TCP	54 57046 → 80 [ACK] Seq=1 Ack=1 Win=64256 Len=0	

000. = Reserved: Not set
...0 = Accurate ECN: Not set
.... 0.... = Congestion Window Reduced: Not set
.... .0.... = ECN-Echo: Not set
.... 0.... = Urgent: Not set
.... .1.... = Acknowledgment: Set
.... 0.... = Push: Not set
.... 0.... = Reset: Not set
....1.... = Syn: Set

0000 a0 d3 7a 87 0
0010 00 34 00 00 0
0020 00 6b 00 50 0
0030 72 10 1a 8b 0
0040 03 07

The value of the Acknowledgement field in the SYNACK segment is **195412908**. Given below the figure shows it.

36 5.643391553	192.168.0.107	128.119.245.12	TCP	74 57056 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SAC	
37 5.659943301	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data	
38 5.659943523	23.37.247.127	192.168.0.107	TCP	66 443 → 46256 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0 T	
39 5.659995431	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0	
40 5.660027903	192.168.0.107	23.37.247.127	TCP	54 46256 → 443 [RST] Seq=2 Win=0 Len=0	
41 5.664744453	23.37.247.127	192.168.0.107	TLSv1.2	90 Application Data	
42 5.664744814	23.37.247.127	192.168.0.107	TCP	66 443 → 46240 [FIN, ACK] Seq=25 Ack=2 Win=501 Len=0 T	
43 5.664791011	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0	
44 5.664827270	192.168.0.107	23.37.247.127	TCP	54 46240 → 443 [RST] Seq=2 Win=0 Len=0	
45 5.695937555	69.173.158.92	192.168.0.107	TCP	66 443 → 42808 [ACK] Seq=1 Ack=2 Win=36200 Len=0 TSval	
46 5.695938125	69.173.158.92	192.168.0.107	TCP	66 443 → 42808 [FIN, ACK] Seq=1 Ack=2 Win=36200 Len=0	
47 5.695999107	192.168.0.107	69.173.158.92	TCP	66 42808 → 443 [ACK] Seq=2 Ack=2 Win=501 Len=0 TSval=2	
48 5.964344413	128.119.245.12	192.168.0.107	TCP	66 80 → 57056 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 M	
49 5.964344639	128.119.245.12	192.168.0.107	TCP	66 80 → 57046 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 M	
50 5.964371926	192.168.0.107	128.119.245.12	TCP	54 57056 → 80 [ACK] Seq=1 Ack=1 Win=64256 Len=0	
51 5.964371926	192.168.0.107	128.119.245.12	TCP	54 57046 → 80 [ACK] Seq=1 Ack=1 Win=64256 Len=0	

[Conversation completeness: Complete, NO_DATA (23)]
[TCP Segment Len: 0]
Sequence Number: 0 (relative sequence number)
Sequence Number (raw): 3152507284
[Next Sequence Number: 1 (relative sequence number)]
[Acknowledgment Number (raw): 195412908]
Flags: 0x012 (SYN, ACK)

0000 a0 d3 7a 87 0
0010 00 34 00 00 0
0020 00 6b 00 50 0
0030 72 10 ea 64 0
0040 03 07

The value of the Acknowledgement field in SYNACK by gaia.cs.umass.edu is determined by the sequence number of the SYN segment received from my computer. It increments the value by 1 which indicates the next sequence number from my computer.

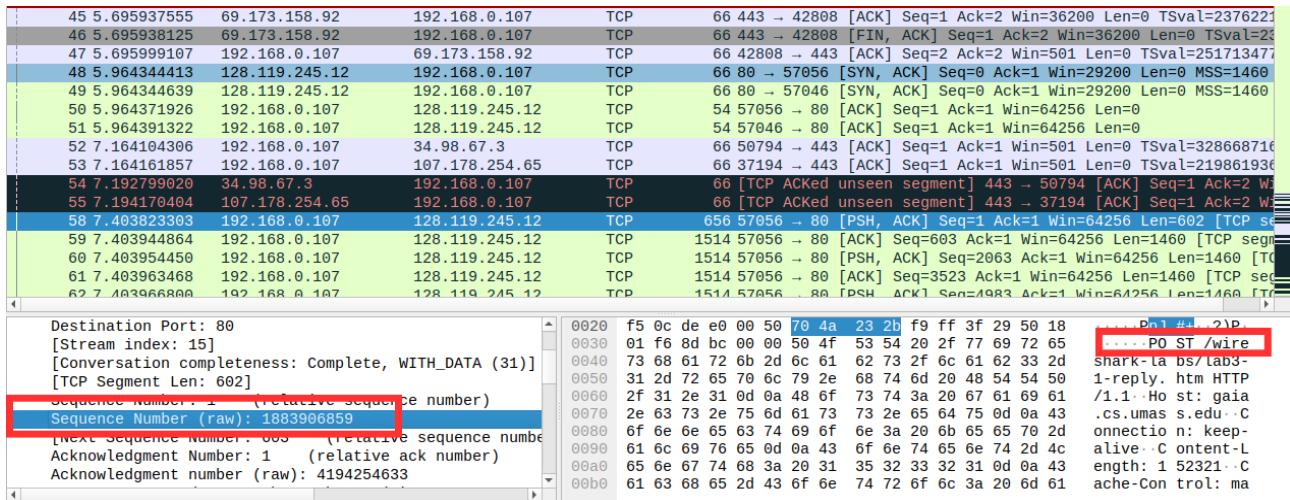
$$195412907 + 1 = 195412908$$

Note: My system sends two SYN requests, gets two SYNACK replies and then again sends two ACK to “gaia.cs.umass.edu”. The second set also follows the same approach

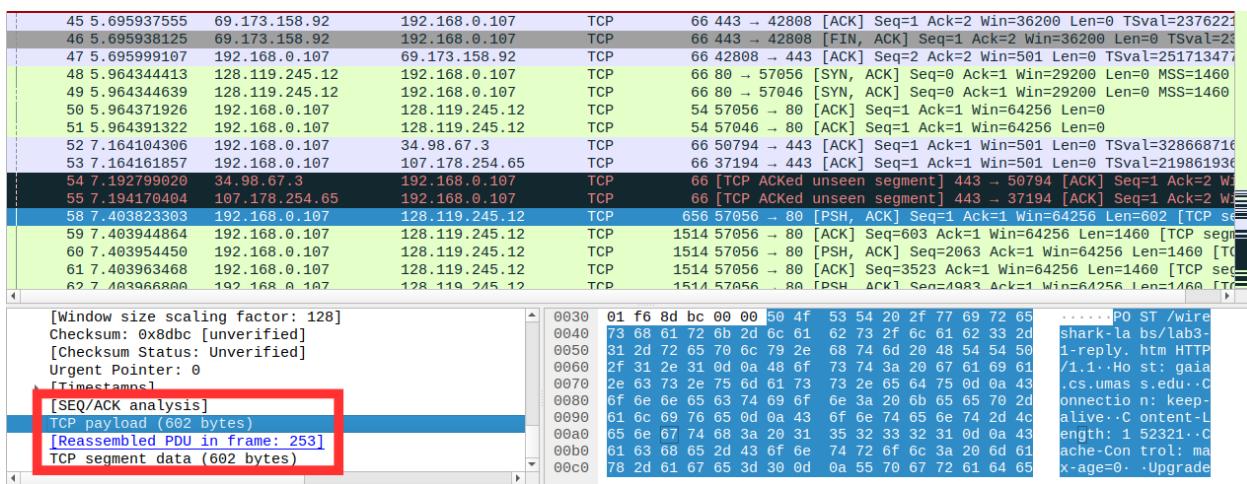
of increments the value by 1 of its sequence number to get the acknowledgement number.

5.

The sequence number of the TCP segment containing the header of the HTTP POST command is **1883906859**. Given below the figure shows it.



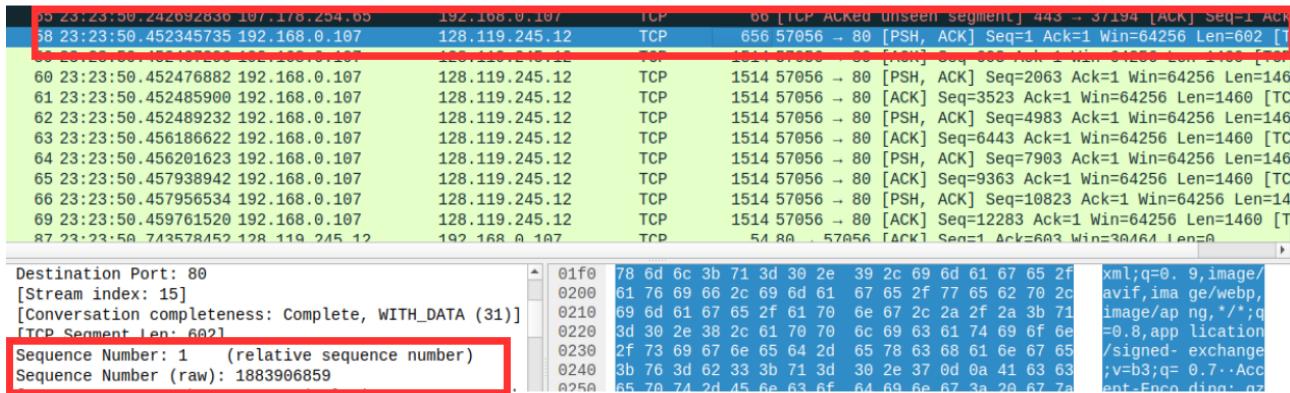
The payload (data) field of this TCP segment contains **602 Bytes**. Given below the figure shows it.



No, all of the data in the transferred file `alice.txt` fit into this single segment. The remaining bytes are transferred in next segments.

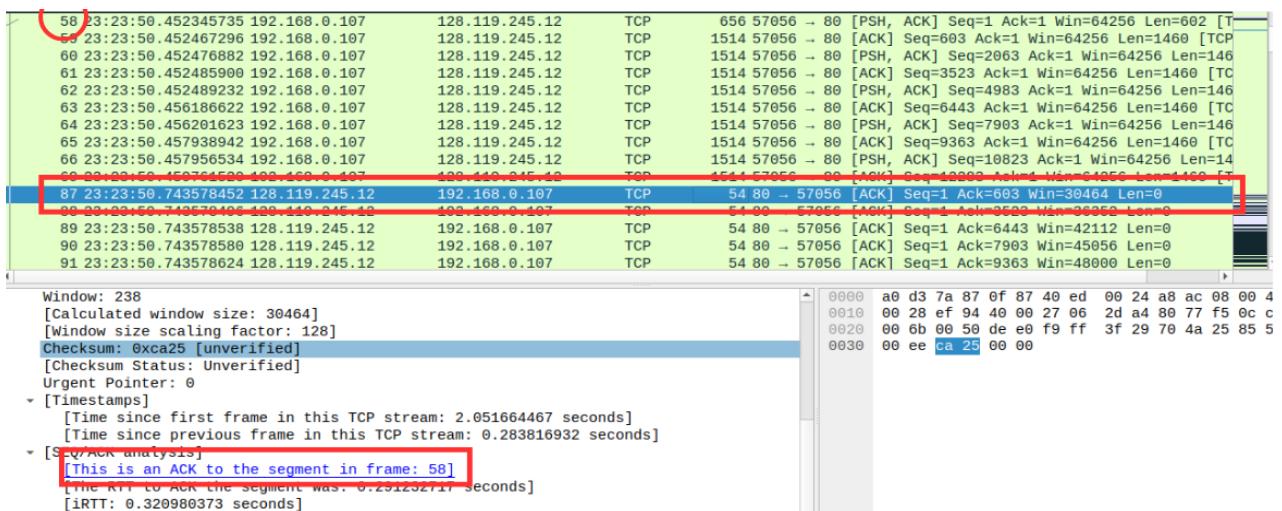
6.

The time at which the first segment was sent in the data-transfer part of the TCP connection is “**23:23:50.452345735**”. Given below the figure shows it.

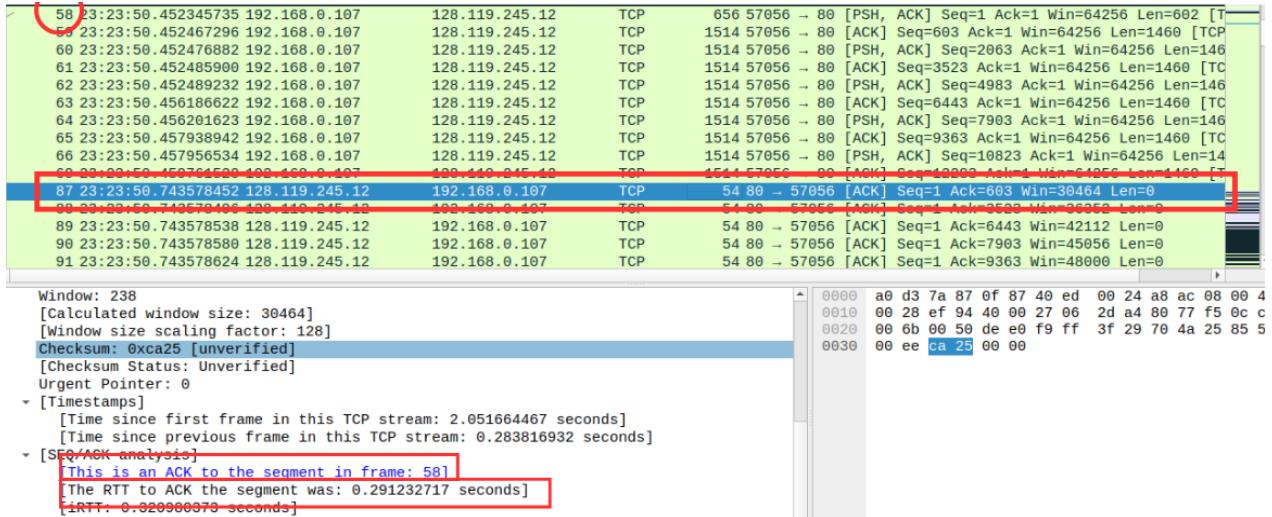


The first packet is of 602 bytes and the next expected relative sequence number is $602+1 = 603$.

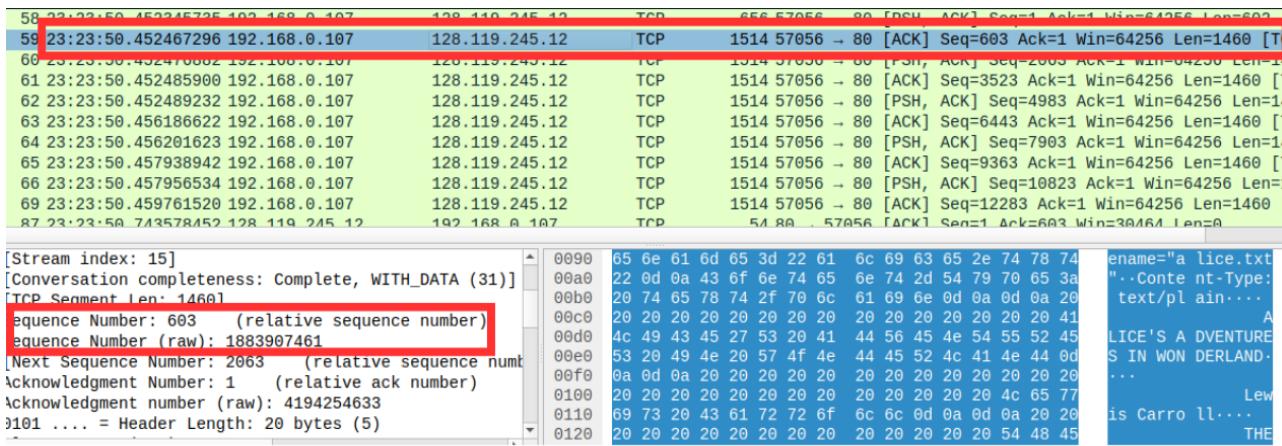
The time at which the ACK of the first segment was received in the data-transfer part of the TCP connection is “**23:23:50.743578452**”. Given below the figure shows it.



The RTT of the first data-containing segment is **0.291232717 seconds**. Given below the figure shows it.



The time at which the second segment was sent in the data-transfer part of the TCP connection is “**23:23:50.452467296**”. Given below the figure shows it.



The time at which the ACK of the second segment was received in the data-transfer part of the TCP connection is “**23:23:50.743578496**”.

Please see that the acknowledgement of the second TCP segment is not received. I tried to filter based on its acknowledgement number using “**tcp.ack==acknowledgment number**” but didn’t find it. Hence, using the acknowledgement of the third segment considering cumulative acknowledgement. Given below the figure shows it.

58 23:23:50.452345735 192.168.0.107	128.119.245.12	TCP	656 57056 - 80 [PSH, ACK] Seq=1 Ack=1 Win=64256 Len=602 [TCP]
59 23:23:50.452467296 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [ACK] Seq=603 Ack=1 Win=64256 Len=1460 [TCP]
60 23:23:50.452476882 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [PSH, ACK] Seq=2063 Ack=1 Win=64256 Len=146
61 23:23:50.452485900 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [ACK] Seq=3523 Ack=1 Win=64256 Len=1460 [TCP]
62 23:23:50.452489232 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [PSH, ACK] Seq=4983 Ack=1 Win=64256 Len=146
63 23:23:50.456186622 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [ACK] Seq=6443 Ack=1 Win=64256 Len=1460 [TCP]
64 23:23:50.456201623 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [PSH, ACK] Seq=7903 Ack=1 Win=64256 Len=146
65 23:23:50.457938942 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [ACK] Seq=9363 Ack=1 Win=64256 Len=1460 [TCP]
66 23:23:50.457956534 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=14
69 23:23:50.459761520 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [TCP]
70 23:23:50.743578492 128.119.245.12	192.168.0.107	TCP	54 80 - 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0
88 23:23:50.743578496 128.119.245.12	192.168.0.107	TCP	54 80 - 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0
89 23:23:50.743578536 128.119.245.12	192.168.0.107	TCP	54 80 - 57056 [ACK] Seq=1 Ack=3643 Win=42112 Len=0
90 23:23:50.743578580 128.119.245.12	192.168.0.107	TCP	54 80 - 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0
91 23:23:50.743578624 128.119.245.12	192.168.0.107	TCP	54 80 - 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0

Window: 284
[Calculated window size: 36352]
[Window size scaling factor: 128]
Checksum: 0xbe8f [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0

- [Timestamps]
 - [Time since first frame in this TCP stream: 2.051664511 seconds]
 - [Time since previous frame in this TCP stream: 0.000000044 seconds]
- [SEQ/ACK analysis]
 - [This is an ACK to the segment in frame: 60]**
 - [The RTT to ACK the segment was: 0.291101614 seconds]
 - [iRTT: 0.320980373 seconds]

The RTT of the second data-containing segment is **0.291101614 seconds**. Given below the figure shows it.

58 23:23:50.452345735 192.168.0.107	128.119.245.12	TCP	656 57056 - 80 [PSH, ACK] Seq=1 Ack=1 Win=64256 Len=602 [TCP]
59 23:23:50.452467296 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [ACK] Seq=603 Ack=1 Win=64256 Len=1460 [TCP]
60 23:23:50.452476882 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [PSH, ACK] Seq=2063 Ack=1 Win=64256 Len=146
61 23:23:50.452485900 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [ACK] Seq=3523 Ack=1 Win=64256 Len=1460 [TCP]
62 23:23:50.452489232 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [PSH, ACK] Seq=4983 Ack=1 Win=64256 Len=146
63 23:23:50.456186622 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [ACK] Seq=6443 Ack=1 Win=64256 Len=1460 [TCP]
64 23:23:50.456201623 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [PSH, ACK] Seq=7903 Ack=1 Win=64256 Len=146
65 23:23:50.457938942 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [ACK] Seq=9363 Ack=1 Win=64256 Len=1460 [TCP]
66 23:23:50.457956534 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=14
69 23:23:50.459761520 192.168.0.107	128.119.245.12	TCP	1514 57056 - 80 [ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [TCP]
70 23:23:50.743578492 128.119.245.12	192.168.0.107	TCP	54 80 - 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0
88 23:23:50.743578496 128.119.245.12	192.168.0.107	TCP	54 80 - 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0
89 23:23:50.743578536 128.119.245.12	192.168.0.107	TCP	54 80 - 57056 [ACK] Seq=1 Ack=3643 Win=42112 Len=0
90 23:23:50.743578580 128.119.245.12	192.168.0.107	TCP	54 80 - 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0
91 23:23:50.743578624 128.119.245.12	192.168.0.107	TCP	54 80 - 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0

Window: 284
[Calculated window size: 36352]
[Window size scaling factor: 128]
Checksum: 0xbe8f [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0

- [Timestamps]
 - [Time since first frame in this TCP stream: 2.051664511 seconds]
 - [Time since previous frame in this TCP stream: 0.000000044 seconds]
- [SEQ/ACK analysis]
 - [This is an ACK to the segment in frame: 60]**
 - [The RTT to ACK the segment was: 0.291101614 seconds]
 - [iRTT: 0.320980373 seconds]

$$\text{EstimatedRTT} = (1 - \alpha) * \text{EstimatedRTT} + \alpha * \text{SampleRTT}$$

$$\text{EstimatedRTT} = \text{RTT of first segment} = 0.291232717 \text{ seconds}$$

$$\text{SampleRTT} = \text{RTT of current segment} = 0.291101614 \text{ seconds}$$

$$\alpha = 0.125$$

$$\text{EstimatedRTT} = (1 - \alpha) * \text{EstimatedRTT} + \alpha * \text{SampleRTT}$$

$$\text{EstimatedRTT} = (1 - 0.125) * 0.291232717 + 0.125 * 0.291101614$$

$$\text{EstimatedRTT} = 0.2912163292 \text{ seconds}$$

7.

The length (header plus payload) of each of the first four data-carrying TCP segments are **602, 1460, 1460, and 1460 Bytes**. Given below the figure shows it.

58 23:23:50.452345735 192.168.0.107	128.119.245.12	TCP	656 57056 -> 80 [PSH, ACK] Seq=1 Ack=1 Win=64256 Len=602 [TCP]
59 23:23:50.452467296 192.168.0.107	128.119.245.12	TCP	1514 57056 -> 80 [ACK] Seq=603 Ack=1 Win=64256 Len=1460 [TCP]
60 23:23:50.452476882 192.168.0.107	128.119.245.12	TCP	1514 57056 -> 80 [PSH, ACK] Seq=2063 Ack=1 Win=64256 Len=1460
61 23:23:50.452485900 192.168.0.107	128.119.245.12	TCP	1514 57056 -> 80 [ACK] Seq=3523 Ack=1 Win=64256 Len=1460 [TCP]
62 23:23:50.452489232 192.168.0.107	128.119.245.12	TCP	1514 57056 -> 80 [PSH, ACK] Seq=4983 Ack=1 Win=64256 Len=1460
63 23:23:50.456186622 192.168.0.107	128.119.245.12	TCP	1514 57056 -> 80 [ACK] Seq=6443 Ack=1 Win=64256 Len=1460 [TCP]

Transmission Control Protocol, Src Port: 57056, Dst Port: 80, Seq: 2063, Ack: 1, Len: 1

```

Source Port: 57056
Destination Port: 80
[Stream index: 15]
[Conversation completeness: Complete, WITH_DATA (31)]
[TCP Segment Len: 1460]
Sequence Number: 2063 (relative sequence number)
Sequence Number (raw): 1883908921
[Next Sequence Number: 3523 (relative sequence number)]
Acknowledgment Number: 1 (relative ack number)
Acknowledgment number (raw): 4194254633
0101 .... = Header Length: 20 bytes (5)
Flags: 0x010 (PSH, ACK)
Window: 502
[Calculated window size: 64256]
[Window size scaling factor: 128]
Checksum: 0xd9fb [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0

```

58 23:23:50.452345735 192.168.0.107	128.119.245.12	TCP	656 57056 -> 80 [PSH, ACK] Seq=1 Ack=1 Win=64256 Len=602 [TCP]
59 23:23:50.452467296 192.168.0.107	128.119.245.12	TCP	1514 57056 -> 80 [ACK] Seq=603 Ack=1 Win=64256 Len=1460 [TCP]
60 23:23:50.452476882 192.168.0.107	128.119.245.12	TCP	1514 57056 -> 80 [PSH, ACK] Seq=2063 Ack=1 Win=64256 Len=1460
61 23:23:50.452485900 192.168.0.107	128.119.245.12	TCP	1514 57056 -> 80 [ACK] Seq=3523 Ack=1 Win=64256 Len=1460 [TCP]
62 23:23:50.452489232 192.168.0.107	128.119.245.12	TCP	1514 57056 -> 80 [PSH, ACK] Seq=4983 Ack=1 Win=64256 Len=1460
63 23:23:50.456186622 192.168.0.107	128.119.245.12	TCP	1514 57056 -> 80 [ACK] Seq=6443 Ack=1 Win=64256 Len=1460 [TCP]

Transmission Control Protocol, Src Port: 57056, Dst Port: 80, Seq: 3523, Ack: 1, Len: 1

```

Source Port: 57056
Destination Port: 80
[Stream index: 15]
[Conversation completeness: Complete, WITH_DATA (31)]
[TCP Segment Len: 1460]
Sequence Number: 6523 (relative sequence number)
Sequence Number (raw): 1883910381
[Next Sequence Number: 4983 (relative sequence number)]
Acknowledgment Number: 1 (relative ack number)
Acknowledgment number (raw): 4194254633
0101 .... = Header Length: 20 bytes (5)
Flags: 0x010 (ACK)
Window: 502
[Calculated window size: 64256]
[Window size scaling factor: 128]
Checksum: 0x8656 [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0

```

8.

The minimum amount of available buffer space advertised to the client by gaia.cs.umass.edu among these first five data-carrying TCP segments is **238** which is equivalent to $238 * 128 = 30464$ Bytes

No, the lack of receiver buffer space ever throttles the sender for these first five data carrying segments because the advertised window size has ample buffer space for smooth communication between sender and receiver as the sender is sending packets of 1460 Bytes. Given below the figure shows it.

<p>Flags: 0x010 (ACK)</p> <p>Window: 375</p> <p>[Calculated window size: 48000]</p> <p>[Window size scaling factor: 128]</p> <p>Checksum: 0xa704 [Unverified]</p> <p>[Checksum Status: Unverified]</p> <p>Urgent Pointer: 0</p> <ul style="list-style-type: none"> - [Timestamps] <ul style="list-style-type: none"> [Time since first frame in this TCP stream: 2.051664639 seconds] [Time since previous frame in this TCP stream: 0.000000044 seconds] - [SEQ/ACK analysis] <ul style="list-style-type: none"> [This is an ACK to the segment in frame: 64] [The RTT to ACK the segment was: 0.287377001 seconds] 	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>1514 57056 → 80 [ACK] Seq=10823 Ack=1 Win=64256 Len=14</td></tr> <tr><td>1514 57056 → 80 [PSH, ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [T]</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=6443 Win=42112 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=12283 Win=53888 Len=0</td></tr> <tr><td>1514 57056 → 80 [ACK] Seq=13743 Ack=1 Win=64256 Len=1460 [T]</td></tr> <tr><td>1514 57056 → 80 [PSH, ACK] Seq=15203 Ack=1 Win=64256 Len=14</td></tr> <tr><td>1514 57056 → 80 [ACK] Seq=16663 Ack=1 Win=64256 Len=1460 [T]</td></tr> <tr><td>1514 57056 → 80 [PSH, ACK] Seq=18123 Ack=1 Win=64256 Len=14</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=13743 Win=56704 Len=0</td></tr> </table>	1514 57056 → 80 [ACK] Seq=10823 Ack=1 Win=64256 Len=14	1514 57056 → 80 [PSH, ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [T]	54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=6443 Win=42112 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=12283 Win=53888 Len=0	1514 57056 → 80 [ACK] Seq=13743 Ack=1 Win=64256 Len=1460 [T]	1514 57056 → 80 [PSH, ACK] Seq=15203 Ack=1 Win=64256 Len=14	1514 57056 → 80 [ACK] Seq=16663 Ack=1 Win=64256 Len=1460 [T]	1514 57056 → 80 [PSH, ACK] Seq=18123 Ack=1 Win=64256 Len=14	54 80 → 57056 [ACK] Seq=1 Ack=13743 Win=56704 Len=0
1514 57056 → 80 [ACK] Seq=10823 Ack=1 Win=64256 Len=14														
1514 57056 → 80 [PSH, ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [T]														
54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=6443 Win=42112 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=12283 Win=53888 Len=0														
1514 57056 → 80 [ACK] Seq=13743 Ack=1 Win=64256 Len=1460 [T]														
1514 57056 → 80 [PSH, ACK] Seq=15203 Ack=1 Win=64256 Len=14														
1514 57056 → 80 [ACK] Seq=16663 Ack=1 Win=64256 Len=1460 [T]														
1514 57056 → 80 [PSH, ACK] Seq=18123 Ack=1 Win=64256 Len=14														
54 80 → 57056 [ACK] Seq=1 Ack=13743 Win=56704 Len=0														
<p>Flags: 0x010 (ACK)</p> <p>Window: 329</p> <p>[Calculated window size: 42112]</p> <p>[Window size scaling factor: 128]</p> <p>Checksum: 0xb21a [Unverified]</p> <p>[Checksum Status: Unverified]</p> <p>Urgent Pointer: 0</p> <ul style="list-style-type: none"> - [Timestamps] <ul style="list-style-type: none"> [Time since first frame in this TCP stream: 2.051664553 seconds] [Time since previous frame in this TCP stream: 0.000000042 seconds] - [SEQ/ACK analysis] <ul style="list-style-type: none"> [This is an ACK to the segment in frame: 62] [The RTT to ACK the segment was: 0.291089306 seconds] 	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>1514 57056 → 80 [PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=14</td></tr> <tr><td>1514 57056 → 80 [ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [T]</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=6443 Win=42112 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=12283 Win=53888 Len=0</td></tr> <tr><td>1514 57056 → 80 [ACK] Seq=13743 Ack=1 Win=64256 Len=1460 [T]</td></tr> <tr><td>1514 57056 → 80 [PSH, ACK] Seq=15203 Ack=1 Win=64256 Len=14</td></tr> <tr><td>1514 57056 → 80 [ACK] Seq=16663 Ack=1 Win=64256 Len=1460 [T]</td></tr> <tr><td>1514 57056 → 80 [PSH, ACK] Seq=18123 Ack=1 Win=64256 Len=14</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=13743 Win=56704 Len=0</td></tr> </table>	1514 57056 → 80 [PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=14	1514 57056 → 80 [ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [T]	54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=6443 Win=42112 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=12283 Win=53888 Len=0	1514 57056 → 80 [ACK] Seq=13743 Ack=1 Win=64256 Len=1460 [T]	1514 57056 → 80 [PSH, ACK] Seq=15203 Ack=1 Win=64256 Len=14	1514 57056 → 80 [ACK] Seq=16663 Ack=1 Win=64256 Len=1460 [T]	1514 57056 → 80 [PSH, ACK] Seq=18123 Ack=1 Win=64256 Len=14	54 80 → 57056 [ACK] Seq=1 Ack=13743 Win=56704 Len=0
1514 57056 → 80 [PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=14														
1514 57056 → 80 [ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [T]														
54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=6443 Win=42112 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=12283 Win=53888 Len=0														
1514 57056 → 80 [ACK] Seq=13743 Ack=1 Win=64256 Len=1460 [T]														
1514 57056 → 80 [PSH, ACK] Seq=15203 Ack=1 Win=64256 Len=14														
1514 57056 → 80 [ACK] Seq=16663 Ack=1 Win=64256 Len=1460 [T]														
1514 57056 → 80 [PSH, ACK] Seq=18123 Ack=1 Win=64256 Len=14														
54 80 → 57056 [ACK] Seq=1 Ack=13743 Win=56704 Len=0														
<p>Flags: 0x010 (ACK)</p> <p>Window: 352</p> <p>[Calculated window size: 45056]</p> <p>[Window size scaling factor: 128]</p> <p>Checksum: 0xa7a21 [Unverified]</p> <p>[Checksum Status: Unverified]</p> <p>Urgent Pointer: 0</p> <ul style="list-style-type: none"> - [Timestamps] <ul style="list-style-type: none"> [Time since first frame in this TCP stream: 2.051664595 seconds] [Time since previous frame in this TCP stream: 0.000000042 seconds] - [SEQ/ACK analysis] <ul style="list-style-type: none"> [This is an ACK to the segment in frame: 63] [The RTT to ACK the segment was: 0.287391958 seconds] 	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>1514 57056 → 80 [PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=14</td></tr> <tr><td>1514 57056 → 80 [ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [T]</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=6443 Win=42112 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=12283 Win=53888 Len=0</td></tr> <tr><td>1514 57056 → 80 [ACK] Seq=13743 Ack=1 Win=64256 Len=1460 [T]</td></tr> <tr><td>1514 57056 → 80 [PSH, ACK] Seq=15203 Ack=1 Win=64256 Len=14</td></tr> <tr><td>1514 57056 → 80 [ACK] Seq=16663 Ack=1 Win=64256 Len=1460 [T]</td></tr> <tr><td>1514 57056 → 80 [PSH, ACK] Seq=18123 Ack=1 Win=64256 Len=14</td></tr> <tr><td>54 80 → 57056 [ACK] Seq=1 Ack=13743 Win=56704 Len=0</td></tr> </table>	1514 57056 → 80 [PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=14	1514 57056 → 80 [ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [T]	54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=6443 Win=42112 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0	54 80 → 57056 [ACK] Seq=1 Ack=12283 Win=53888 Len=0	1514 57056 → 80 [ACK] Seq=13743 Ack=1 Win=64256 Len=1460 [T]	1514 57056 → 80 [PSH, ACK] Seq=15203 Ack=1 Win=64256 Len=14	1514 57056 → 80 [ACK] Seq=16663 Ack=1 Win=64256 Len=1460 [T]	1514 57056 → 80 [PSH, ACK] Seq=18123 Ack=1 Win=64256 Len=14	54 80 → 57056 [ACK] Seq=1 Ack=13743 Win=56704 Len=0
1514 57056 → 80 [PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=14														
1514 57056 → 80 [ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [T]														
54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=6443 Win=42112 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0														
54 80 → 57056 [ACK] Seq=1 Ack=12283 Win=53888 Len=0														
1514 57056 → 80 [ACK] Seq=13743 Ack=1 Win=64256 Len=1460 [T]														
1514 57056 → 80 [PSH, ACK] Seq=15203 Ack=1 Win=64256 Len=14														
1514 57056 → 80 [ACK] Seq=16663 Ack=1 Win=64256 Len=1460 [T]														
1514 57056 → 80 [PSH, ACK] Seq=18123 Ack=1 Win=64256 Len=14														
54 80 → 57056 [ACK] Seq=1 Ack=13743 Win=56704 Len=0														

66 23:23:50.457956534 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=14
69 23:23:50.459761520 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [T]
87 23:23:50.743578452 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0
88 23:23:50.743578496 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0
89 23:23:50.743578538 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=6443 Win=42112 Len=0
90 23:23:50.743578580 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0
91 23:23:50.743578624 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0
92 23:23:50.743578669 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=12283 Win=53888 Len=0
93 23:23:50.743621197 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=13743 Ack=1 Win=64256 Len=1460 [T]
94 23:23:50.743637291 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=15203 Ack=1 Win=64256 Len=14
95 23:23:50.743649341 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=16663 Ack=1 Win=64256 Len=1460 [T]
96 23:23:50.743652325 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=18123 Ack=1 Win=64256 Len=14
97 23:23:50.743670550 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=13743 Win=56704 Len=0

Flags: 0x010 (ACK)
Window: 284
[Calculated window size: 36352]
[Window size scaling factor: 128]
Checksum: 0x0eef [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0
+ [timestamps]
[Time since first frame in this TCP stream: 2.051664511 seconds]
[Time since previous frame in this TCP stream: 0.000000044 seconds]
+ [SEQ/ACK analysis]
[This is an ACK to the segment in frame: 60]
[The RTT to ACK the segment was: 0.291101614 seconds]

66 23:23:50.457956534 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=14
69 23:23:50.459761520 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [T]
87 23:23:50.743578452 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0
88 23:23:50.743578496 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0
89 23:23:50.743578538 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=6443 Win=42112 Len=0
90 23:23:50.743578580 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=7903 Win=45056 Len=0
91 23:23:50.743578624 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=9363 Win=48000 Len=0
92 23:23:50.743578669 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=12283 Win=53888 Len=0
93 23:23:50.743621197 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=13743 Ack=1 Win=64256 Len=1460 [T]
94 23:23:50.743637291 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=15203 Ack=1 Win=64256 Len=14
95 23:23:50.743649341 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=16663 Ack=1 Win=64256 Len=1460 [T]
96 23:23:50.743652325 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=18123 Ack=1 Win=64256 Len=14
97 23:23:50.743670550 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=13743 Win=56704 Len=0

Acknowledgment Number: 603 (relative ack number)
Acknowledgment number (raw): 1883907461
0101 ... = Header Length: 20 bytes (5)
Flags: 0x010 (ACK)
Window: 238
[Calculated window size: 30464]
[Window size scaling factor: 128]
Checksum: 0xca29 [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0
+ [timestamps]
[Time since first frame in this TCP stream: 2.051664467 seconds]
[Time since previous frame in this TCP stream: 0.283816932 seconds]

9.

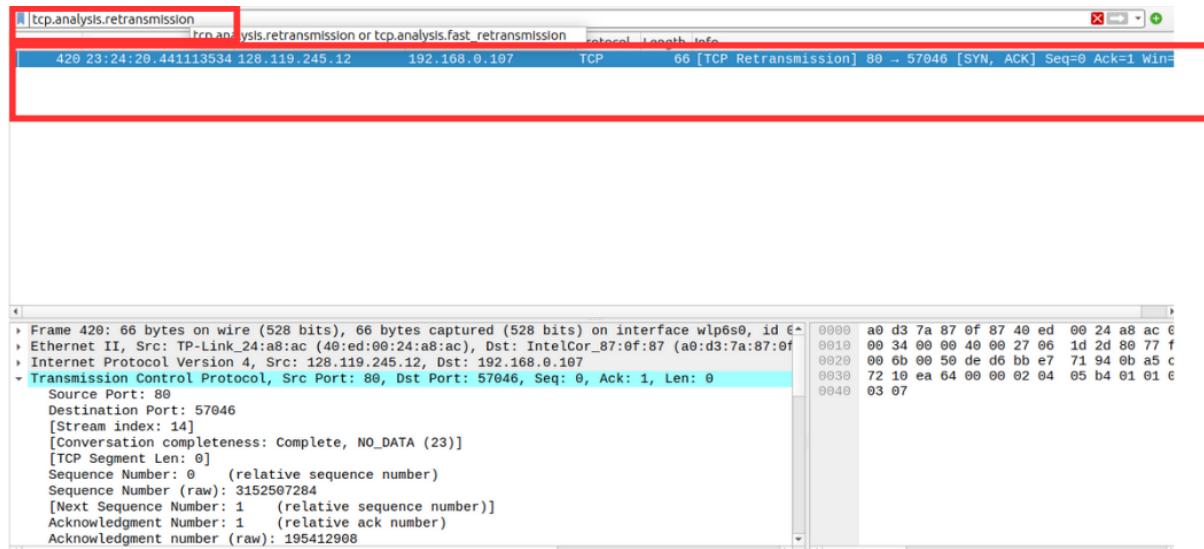
The minimum amount of available buffer space advertised by the client to gaia.cs.umass.edu is **502** which is equivalent to $502 \times 128 = \textbf{64256 Bytes}$. Given below the figure shows it.

54 23:23:50.242692836 107.178.254.65	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 37194 [ACK] Seq=1 Ack=602 [T]
55 23:23:50.452467296 192.168.0.107	128.119.245.12	TCP	656 57056 → 80 [PSH, ACK] Seq=1 Ack=1 Win=64256 Len=602 [TCP]
58 23:23:50.452345735 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=603 Ack=1 Win=64256 Len=1460 [TCP]
59 23:23:50.452467296 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=2063 Ack=1 Win=64256 Len=146
60 23:23:50.452476882 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=3523 Ack=1 Win=64256 Len=1466 [TCP]
61 23:23:50.452485900 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=3523 Ack=1 Win=64256 Len=1466 [TCP]
62 23:23:50.452489232 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=4983 Ack=1 Win=64256 Len=146
63 23:23:50.456186622 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=6443 Ack=1 Win=64256 Len=1466 [TCP]
64 23:23:50.456201623 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=7903 Ack=1 Win=64256 Len=146
65 23:23:50.457938942 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=9363 Ack=1 Win=64256 Len=1460 [TCP]
66 23:23:50.457956534 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=1460 [TCP]
69 23:23:50.459761520 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [TCP]
87 23:23:50.743578452 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0
88 23:23:50.743578496 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0
Flags: 0x010 (ACK)			
Window: 502			
[Calculated window size: 64256]			
[Window size scaling factor: 128]			
Checksum: 0x8050 [unverified]			
[Checksum Status: Unverified]			
Urgent Pointer: 0			
+ [Timestamps]			
[Time since first frame in this TCP stream: 1.760571915 seconds]			
[Time since previous frame in this TCP stream: 0.000009018 seconds]			
+ [SEQ/ACK analysis]			
[iRTT: 0.320980373 seconds]			
[Bytes in flight: 4982]			
55 23:23:50.242692836 107.178.254.65	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 37194 [ACK] Seq=1 Ack=602 [TCP]
58 23:23:50.452345735 192.168.0.107	128.119.245.12	TCP	656 57056 → 80 [PSH, ACK] Seq=1 Ack=1 Win=64256 Len=602 [TCP]
59 23:23:50.452467296 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=603 Ack=1 Win=64256 Len=1460 [TCP]
60 23:23:50.452476882 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=2063 Ack=1 Win=64256 Len=146
61 23:23:50.452485900 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=3523 Ack=1 Win=64256 Len=1460 [TCP]
62 23:23:50.452489232 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=4983 Ack=1 Win=64256 Len=146
63 23:23:50.456186622 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=6443 Ack=1 Win=64256 Len=1460 [TCP]
64 23:23:50.456201623 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=7903 Ack=1 Win=64256 Len=146
65 23:23:50.457938942 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=9363 Ack=1 Win=64256 Len=1460 [TCP]
66 23:23:50.457956534 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=1460 [TCP]
69 23:23:50.459761520 192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=12283 Ack=1 Win=64256 Len=1460 [TCP]
87 23:23:50.743578452 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=603 Win=30464 Len=0
88 23:23:50.743578496 128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=3523 Win=36352 Len=0
Flags: 0x010 (PSH, ACK)			
Window: 502			
[Calculated window size: 64256]			
[Window size scaling factor: 128]			
Checksum: 0x5c1a [unverified]			
[Checksum Status: Unverified]			
Urgent Pointer: 0			
+ [Timestamps]			
[Time since first frame in this TCP stream: 1.760575247 seconds]			
[Time since previous frame in this TCP stream: 0.000003332 seconds]			
+ [SEQ/ACK analysis]			
[iRTT: 0.320980373 seconds]			
[Bytes in flight: 6442]			

The first observation is that each TCP segment from client to gaia.cs.umass.edu has the same window size whereas window size varies for the case of gaia.cs.umass.edu to client. One of the reasons for the given observation would be that data is being sent from client to gaia.cs.umass.edu which leads to a lesser buffer because of delay in processing. There is no data sent from gaia.cs.umass.edu to the client and hence the buffer is empty all the time.

10.

Yes, there are retransmitted segments in the trace file. The retransmitted segments are found using the filter “tcp.analysis.retransmission”.



11.

Typically ACK acknowledges 1460 Bytes of data among the first ten data-carrying segments sent from the client to gaia.cs.umass.edu. Also, the segment size of each ACK segment is 0 Bytes.

There are certain instances where every packet is acknowledged and few acknowledgements are skipped as cumulative acknowledgment.

- 1st segment is acknowledged
- 2nd segment is not acknowledged
- 3rd segment is acknowledged
- 4th segment is not acknowledged
- 5th segment is acknowledged
- 6th segment is acknowledged
- 7th segment is acknowledged
- 8th segment is not acknowledged
- 9th segment is acknowledged
- 10th segment is acknowledged

Given below the figure showing details of the transmission:

1	58	23:23:50.452345735	192.168.0.107	128.119.245.12	TCP	656	57056	- 80	[PSH, ACK] Seq=1 Ack=1 Win=64256 Len=682
2	59	23:23:50.452467298	192.168.0.107	128.119.245.12	TCP	1514	57056	- 80	[ACK] Seq=683 Ack=1 Win=64256 Len=1460
3	60	23:23:50.452476882	192.168.0.107	128.119.245.12	TCP	1514	57056	- 80	[PSH, ACK] Seq=2063 Ack=1 Win=64256 Len=1460
4	61	23:23:50.452485900	192.168.0.107	128.119.245.12	TCP	1514	57056	- 80	[ACK] Seq=3523 Ack=1 Win=64256 Len=1460
5	62	23:23:50.452489232	192.168.0.107	128.119.245.12	TCP	1514	57056	- 80	[PSH, ACK] Seq=4983 Ack=1 Win=64256 Len=1460
6	63	23:23:50.456186622	192.168.0.107	128.119.245.12	TCP	1514	57056	- 80	[ACK] Seq=6443 Ack=1 Win=64256 Len=1460
7	64	23:23:50.456201623	192.168.0.107	128.119.245.12	TCP	1514	57056	- 80	[PSH, ACK] Seq=7983 Ack=1 Win=64256 Len=1460
8	65	23:23:50.457938942	192.168.0.107	128.119.245.12	TCP	1514	57056	- 80	[ACK] Seq=9363 Ack=1 Win=64256 Len=1460
9	66	23:23:50.457956534	192.168.0.107	128.119.245.12	TCP	1514	57056	- 80	[PSH, ACK] Seq=10823 Ack=1 Win=64256 Len=1460
10	69	23:23:50.459761520	192.168.0.107	128.119.245.12	TCP	1514	57056	- 80	[ACK] Seq=12283 Ack=1 Win=64256 Len=1460
87	23:23:50.743578452	128.119.245.12	192.168.0.107		TCP	ACK 1	54 80	- 57056	[ACK] Seq=1 Ack=683 Win=30464 Len=0
88	23:23:50.743578496	128.119.245.12	192.168.0.107		TCP	ACK 2	54 80	- 57056	[ACK] Seq=1 Ack=3523 Win=36352 Len=0
89	23:23:50.743578538	128.119.245.12	192.168.0.107		TCP	ACK 3	54 80	- 57056	[ACK] Seq=1 Ack=6443 Win=42112 Len=0
90	23:23:50.743578580	128.119.245.12	192.168.0.107		TCP	ACK 4	54 80	- 57056	[ACK] Seq=1 Ack=7983 Win=45956 Len=0
91	23:23:50.743578624	128.119.245.12	192.168.0.107		TCP	ACK 5	54 80	- 57056	[ACK] Seq=1 Ack=9363 Win=48966 Len=0
92	23:23:50.743578669	128.119.245.12	192.168.0.107		TCP	ACK 6	54 80	- 57056	[ACK] Seq=1 Ack=12283 Win=53888 Len=0
93	23:23:50.743621197	192.168.0.107	128.119.245.12		TCP	ACK 7	54 80	- 57056	[ACK] Seq=1 Ack=13743 Win=64256 Len=1460
94	23:23:50.743637291	192.168.0.107	128.119.245.12		TCP	ACK 8	54 80	- 57056	[ACK] Seq=15203 Ack=1 Win=64256 Len=1460
95	23:23:50.743649341	192.168.0.107	128.119.245.12		TCP	ACK 9	54 80	- 57056	[ACK] Seq=16663 Ack=1 Win=64256 Len=1460
96	23:23:50.743652325	192.168.0.107	128.119.245.12		TCP	ACK 10	54 80	- 57056	[ACK] Seq=18123 Ack=1 Win=64256 Len=1460
97	23:23:50.743670550	128.119.245.12	192.168.0.107		TCP	ACK 11	54 80	- 57056	[ACK] Seq=1 Ack=13743 Win=56704 Len=0
101	23:23:50.744023464	192.168.0.107	128.119.245.12		TCP	ACK 12	54 80	- 57056	[ACK] Seq=19583 Ack=1 Win=64256 Len=1460
102	23:23:50.744033665	192.168.0.107	128.119.245.12		TCP	ACK 13	54 80	- 57056	[ACK] Seq=21043 Ack=1 Win=64256 Len=1460
103	23:23:50.746684010	192.168.0.107	128.119.245.12		TCP	ACK 14	54 80	- 57056	[ACK] Seq=22503 Ack=1 Win=64256 Len=1460

Ethernet II, Src: IntelCor_87:0f:87 (a0:d3:7a:87:0f:87), Dst: TP-Link_24:a8:ac (40:ed:00:24:a8:ac) [0000 40 ed 00 24 a8 ac a0 d3 7a 87]
Internet Protocol Version 4, Src: 192.168.0.107, Dst: 107.178.254.65 [0010 00 34 5a dd 40 00 40 06 b4 df]

12.

Initial time of establishing connection = 23:23:48.691815969

Time at which connection closed = 23:23:57.032545642

Total data sent = 152923 bytes

Total time taken = 23:23:57.032545642 - 23:23:48.691815969

$$= 6.340729673 \text{ seconds}$$

Throughput = data sent/ time taken

$$= 152923 \text{ bytes} / 6.340729673 \text{ seconds}$$

$$= 24117.57 \text{ Bytes/second}$$

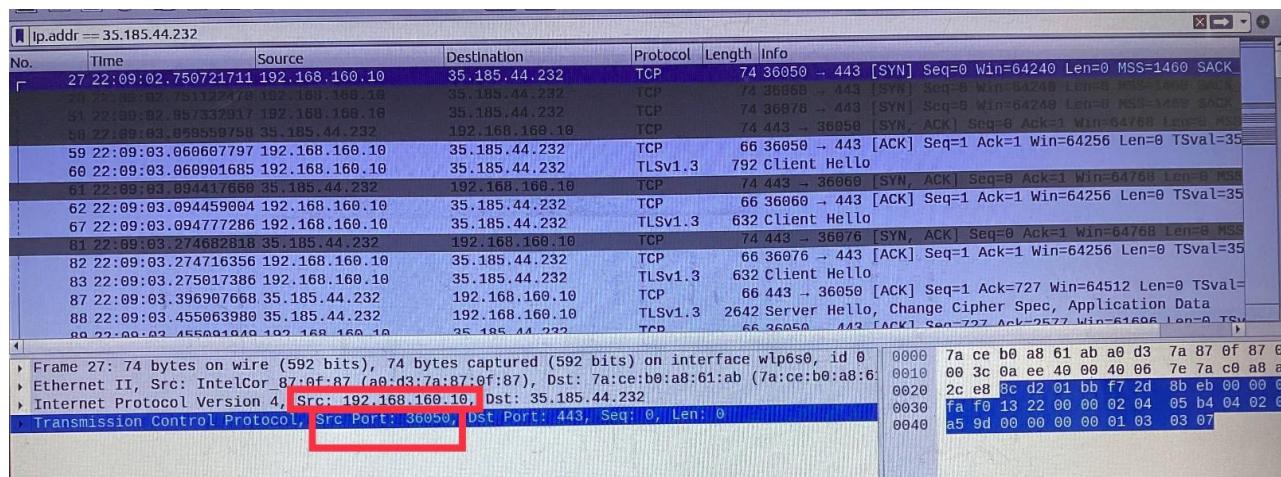
Given below the figure showing details of the transmission:

29	23:23:57.032545642	12.168.0.107	128.119.245.12	TCP	54 57056 → 80 [ACK] Seq=152924 Ack=779 Win=64128 Len=0	
331	23:24:00.196042346	192.168.0.107	23.41.186.17	TCP	66 55442 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=2401	
332	23:24:00.238897585	23.41.186.17	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 55442 [ACK] Seq=1 Ack=1	
337	23:24:06.596637693	192.168.0.107	35.227.252.103	TCP	66 39154 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=3493	
338	23:24:06.596697595	192.168.0.107	34.98.64.218	TCP	66 38462 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=2373	
341	23:24:06.625098960	34.98.64.218	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 38462 [ACK] Seq=1 Ack=1	
342	23:24:06.625099184	35.227.252.103	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 39154 [ACK] Seq=1 Ack=1	
359	23:24:10.692544492	192.168.0.107	151.101.157.229	TCP	66 37924 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=2991	
360	23:24:10.735362104	151.101.157.229	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 37924 [ACK] Seq=1 Ack=1	
363	23:24:12.740546829	192.168.0.107	108.157.238.123	TCP	66 38276 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=2000	
364	23:24:12.747789193	108.157.238.123	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 38276 [ACK] Seq=1 Ack=1	
365	23:24:12.792587981	192.168.0.107	172.217.194.188	TCP	66 37954 → 5228 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=394	
Source Port: 57056 Destination Port: 80 [Stream index: 15] [Conversation completeness: Complete, WITH_DATA (31)] [TCP Segment Len: 0] Sequence Number: 152924 (relative sequence number) Sequence Number (raw): 1884059782 [Next Sequence Number: 152924 (relative sequence number)] Acknowledgment Number: 779 (relative ack number) Acknowledgment number (raw): 4194255411 0101 = Header Length: 20 bytes (5) Flags: 0x010 (ACK) Window: 501 [Calculated window size: 64128]						
296	23:23:56.096002067	12.119.245.12	192.168.0.107	TCP	54 80 → 57056 [FIN, ACK] Seq=778 Ack=152924 Win=259840 Len=0	
29	23:23:57.032545642	192.168.0.107	128.119.245.12	TCP	54 57056 → 80 [ACK] Seq=152924 Ack=779 Win=64128 Len=0	
331	23:24:00.196042346	192.168.0.107	23.41.186.17	TCP	66 55442 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=2401	
332	23:24:00.238897585	23.41.186.17	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 55442 [ACK] Seq=1 Ack=1	
337	23:24:06.596637693	192.168.0.107	35.227.252.103	TCP	66 39154 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=3493	
338	23:24:06.596697595	192.168.0.107	34.98.64.218	TCP	66 38462 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=2373	
341	23:24:06.625098960	34.98.64.218	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 38462 [ACK] Seq=1 Ack=1	
342	23:24:06.625099184	35.227.252.103	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 39154 [ACK] Seq=1 Ack=1	
359	23:24:10.692544492	192.168.0.107	151.101.157.229	TCP	66 37924 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=2991	
360	23:24:10.735362104	151.101.157.229	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 37924 [ACK] Seq=1 Ack=1	
363	23:24:12.740546829	192.168.0.107	108.157.238.123	TCP	66 38276 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=2000	
364	23:24:12.747789193	108.157.238.123	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 38276 [ACK] Seq=1 Ack=1	
365	23:24:12.792587981	192.168.0.107	172.217.194.188	TCP	66 37954 → 5228 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=394	
Source Port: 57056 Destination Port: 80 [Stream index: 15] [Conversation completeness: Complete, WITH_DATA (31)] [TCP Segment Len: 0] Sequence Number: 152924 (relative sequence number) Sequence Number (raw): 1884059782 [Next Sequence Number: 152924 (relative sequence number)] Acknowledgment Number: 779 (relative ack number) Acknowledgment number (raw): 4194255411 0101 = Header Length: 20 bytes (5) Flags: 0x010 (ACK) Window: 501						
251	23:23:51.668217562	192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [PSH, ACK] Seq=149523 Ack=1 Win=64256 Len=1	
252	23:23:51.668224799	192.168.0.107	128.119.245.12	TCP	1514 57056 → 80 [ACK] Seq=150983 Ack=1 Win=64256 Len=1460	
+ 253	23:23:51.668227473	192.168.0.107	128.119.245.12	HTTP	535 POST /wireshark-labs/lab3-1-reply.htm HTTP/1.1 (text/	
254	23:23:51.975766126	128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=15143 Win=258816 Len=0	
255	23:23:51.975766358	128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=148063 Win=256896 Len=0	
256	23:23:51.975766403	128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=150983 Win=254848 Len=0	
257	23:23:51.975766447	128.119.245.12	192.168.0.107	TCP	54 80 → 57056 [ACK] Seq=1 Ack=152924 Win=252928 Len=0	
258	23:23:51.975766489	128.119.245.12	192.168.0.107	HTTP	831 HTTP/1.1 200 OK (text/html)	
259	23:23:51.975805860	192.168.0.107	128.119.245.12	TCP	54 57056 → 80 [ACK] Seq=152924 Ack=778 Win=63488 Len=0	
260	23:23:52.432617263	192.168.0.107	151.101.154.49	TCP	66 39388 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=6303	
261	23:23:52.635270733	151.101.154.49	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 39388 [ACK] Seq=1 Ack=1	
264	23:23:54.324575683	192.168.0.107	104.81.21.87	TCP	66 55362 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0 TStamp=7922	
265	23:23:54.382171791	104.81.21.87	192.168.0.107	TCP	66 [TCP ACKed unseen segment] 443 → 55362 [ACK] Seq=1 Ack=1	
Urgent Pointer: 0 + [Timestamps] [Time since first frame in this TCP stream: 2.976313488 seconds] [Time since previous frame in this TCP stream: 0.000002674 seconds] + [SEQ/ACK analysis] [iRTT: 0.320980373 seconds] [Bytes in flight: 10701] [Bytes sent since last PSH flag: 1941] TCP payload (481 bytes) TCP segment data (481 bytes)						
[106 Reassembled TCP Segments (152923 bytes): #5 (602), #59(1460), #60(1460), #61(1460), #62(1460)]	00000000 50 4f 53 54 20 2f 77 69 72 65 73 00000010 6c 61 62 73 2f 6c 61 62 33 2d 31 00000020 79 2e 68 74 6d 20 48 54 54 50 2f 00000030 48 6f 73 74 3a 20 67 61 69 61 2e 00000040 61 73 73 2e 65 64 75 0d 0a 43 6f 00000050 69 6f 6e 3a 20 6b 65 65 70 2d 61 00000060 0a 43 6f 6e 74 65 6e 74 2d 4c 65 00000070 20 31 35 32 33 32 31 0d 0a 43 61 00000080 6f 6e 74 72 6f 6c 3a 20 0d 61 78 00000090 30 0d 0a 55 70 67 72 61 64 65 2d 000000a0 75 72 65 2d 52 65 71 75 65 73 74 000000b0 6a 55 73 65 72 2d 41 67 65 6e 74 000000c0 69 6c 61 2f 35 2e 30 20 28 58					
Hypertext Transfer Protocol	MIME Multipart Media Encapsulation, Type: multipart/form-data, Boundary: "----WebKitFormBoundary					

PART-B

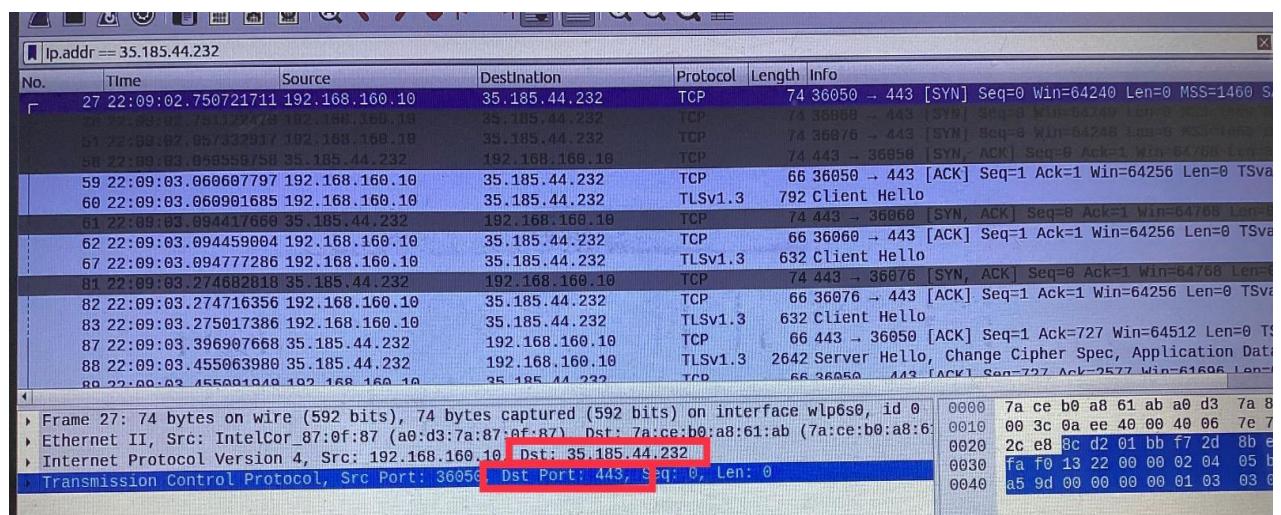
1.

The IP address and TCP port number used by the client computer (source) to get the homepage of cse.iith.ac.in is **192.168.160.10** and **36050** respectively. Given below the figure shows it.



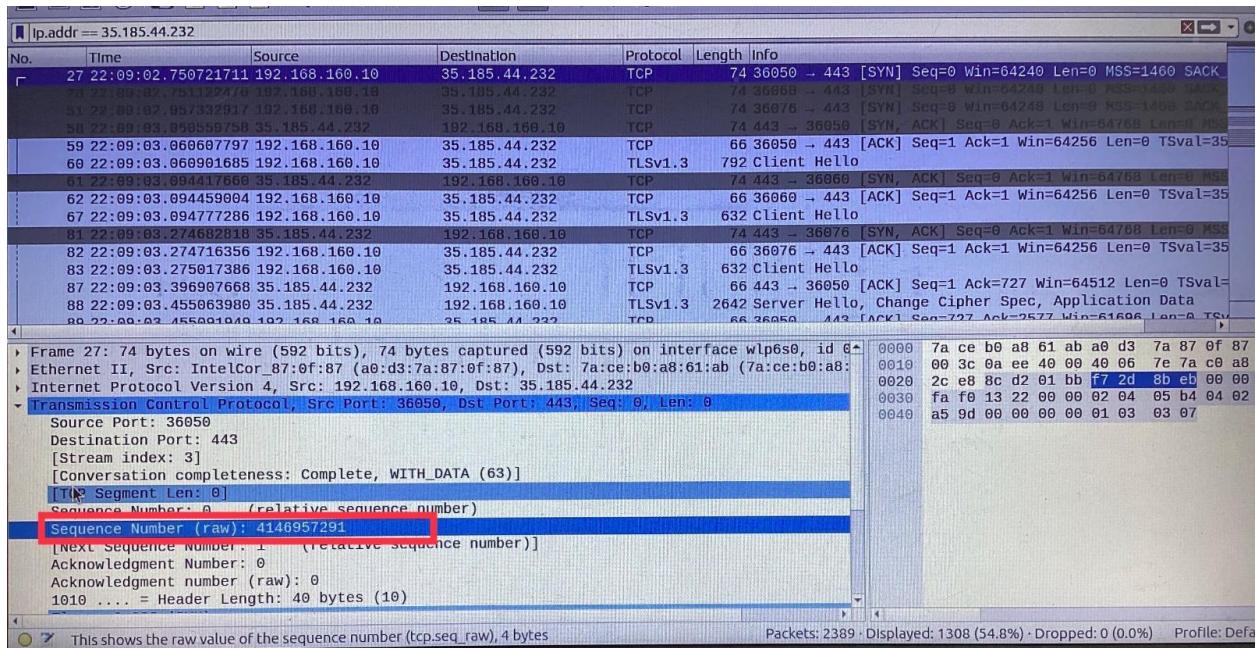
2.

The IP address of cse.iith.ac.in is **35.185.44.232** and the port number it is sending and receiving TCP segments for this connection is **443**. Given below the figure shows it.

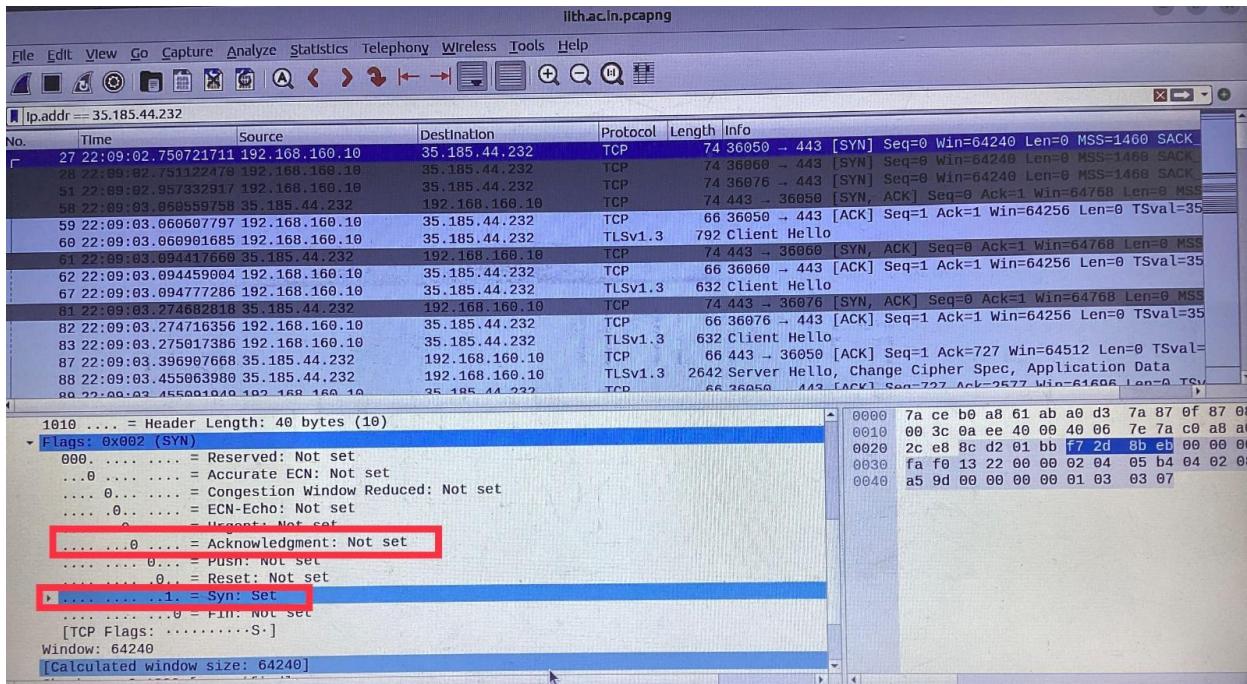


3.

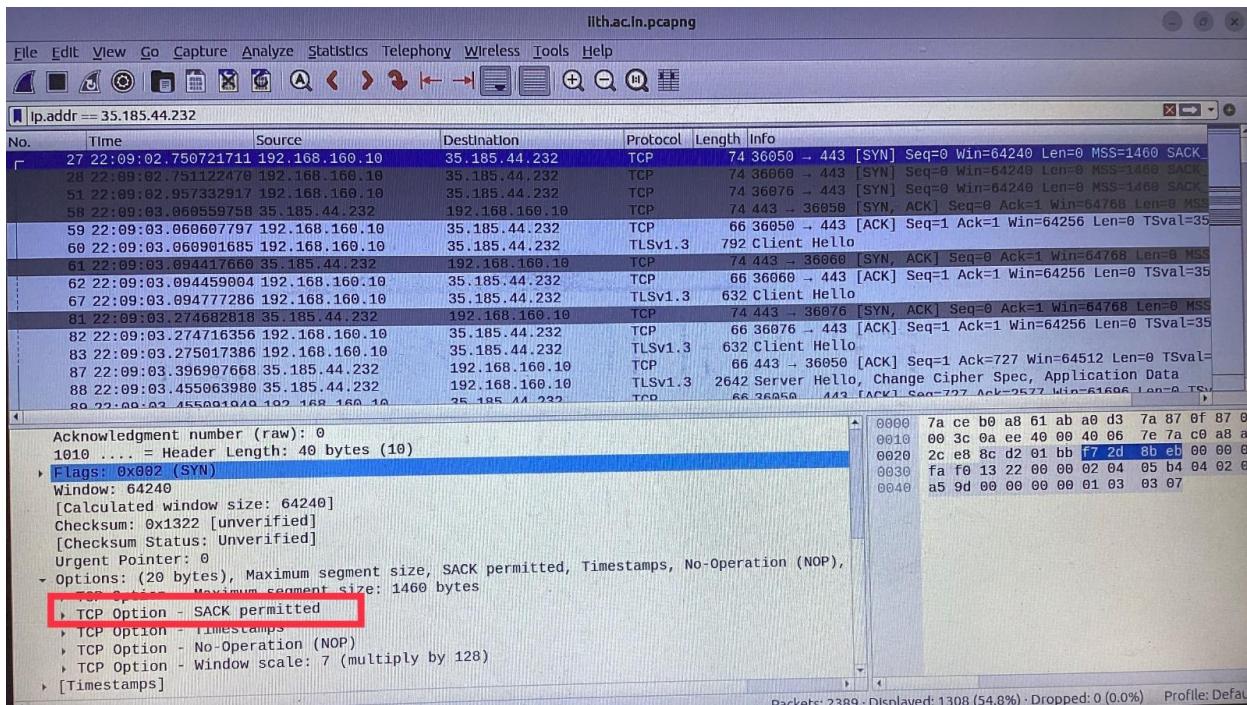
The sequence number of the TCP SYN segment that is used to initiate the TCP connection between the client computer and cse.iith.ac.in is **4146957291**. Given below the figure shows it.



The **SYN bit is set to 1** inside the flags of the TCP header and tells us that the selected TCP segment identifies the SYN segment. Given below the figure shows it.



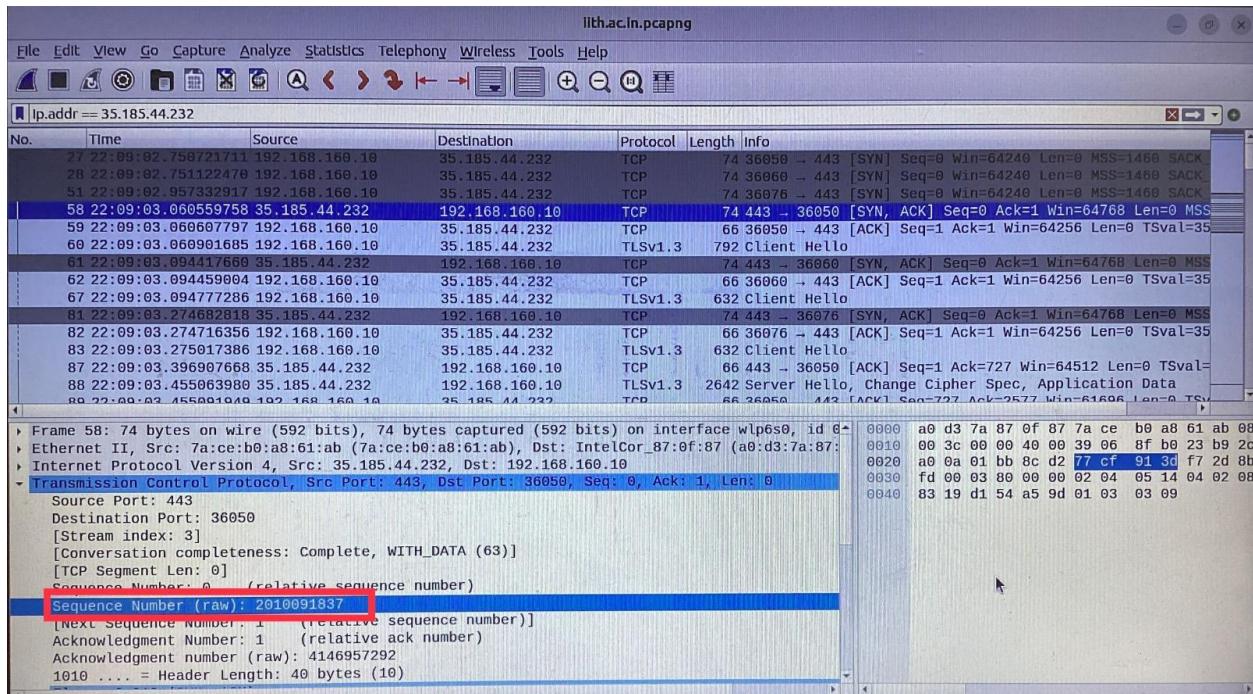
Yes, the TCP receiver in this session will be able to **use selective acknowledgements** as the SACK Permitted option is present in the TCP options section. Given below the figure shows it.



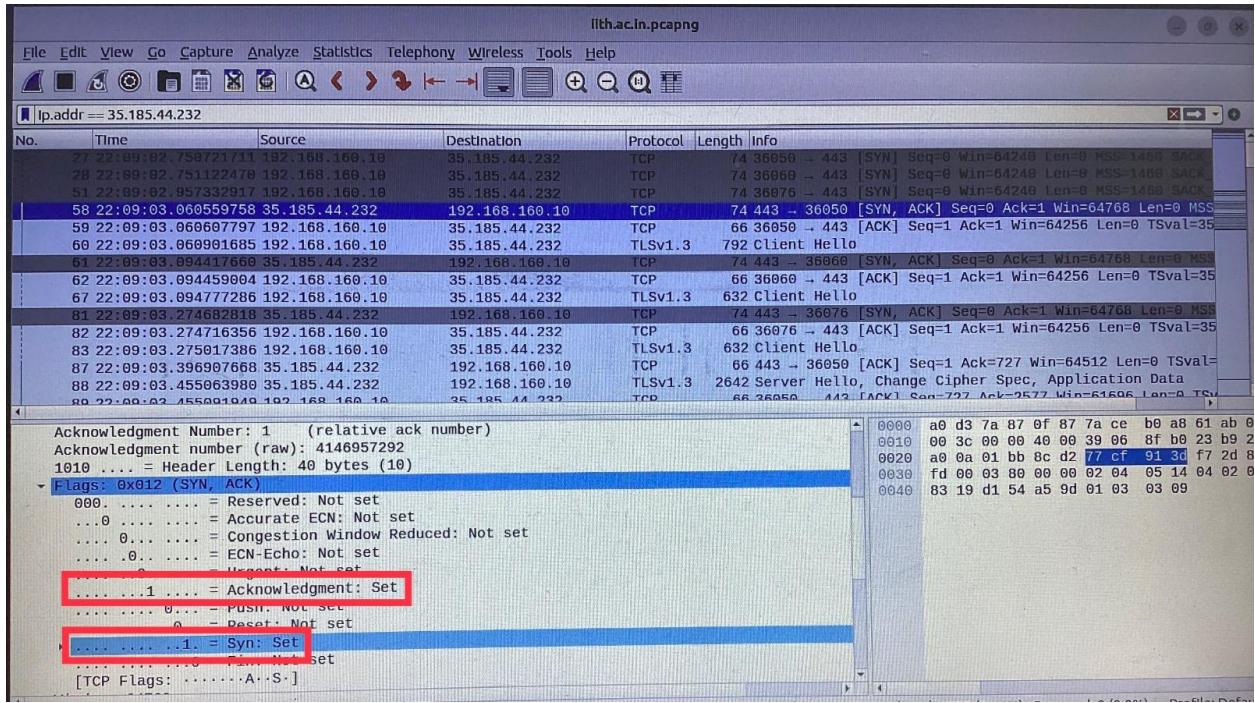
Note: My system sends three SYN requests, gets three SYNACK replies and then again sends three ACK to “cse.iith.ac.in”.

4.

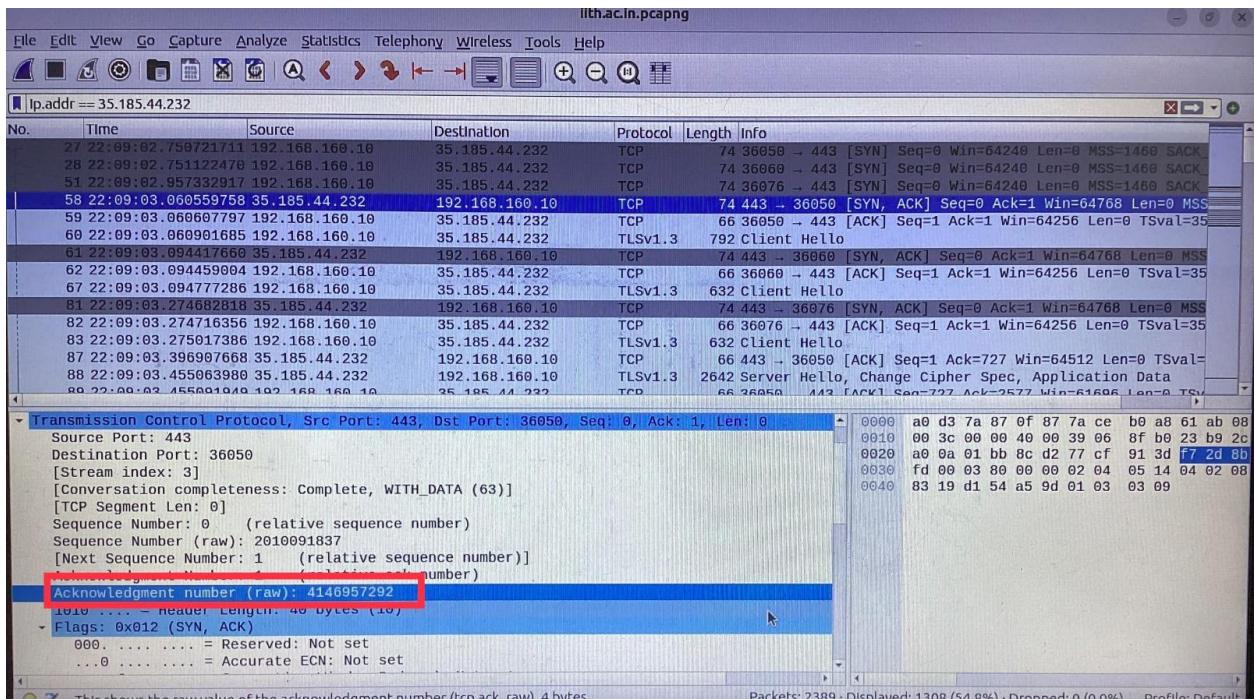
The sequence number of the TCP SYNACK segment that was sent by cse.iith.ac.in to the client computer in reply to the SYN is **2010091837**. Given below the figure shows it.



The **SYN and acknowledgment bit is set to 1** inside the flags of the TCP header and tells us that the selected TCP segment identifies the SYNACK segment. Given below the figure shows it.



The value of the Acknowledgement field in the SYNACK segment is **4146957292**. Given below the figure shows it.



The value of the Acknowledgement field in SYNACK by gaia.cs.umass.edu is determined by the sequence number of the SYN segment received from my computer. It increments the value by 1 which indicates the next sequence number from my computer.

$$4146957291 + 1 = 4146957292$$

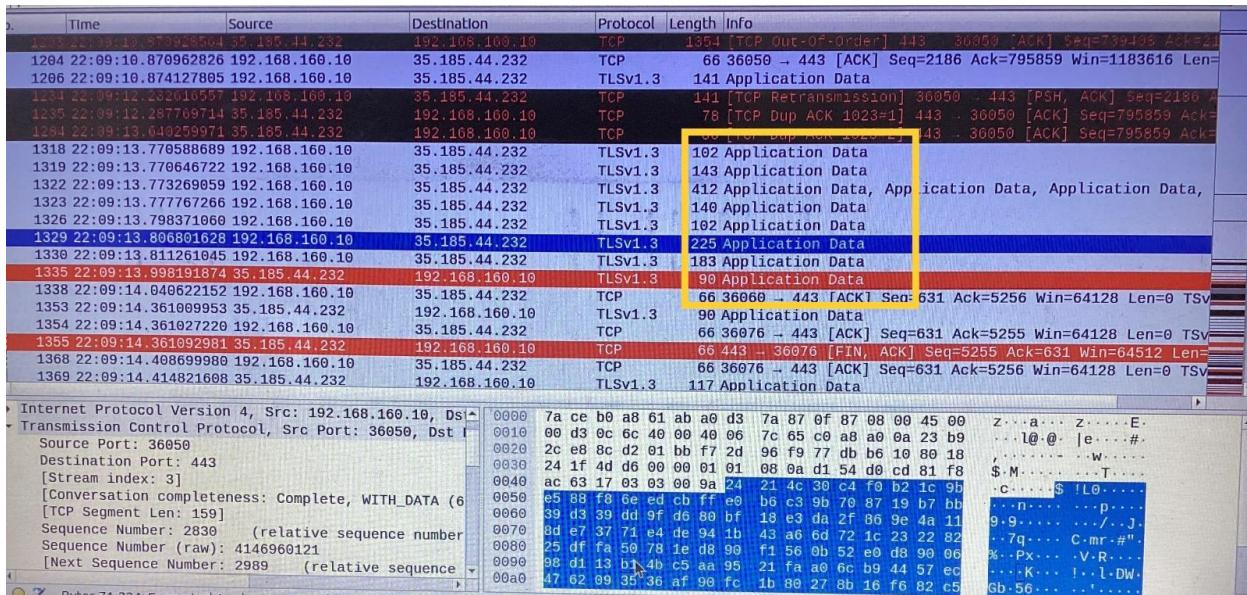
Note: My system sends three SYN requests, gets two SYNACK replies and then again sends three ACK to "cse.iith.ac.in". The second and third set also follow the same approach of incrementing the value by 1 of its sequence number to get the acknowledgement number.

5.

I am not able to see the GET request or any other details of the encrypted communication. To decrypt HTTPS traffic in Wireshark, It is required to have access to the private key associated with the SSL/TLS certificate used during the communication.

The answer below is mentioned based on the TLS communication sequence diagram.

- It is visible that first TCP connection is made and then the TLS hello and its reply is done.
- Also, the key exchange and data transfer take place, but the place where data transfer takes place i.e., "GET" message in data content is not visible.
- **No, all of the data in the transfer from the IITH web server to client does not fit into a single segment.** Multiple segments can be seen in the wireshark to get the content of the web page from the server.



6.

I am not able to see the GET request or any other details of the encrypted communication. To decrypt HTTPS traffic in Wireshark, It is required to have access to the private key associated with the SSL/TLS certificate used during the communication.

The answer below is mentioned based on the TLS communication sequence diagram.

- It is visible that first TCP connection is made and then the TLS hello and its reply is done.
- Also, the key exchange and data transfer take place, but the place where data transfer takes place i.e., “GET” message in data content is not visible.

The RTT calculation below is based on the the first two request sent from client to “cse.iith.ac.in”

The time at which the first segment was sent is “**22:09:02.750721711**”. Given below the figure shows it.

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Ip.addr == 35.185.44.232 &

No.	Time	Source	Destination	Protocol	Length	Info
27	22:09:02.750721711	192.168.160.10	35.185.44.232	TCP	74	36050 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460
28	22:09:02.751122470	192.168.160.10	35.185.44.232	TCP	74	36060 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460
51	22:09:02.957332917	192.168.160.10	35.185.44.232	TCP	74	36076 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460
58	22:09:03.068559758	35.185.44.232	192.168.160.10	TCP	74	443 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=64256
59	22:09:03.068607797	192.168.160.10	35.185.44.232	TCP	66	36050 → 443 [ACK] Seq=1 Ack=1 Win=64256
60	22:09:03.0690901685	192.168.160.10	35.185.44.232	TLSv1.3	792	Client Hello
61	22:09:03.094417660	35.185.44.232	192.168.160.10	TCP	74	443 → 36060 [SYN, ACK] Seq=0 Ack=1 Win=64256
62	22:09:03.094459004	192.168.160.10	35.185.44.232	TCP	66	36060 → 443 [ACK] Seq=1 Ack=1 Win=64256
67	22:09:03.094777286	192.168.160.10	35.185.44.232	TLSv1.3	632	Client Hello
81	22:09:03.274682818	35.185.44.232	192.168.160.10	TCP	74	443 → 36076 [SYN, ACK] Seq=0 Ack=1 Win=64256
82	22:09:03.274716356	192.168.160.10	35.185.44.232	TCP	66	36076 → 443 [ACK] Seq=1 Ack=1 Win=64256
83	22:09:03.275017386	192.168.160.10	35.185.44.232	TLSv1.3	632	Client Hello
88	22:09:03.455063980	35.185.44.232	192.168.160.10	TCP	66	443 → 36050 [SYN] Seq=0 Ack=1 Win=64512 Len=0
89	22:09:03.455091949	192.168.160.10	35.185.44.232	TCP	66	36050 → 443 [ACK] Seq=1 Ack=1 Win=64512 Len=0
90	22:09:03.456583198	35.185.44.232	192.168.160.10	TLSv1.3	2642	Application Data, Application Data, Application Data
91	22:09:03.456602002	192.168.160.10	35.185.44.232	TCP	66	36050 → 443 [ACK] Seq=727 Ack=5153 Win=61056 Len=0
92	22:09:03.456583346	35.185.44.232	192.168.160.10	TLSv1.3	83	Application Data
93	22:09:03.456619394	192.168.160.10	35.185.44.232	TCP	66	36050 → 443 [ACK] Seq=727 Ack=5170 Win=61056 Len=0
94	22:09:03.456583413	35.185.44.232	192.168.160.10	TCP	66	443 → 36060 [ACK] Seq=1 Ack=567 Win=645

The time at which the ACK of the first segment was received is “22:09:03.060559758”. Given below the figure shows it.

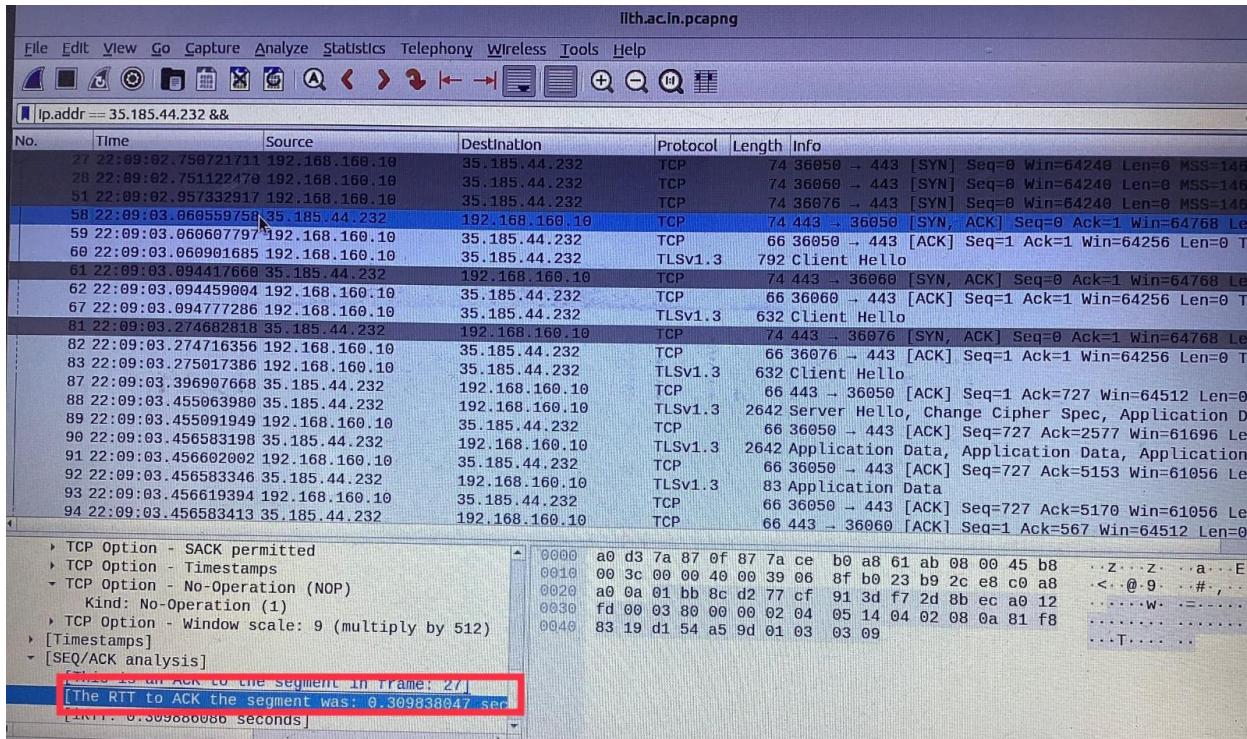
lith.ac.in.pcapng

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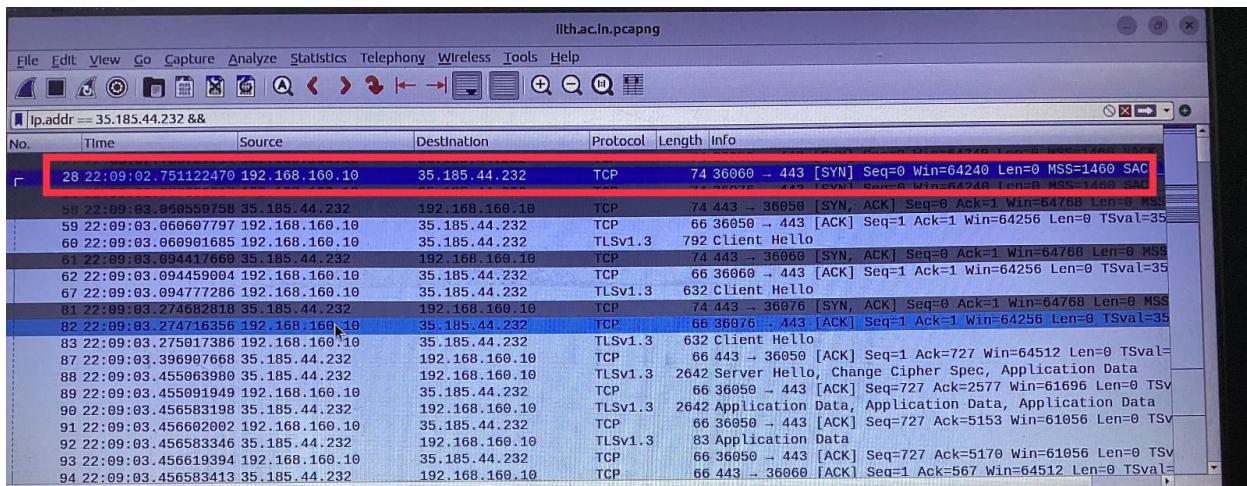
Ip.addr == 35.185.44.232 &

No.	Time	Source	Destination	Protocol	Length	Info
27	22:09:02.750721711	192.168.160.10	35.185.44.232	TCP	74	36050 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460
28	22:09:02.751122470	192.168.160.10	35.185.44.232	TCP	74	36060 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460
58	22:09:03.068559758	35.185.44.232	192.168.160.10	TCP	74	443 → 36050 [SYN, ACK] Seq=0 Ack=1 Win=64768 Len=0
59	22:09:03.0690901685	192.168.160.10	35.185.44.232	TLSv1.3	632	Client Hello
60	22:09:03.094417660	35.185.44.232	192.168.160.10	TLSv1.3	792	Client Hello
61	22:09:03.094417660	35.185.44.232	192.168.160.10	TCP	74	443 → 36060 [SYN, ACK] Seq=0 Ack=1 Win=64768 Len=0
62	22:09:03.094459004	192.168.160.10	35.185.44.232	TCP	66	36060 → 443 [ACK] Seq=1 Ack=1 Win=64256 Len=0 TSV
67	22:09:03.094777286	192.168.160.10	35.185.44.232	TLSv1.3	632	Client Hello
81	22:09:03.274682818	35.185.44.232	192.168.160.10	TCP	74	443 → 36076 [SYN, ACK] Seq=0 Ack=1 Win=64768 Len=0
82	22:09:03.274716356	192.168.160.10	35.185.44.232	TCP	66	36076 → 443 [ACK] Seq=1 Ack=1 Win=64256 Len=0 TSV
83	22:09:03.275017386	192.168.160.10	35.185.44.232	TLSv1.3	632	Client Hello
87	22:09:03.396907668	35.185.44.232	192.168.160.10	TCP	66	443 → 36050 [ACK] Seq=1 Ack=727 Win=64512 Len=0 TSV
88	22:09:03.455063980	35.185.44.232	192.168.160.10	TLSv1.3	2642	Server Hello, Change Cipher Spec, Application Data
89	22:09:03.455091949	192.168.160.10	35.185.44.232	TCP	66	36050 → 443 [ACK] Seq=727 Ack=2577 Win=61696 Len=0 TSV
90	22:09:03.456583198	35.185.44.232	192.168.160.10	TLSv1.3	2642	Application Data, Application Data, Application Data
91	22:09:03.456602002	192.168.160.10	35.185.44.232	TCP	66	36050 → 443 [ACK] Seq=727 Ack=5153 Win=61056 Len=0 TSV
92	22:09:03.456583346	35.185.44.232	192.168.160.10	TLSv1.3	83	Application Data
93	22:09:03.456619394	192.168.160.10	35.185.44.232	TCP	66	36050 → 443 [ACK] Seq=727 Ack=5170 Win=61056 Len=0 TSV
94	22:09:03.456583413	35.185.44.232	192.168.160.10	TCP	66	443 → 36060 [ACK] Seq=1 Ack=567 Win=64512 Len=0 TSV

The RTT of the first data-containing segment is **0.309838047 seconds**. Given below the figure shows it.



The time at which the second segment was sent is “**22:09:02.751122470**”. Given below the figure shows it.



The time at which the ACK of the second segment was received is “**22:09:03.094417660**”. Given below the figure shows it.

No.	Time	Source	Destination	Protocol	Length	Info
59	22:09:03.060607779	192.168.160.10	35.185.44.232	TCP	66	36050 → 443 [ACK] Seq=1 Ack=1 Win=64256 Len=0 TSVal=35
60	22:09:03.060607785	192.168.160.10	35.185.44.232	TLSv1.3	792	Client Hello
61	22:09:03.094417666	35.185.44.232	192.168.160.10	TCP	74	443 → 36060 [SYN, ACK] Seq=0 Ack=1 Win=64256 Len=0 TSVal=35
62	22:09:03.094417672	35.185.44.232	192.168.160.10	TCP	66	36060 → 443 [ACK] Seq=1 Ack=1 Win=64256 Len=0 TSVal=35
67	22:09:03.094777286	192.168.160.10	35.185.44.232	TLSv1.3	632	Client Hello
68	22:09:03.094777292	35.185.44.232	192.168.160.10	TCP	74	443 → 36076 [SYN, ACK] Seq=0 Ack=1 Win=64256 Len=0 TSVal=35
69	22:09:03.094777298	192.168.160.10	35.185.44.232	TCP	66	36076 → 443 [ACK] Seq=1 Ack=1 Win=64256 Len=0 TSVal=35
70	22:09:03.094777304	35.185.44.232	192.168.160.10	TLSv1.3	632	Client Hello
71	22:09:03.094777310	35.185.44.232	192.168.160.10	TCP	66	443 → 36050 [ACK] Seq=1 Ack=727 Win=64512 Len=0 TSVal=35
72	22:09:03.094777316	35.185.44.232	192.168.160.10	TLSv1.3	2642	Server Hello, Change Cipher Spec, Application Data
73	22:09:03.094777322	35.185.44.232	192.168.160.10	TCP	66	36050 → 443 [ACK] Seq=727 Ack=2577 Win=61696 Len=0 TSVal=35
74	22:09:03.094777328	35.185.44.232	192.168.160.10	TCP	66	36050 → 443 [ACK] Seq=727 Ack=2577 Win=61696 Len=0 TSVal=35
75	22:09:03.094777334	35.185.44.232	192.168.160.10	TLSv1.3	2642	Application Data, Application Data, Application Data
76	22:09:03.094777340	35.185.44.232	192.168.160.10	TCP	66	36050 → 443 [ACK] Seq=727 Ack=5153 Win=61056 Len=0 TSVal=35
77	22:09:03.094777346	35.185.44.232	192.168.160.10	TLSv1.3	83	Application Data
78	22:09:03.094777352	35.185.44.232	192.168.160.10	TCP	66	36050 → 443 [ACK] Seq=727 Ack=5170 Win=61056 Len=0 TSVal=35
79	22:09:03.094777358	35.185.44.232	192.168.160.10	TCP	66	443 → 36060 [ACK] Seq=1 Ack=567 Win=64512 Len=0 TSVal=35
80	22:09:03.094777364	35.185.44.232	192.168.160.10	TCP	66	36060 → 443 [ACK] Seq=1 Ack=567 Win=64512 Len=0 TSVal=35

The RTT of the second data-containing segment is **0.343295190 seconds**. Given below the figure shows it.

$$\text{EstimatedRTT} = (1 - \alpha) * \text{EstimatedRTT} + \alpha * \text{SampleRTT}$$

EstimatedRTT = RTT of first segment = 0.309838047 seconds

SampleRTT = RTT of current segment = 0.343295190 seconds

q = 0.125

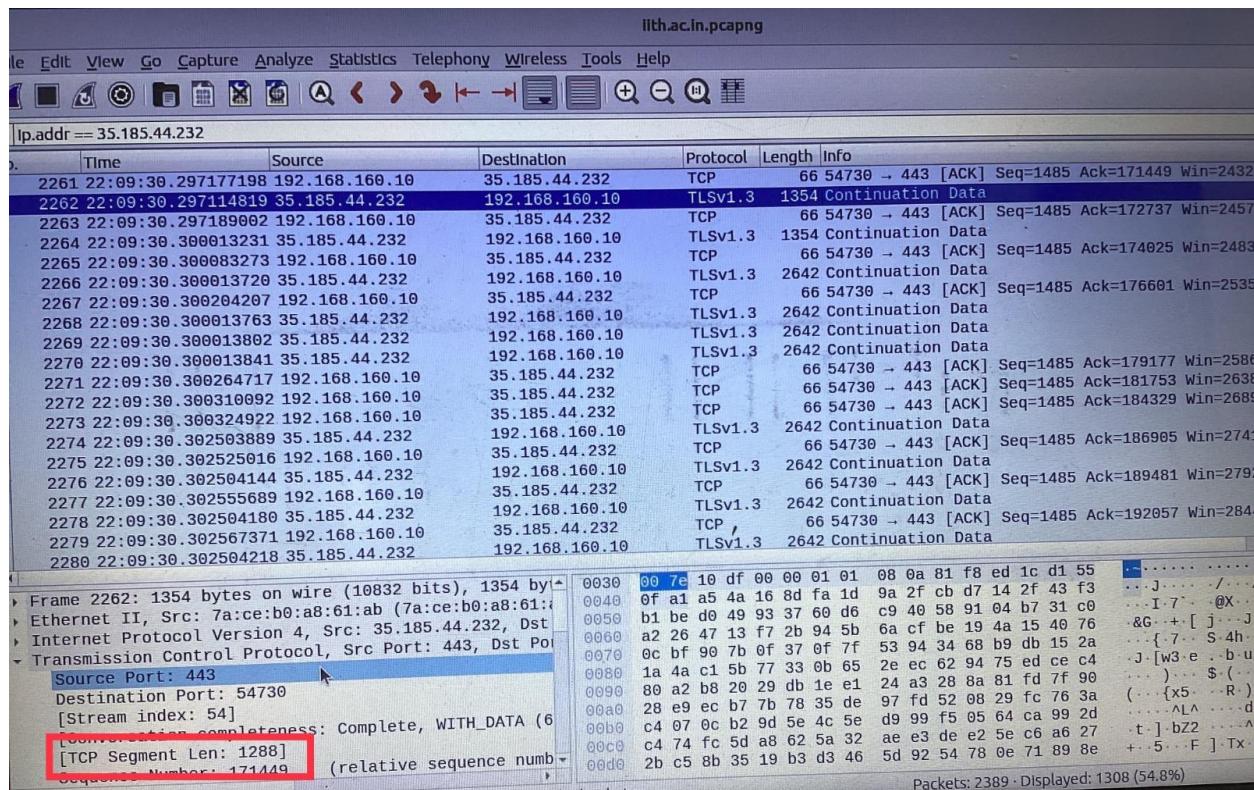
$$\text{EstimatedRTT} = (1 - \alpha) * \text{EstimatedRTT} + \alpha * \text{SampleRTT}$$

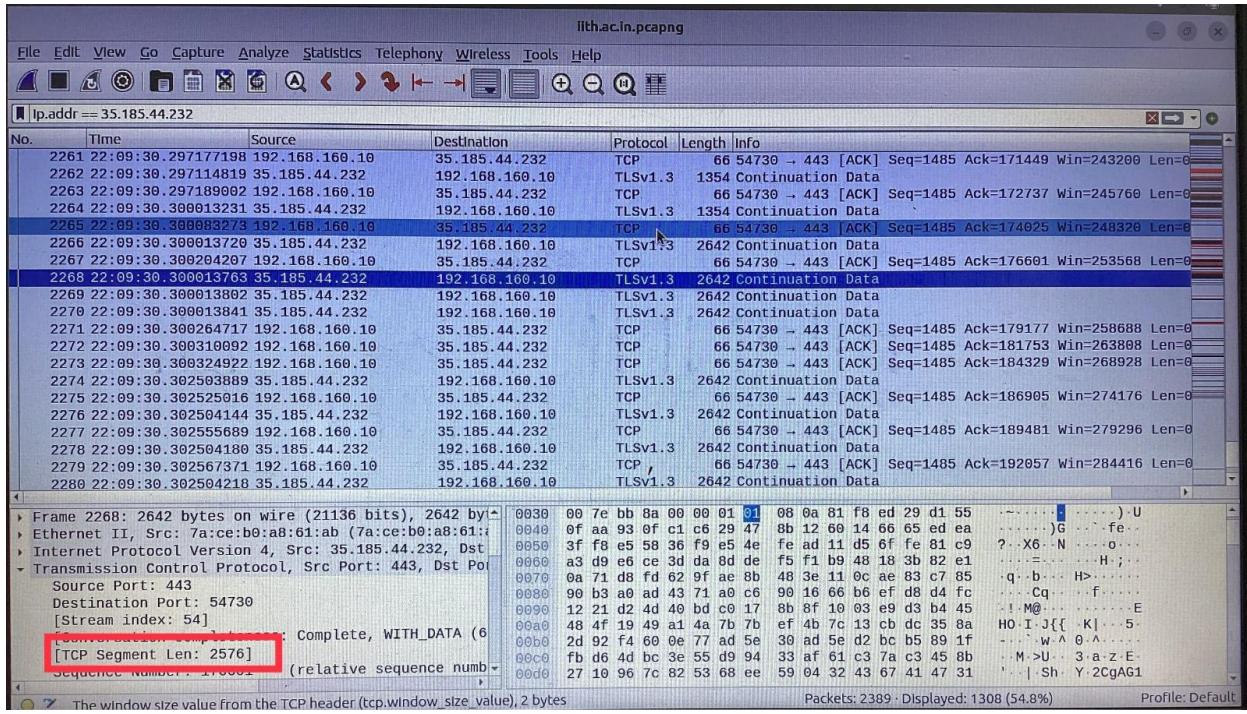
$$\text{EstimatedRTT} = (1 - 0.125) * 0.309838047 + 0.125 * 0.343295190$$

EstimatedRTT = 0.3140205601 seconds

7.

The length (header plus payload) of each of the first four data-carrying TCP segments are **1288, 1288, 2576, and 2576 Bytes**. Given below the figure shows it.

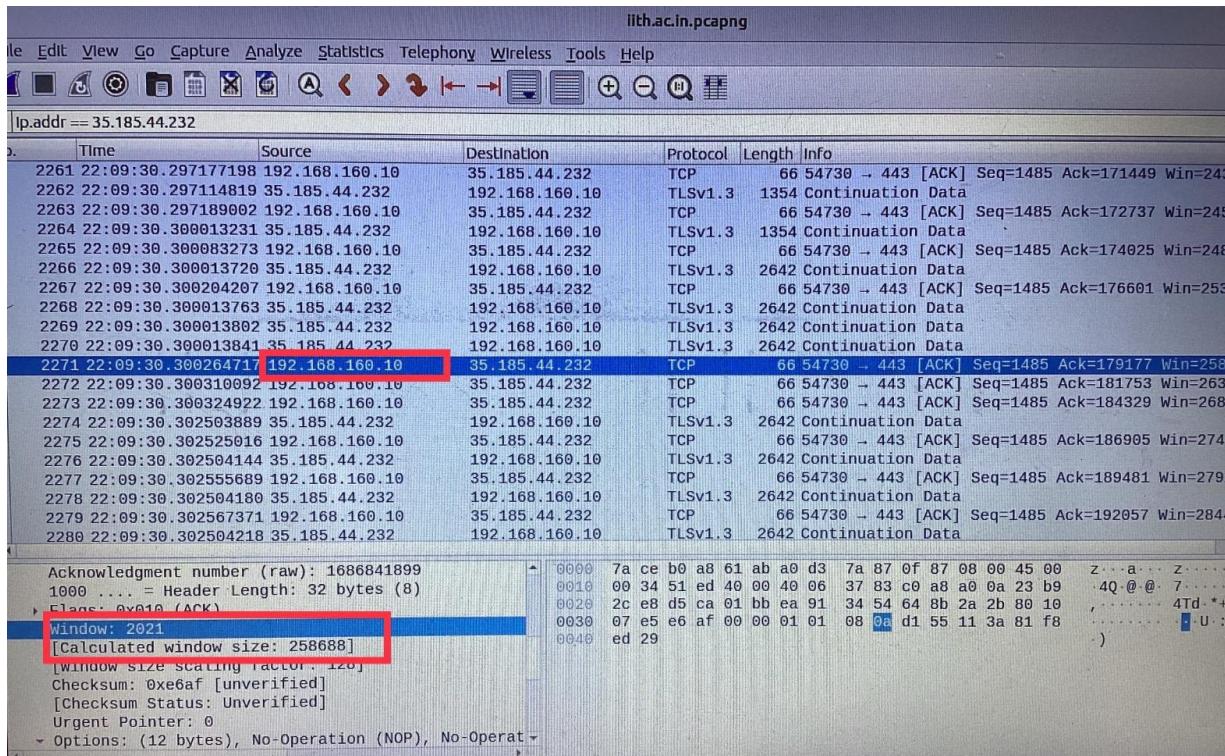




8.

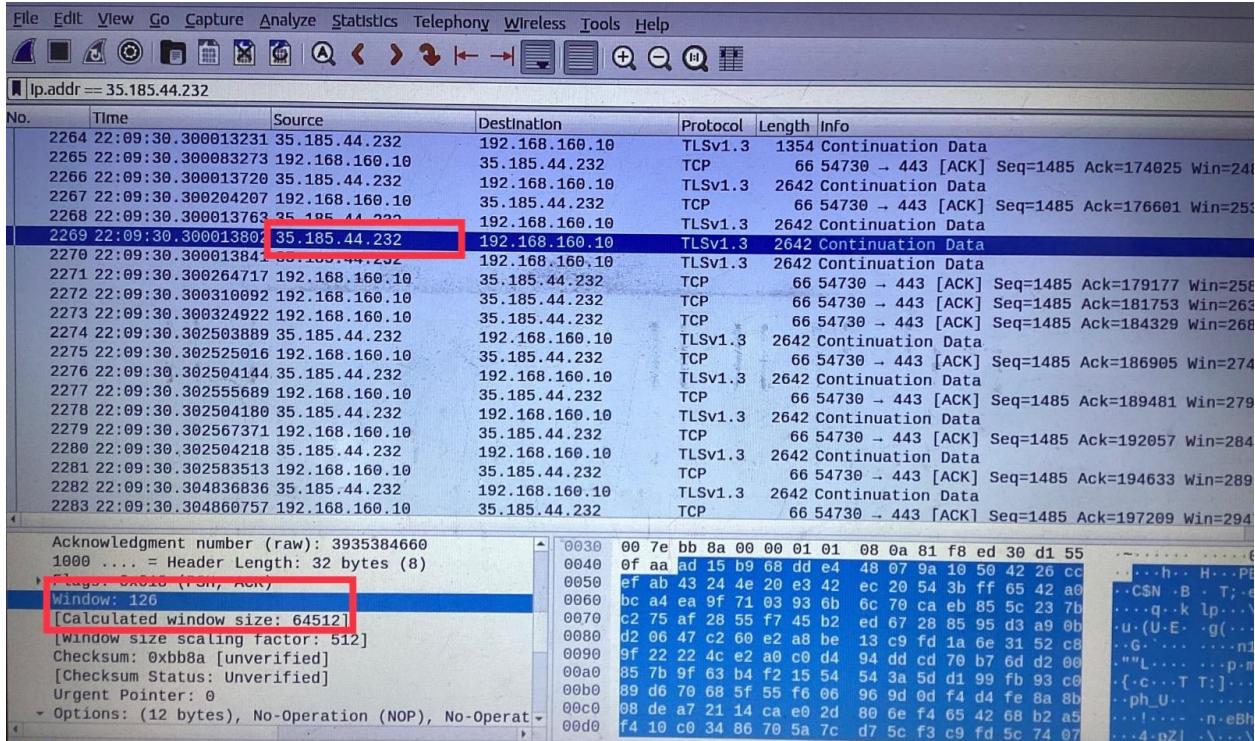
The minimum amount of available buffer space advertised by the client to 'cse.iith.ac.in' among these first five data-carrying TCP segments is **2021** which is equivalent to $2021 * 128 = 258688$ Bytes

No, the lack of receiver buffer space ever throttles the sender for these first five data carrying segments because the advertised window size has ample buffer space for smooth communication between sender and receiver as the sender is sending packets of 2576 Bytes. Given below the figure shows it.



9.

The minimum amount of available buffer space advertised by the 'cse.iiith.ac.in' to client is **126** which is equivalent to $126 \times 512 = \textbf{64512 Bytes}$. Given below the figure shows it.



The first observation is that each TCP segment by 'cse.iith.ac.in' to client has the same window size whereas window size varies for the case of client to 'cse.iith.ac.in'. One of the reasons for the given observation would be that data is being sent from 'cse.iith.ac.in' to the client which leads to a lesser buffer because of delay in processing. There is no data sent from client to 'cse.iith.ac.in' and hence the buffer is empty all the time.

10.

Yes, there are retransmitted segments in the trace file. The retransmitted segments are found using the filter “ip.addr == 35.185.44.232 && tcp.analysis.retransmission”.

iiith.ac.in.pcapng

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Ip.addr == 35.185.44.232 && tcp.analysis.retransmission

No.	Time	Source	Destination	Protocol	Length	Info
0.	22:09:04.817163093	35.185.44.232	192.168.160.10	TLSv1.3	1354	[TCP Fast Retransmission], Application Data
	039 22:09:06.910485618	35.185.44.232	192.168.160.10	TLSv1.3	1354	[TCP Fast Retransmission], Application Data
	697 22:09:07.168041395	35.185.44.232	192.168.160.10	TLSv1.3	1354	[TCP Fast Retransmission], Application Data
	707 22:09:07.269789072	35.185.44.232	192.168.160.10	TLSv1.3	1354	[TCP Fast Retransmission], Application Data
	822 22:09:07.880628231	192.168.160.10	35.185.44.232	TCP	183	[TCP Retransmission] 36050 - 443 [PSH, ACK] Seq=188
	857 22:09:08.252125088	35.185.44.232	192.168.160.10	TLSv1.3	1354	[TCP Fast Retransmission], Application Data
	934 22:09:08.912677851	192.168.160.10	35.185.44.232	TCP	296	[TCP Retransmission] 36050 - 443 [PSH, ACK] Seq=188
	957 22:09:09.126186729	35.185.44.232	192.168.160.10	TCP	1354	[TCP Retransmission] 443 - 6050 [ACK] Seq=526876 Ad
	1234 22:09:12.232616557	192.168.160.10	35.185.44.232	TCP	141	[TCP Retransmission] 36050 - 443 [PSH, ACK] Seq=2180
	1383 22:09:14.569320805	192.168.160.10	35.185.44.232	TLSv1.3	145	[TCP Fast Retransmission], Application Data
	1475 22:09:15.176625297	192.168.160.10	35.185.44.232	TCP	97	[TCP Retransmission] 36060 - 443 [FIN, PSH, ACK] Seq=2180 Win=642
	1480 22:09:15.432622298	192.168.160.10	35.185.44.232	TCP	74	[TCP Retransmission] 40292 - 443 [SYN] Seq=0 Win=642
	1514 22:09:15.720631684	192.168.160.10	35.185.44.232	TCP	74	[TCP Retransmission] 40344 - 443 [SYN] Seq=0 Win=642
	1515 22:09:15.720652987	192.168.160.10	35.185.44.232	TCP	74	[TCP Retransmission] 40338 - 443 [SYN] Seq=0 Win=642
	1516 22:09:15.720658040	192.168.160.10	35.185.44.232	TCP	74	[TCP Retransmission] 40324 - 443 [SYN] Seq=0 Win=642

11.

Typically ACK acknowledges 1460 Bytes of data among the first ten data-carrying segments sent from the cse.iiith.ac.in to client. Also, the segment size of each ACK segment is 0 Bytes.

There are certain instances where every packet is acknowledged and few acknowledgements are cumulative acknowledgments.

1st segment is acknowledged

2nd segment is acknowledged

3rd 4th and 5th are cumulative acknowledged

6th segment is acknowledged

7th segment is acknowledged

8th segment is acknowledged

9th segment is acknowledged

10th segment is acknowledged

Given below the figure showing details of the transmission:

lith.ac.in.pcapng

No.	Time	Source	Destination	Protocol	Length	Info
2264	22:09:30.300013231	35.185.44.232	192.168.160.10	TLSv1.3	1354	Continuation Data
2265	22:09:30.300083273	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1485 Ack=174025 Win=248320 Len=0 MSS=1460 SACK
2266	22:09:30.300013728	35.185.44.232	192.168.160.10	TLSv1.3	2642	Continuation Data
2267	22:09:30.300204207	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1485 Ack=176601 Win=253568 Len=0 MSS=1460 SACK
2268	22:09:30.300013763	35.185.44.232	192.168.160.10	TLSv1.3	2642	Continuation Data
2269	22:09:30.300013802	35.185.44.232	192.168.160.10	TLSv1.3	2642	Continuation Data
2270	22:09:30.300013841	35.185.44.232	192.168.160.10	TLSv1.3	2642	Continuation Data
2271	22:09:30.300264717	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1485 Ack=179177 Win=253688 Len=0 MSS=1460 SACK
2272	22:09:30.300010092	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1485 Ack=181753 Win=263808 Len=0 MSS=1460 SACK
2273	22:09:30.300324922	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1485 Ack=184329 Win=268928 Len=0 MSS=1460 SACK
2274	22:09:30.302503889	35.185.44.232	192.168.160.10	TLSv1.3	2642	Continuation Data
2275	22:09:30.302525010	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1485 Ack=186905 Win=274176 Len=0 MSS=1460 SACK
2276	22:09:30.302504144	35.185.44.232	192.168.160.10	TLSv1.3	2642	Continuation Data
2277	22:09:30.302555689	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1485 Ack=189481 Win=279296 Len=0 MSS=1460 SACK
2278	22:09:30.302504180	35.185.44.232	192.168.160.10	TLSv1.3	2642	Continuation Data
2279	22:09:30.302567371	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1485 Ack=192057 Win=284416 Len=0 MSS=1460 SACK
2280	22:09:30.302504218	35.185.44.232	192.168.160.10	TLSv1.3	2642	Continuation Data
2281	22:09:30.302563513	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1485 Ack=194633 Win=289536 Len=0 MSS=1460 SACK
2282	22:09:30.304836836	35.185.44.232	192.168.160.10	TLSv1.3	2642	Continuation Data
2283	22:09:30.304860757	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1485 Ack=197209 Win=294784 Len=0 MSS=1460 SACK

[OBJ]

12.

Initial time of establishing connection = 22:09:02.750721711

Time at which connection closed = 22:09:36.723582483

Total data sent = 1424 Kbytes

(approx page size of home page of 'cse.ith.ac.in' taken from analytics of third party website as the actual content is not found in wireshark may be due to TLS security)

Total time taken = 22:09:36.723582483 - 22:09:02.750721711

$$= 33.973510772 \text{ seconds}$$

Throughput = data sent/ time taken

$$= 1424000 \text{ bytes} / 33.973510772 \text{ seconds}$$

$$= 41919.34 \text{ Bytes/second}$$

Given below the figure showing details of the transmission:

No.	Time	Source	Destination	Protocol	Length	Info
27	22:09:02.750721711	192.168.160.10	35.185.44.232	TCP	74	36650 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SACK
28	22:09:02.957332917	192.168.160.10	35.185.44.232	TCP	74	36660 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SACK
51	22:09:02.957332917	192.168.160.10	35.185.44.232	TCP	74	36660 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SACK
58	22:09:03.066853978	35.185.44.232	192.168.160.10	TCP	74	443 → 36658 [SYN, ACK] Seq=0 Ack=1 Win=64768 Len=0 MSS=1460 SACK
59	22:09:03.066860779	192.168.160.10	35.185.44.232	TCP	66	36650 → 443 [ACK] Seq=1 Ack=1 Win=64256 Len=0 TSval=35
60	22:09:03.066901685	192.168.160.10	35.185.44.232	TLSv1.3	792	Client Hello
61	22:09:03.094417668	35.185.44.232	192.168.160.10	TCP	74	443 → 36668 [SYN, ACK] Seq=0 Ack=1 Win=64768 Len=0 MSS=1460 SACK
62	22:09:03.094459094	192.168.160.10	35.185.44.232	TCP	66	36660 → 443 [ACK] Seq=1 Ack=1 Win=64256 Len=0 TSval=35
67	22:09:03.094777286	192.168.160.10	35.185.44.232	TLSv1.3	632	Client Hello
81	22:09:03.274682818	35.185.44.232	192.168.160.10	TCP	74	443 → 36676 [SYN, ACK] Seq=0 Ack=1 Win=64768 Len=0 MSS=1460 SACK
82	22:09:03.274716356	192.168.160.10	35.185.44.232	TCP	66	36676 → 443 [ACK] Seq=1 Ack=1 Win=64256 Len=0 TSval=35
83	22:09:03.275017386	192.168.160.10	35.185.44.232	TLSv1.3	632	Client Hello
87	22:09:03.396987668	35.185.44.232	192.168.160.10	TCP	66	443 → 36658 [ACK] Seq=1 Ack=727 Win=64512 Len=0 TSval=35
88	22:09:03.455063980	35.185.44.232	192.168.160.10	TLSv1.3	2642	Server Hello, Change Cipher Spec, Application Data
89	22:09:03.455063980	192.168.160.10	35.185.44.232	TCP	66	36650 → 443 [ACK] Seq=727 Ack=5277 Win=61606 Len=0 TSval=35

ip.addr == 35.185.44.232

No.	Time	Source	Destination	Protocol	Length	Info
2289	22:09:30.304999299	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1485 Ack=204495 Win=309376 Len=0
2290	22:09:30.323484539	192.168.160.10	35.185.44.232	TLSv1.3	217	Application Data
2303	22:09:31.809401347	35.185.44.232	192.168.160.10	TCP	66	443 → 54730 [ACK] Seq=204495 Ack=1636 Win=64512 Len=0
2304	22:09:31.809401860	35.185.44.232	192.168.160.10	TLSv1.3	165	Application Data
2305	22:09:31.809401942	35.185.44.232	192.168.160.10	TCP	2642	443 → 54730 [PSH, ACK] Seq=204594 Ack=1636 Win=64512 Len=0
2306	22:09:31.809446052	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1636 Ack=207170 Win=314496 Len=0
2307	22:09:31.809401994	35.185.44.232	192.168.160.10	TLSv1.3	2097	Application Data, Application Data
2308	22:09:31.809473245	192.168.160.10	35.185.44.232	TCP	66	54730 → 443 [ACK] Seq=1636 Ack=209201 Win=318592 Len=0
2309	22:09:32.720446244	35.185.44.232	192.168.160.10	TLSv1.3	105	Application Data
2381	22:09:36.723582483	92.168.160.10	35.185.44.232	TCP	66	54730 → 443 [FIN, ACK] Seq=1636 Ack=209240 Win=318592
2383	22:09:37.459096981	35.185.44.232	192.168.160.10	TLSv1.3	90	Application Data