

Used Trace files for all questions except question no 3.

1. What is the IP address and TCP port number used by the client computer (source) that is transferring the file to gaia.cs.umass.edu? To answer this question, it's probably easiest to select an HTTP message and explore the details of the TCP packet used to carry this HTTP message, using the "details of the selected packet header window".

Ans: Source IP Address :- 192.168.1.102

TCP Port number used by the client : 1161

The image shows a Wireshark packet capture analysis of a network trace. The top pane displays a list of captured packets. Packet 199 is selected, which is an HTTP POST request. The details pane below shows the structure of the selected packet, including the Ethernet II header, Internet Protocol Version 4 header, and Transmission Control Protocol header. The source IP address is 192.168.1.102 and the destination IP address is 128.119.245.12. The source port is 1161 and the destination port is 80. The packet length is 104 bytes. The bottom pane shows the raw packet data in hexadecimal and ASCII format.

No.	Time	Source	Destination	Protocol	Length	Info
196	5.201150	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=162309 Ack=1 Win=17520 Len=1460 [TCP s...
197	5.202024	192.168.1.102	128.119.245.12	TCP	326	1161 → 80 [PSH, ACK] Seq=163769 Ack=1 Win=17520 Len=272 [T...
198	5.297257	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=159389 Win=62780 Len=0
199	5.297341	192.168.1.102	128.119.245.12	HTTP	104	POST /ethereal-labs/lab3-1-reply.htm HTTP/1.1 (text/plain)
200	5.389471	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=162309 Win=62780 Len=0
201	5.447887	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=164041 Win=62780 Len=0
202	5.455830	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=164091 Win=62780 Len=0
203	5.461175	128.119.245.12	192.168.1.102	HTTP	784	HTTP/1.1 200 OK (text/html)
206	5.651141	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=164091 Ack=731 Win=16790 Len=0
213	7.595557	192.168.1.102	199.2.53.206	TCP	62	1162 → 631 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1

Frame 199: 104 bytes on wire (832 bits), 104 bytes captured (832 bits)  
Ethernet II, Src: PremaxPe\_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG\_da:af:73 (00:06:25:da:af:73)  
Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.119.245.12  
Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 164041, Ack: 1, Len: 50  
Source Port: 1161  
Destination Port: 80  
[Stream index: 0]  
[TCP Segment Len: 50]  
Sequence number: 164041 (relative sequence number)  
[Next sequence number: 164091 (relative sequence number)]  
Acknowledgment number: 1 (relative ack number)

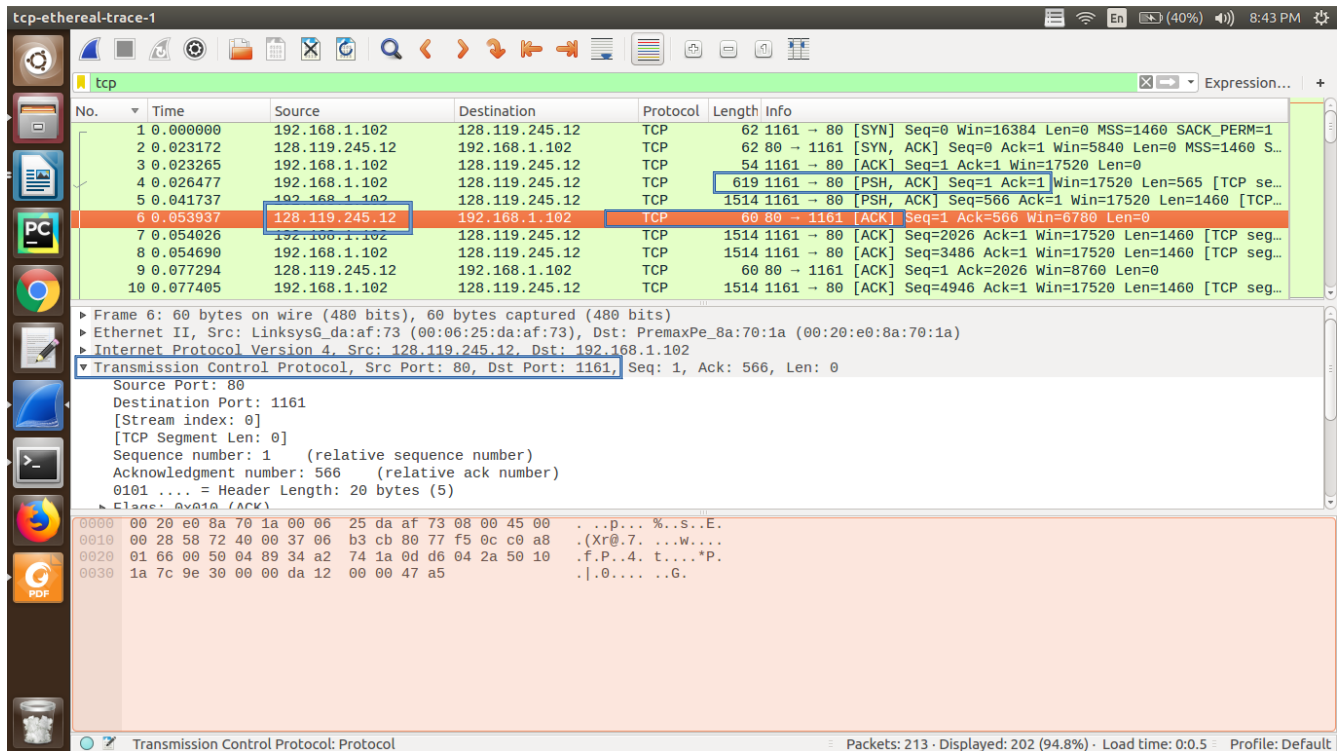
00000000 50 4f 53 54 20 2f 65 74 68 65 72 65 61 6c 2d 6c POST /et hereal-l  
00000010 61 62 73 2f 6c 61 62 33 2d 31 2d 72 65 70 6c 79 abs/lab3 -1-reply  
00000020 2e 68 74 6d 20 48 54 54 50 2f 31 2e 31 0d 0a 48 .htm HTTP/1.1.H  
00000030 6f 73 74 3a 20 67 61 69 61 2e 63 73 2e 75 6d 61 ost: gai a.cs.uma  
00000040 73 73 2e 65 64 75 0d 0a 55 73 65 72 2d 41 67 65 ss.edu.. User-Age  
00000050 6e 74 3a 20 4d 6f 7a 69 6c 6c 61 2f 35 2e 30 20 nt; Mozi lla/5.0  
00000060 28 57 69 6e 64 6f 77 73 3b 20 55 3b 20 57 69 6e (Windows ; U; Win  
00000070 64 6f 77 73 20 4e 54 20 35 2e 31 3b 20 65 6e 2d dows NT 5.1; en-  
00000080 55 53 3b 20 72 76 3a 31 2e 30 2e 32 29 20 47 65 US; rv:1 .0.2) Ge  
00000090 63 6b 6f 2f 32 30 30 33 30 32 30 38 20 4e 65 74 cko/2003 0208 Net  
000000a0 73 63 61 70 65 2f 37 2e 30 32 0d 0a 41 63 63 65 scape/7. 02..Acce

Frame (104 bytes) Reassembled TCP (164090 bytes)  
TCP Segments (tcp.segments), 164090 bytes  
Packets: 213 · Displayed: 202 (94.8%) · Load time: 0:0.5 · Profile: Default

2. What is the IP address of gaia.cs.umass.edu? On what port number is it sending and receiving TCP segments for this connection?

Ans:- 1) IP Address of gaia.cs.umass.edu = **128.119.245.12**

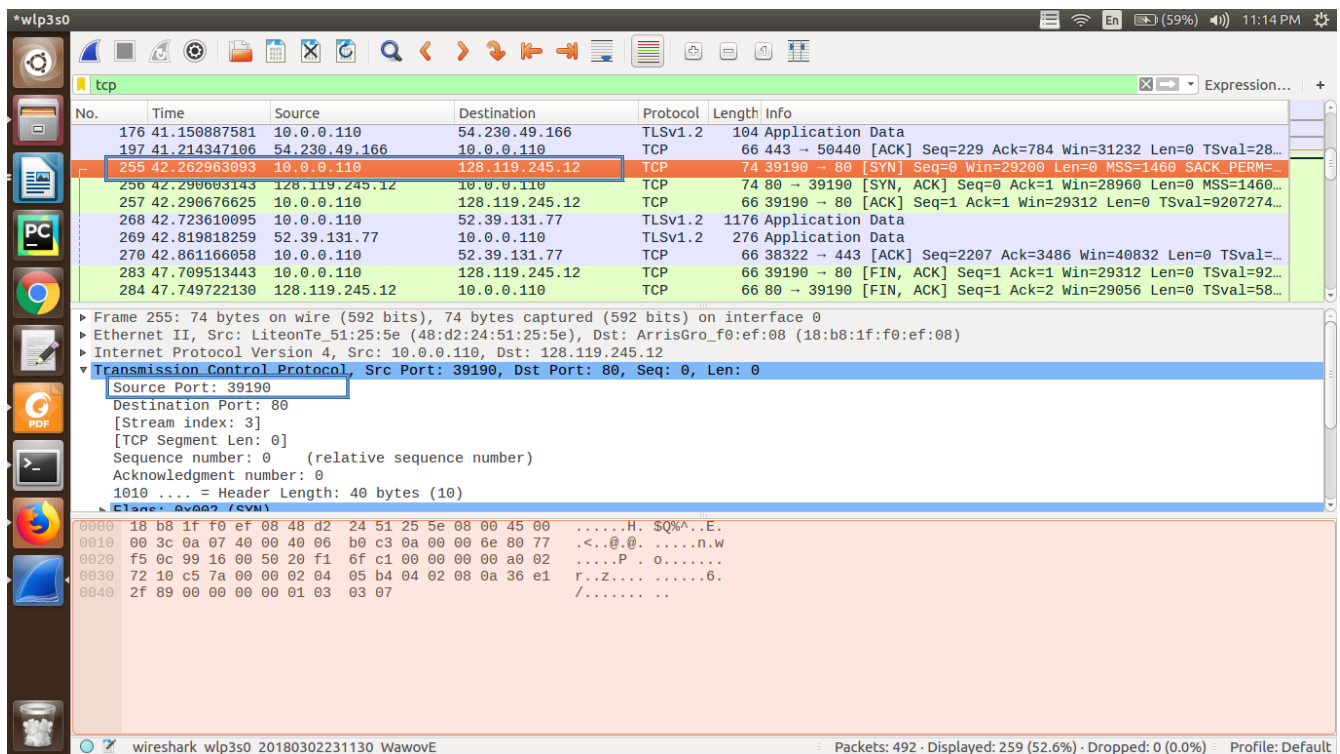
2) gaia.cs.umass.edu is receiving TCP connections on Port 80 and sending response to this to client on port 1161.



3. What is the IP address and TCP port number used by your client computer (source) to transfer the file to gaia.cs.umass.edu?

Ans: IP address : 10.0.0.110

Port used by client : 39190



4. What is 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? What is it in the segment that identifies the segment as a SYN segment?

Ans:- Sequence number of the packet in which TCP SYN segment used to indicate the TCP connection is 'seq=0'. The SYN Flag being set to '1' in the flags section identifies the segment as a SYN segment. Below Screen shot highlights the sequence number used by the client to initiate TCP connection and highlights the SYN flag being set to 1, this shows the handshake initiation.

tcp-ethereal-trace-1

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1
2	0.023172	128.119.245.12	192.168.1.102	TCP	62	80 → 1161 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 S...
3	0.023265	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=1 Ack=1 Win=17520 Len=0
4	0.026477	192.168.1.102	128.119.245.12	TCP	619	1161 → 80 [PSH, ACK] Seq=1 Ack=1 Win=17520 Len=565
5	0.041737	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [PSH, ACK] Seq=566 Ack=1 Win=17520 Len=1460
6	0.053937	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
7	0.054026	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2026 Ack=1 Win=17520 Len=1460
8	0.054690	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=3486 Ack=1 Win=17520 Len=1460
9	0.077294	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=2026 Win=8760 Len=0
10	0.077495	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=4946 Ack=1 Win=17520 Len=1460

0111 .... = Header Length: 28 bytes (7)

▼ Flags: 0x002 (SYN)

- 000. .... = Reserved: Not set
- ...0 .... = Nonce: Not set
- ....0 .... = Congestion Window Reduced (CWR): 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

0000 00 06 25 da af 73 00 20 e0 8a 70 1a 08 00 45 00 ...s...p...E

0010 00 30 1e 1d 40 00 80 06 a5 18 c0 a8 01 66 80 77 ...@...f.w

0020 f5 0c 04 89 00 50 0d d6 01 f4 00 00 00 00 70 02 ...P...p

0030 40 00 f6 e9 00 00 02 04 05 b4 01 01 04 02 ...

Frame (frame), 62 bytes      Packets: 213 · Displayed: 202 (94.8%) · Load time: 0:0.19 · Profile: Default

5. What is the sequence number of the SYNACK segment sent by gaia.cs.umass.edu to the client computer in reply to the SYN? What is the value of the Acknowledgement field in the SYNACK segment? How did gaia.cs.umass.edu determine that value? What is it in the segment that identifies the segment as a SYNACK segment?

Ans :- 1) Sequence number of the SYNACK segment sent by gaia.cs.umass.edu to client in reply to SYN is '0'.

2) Value of the acknowledgement field in the SYNACK segment is set to '1'.

3) When gaia.cs.umass.edu received the segment with seq=0 and SYN flag set to one. It understood that a new TCP connection initiation request has arrived with the flag set and to let the remote computer know and go further in the handshake process it sets the SYN and ACK flag to 1 determining the client that is ready to accept the connection and go ahead with the setup.

4) Both the SYN and ACK flag are set in the segment determines that it is a SYNACK segment.

The image shows a Wireshark packet capture of a TCP SYN-ACK segment. The packet list at the top shows a packet with sequence number 80, source 128.119.245.12, and destination 192.168.1.102. The packet details pane shows the TCP flags SYN and ACK set. The packet bytes pane shows the raw data of the segment.

No.	Time	Source	Destination	Protocol	Length	Info
000000	0.000000	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1
000001	0.000000	128.119.245.12	192.168.1.102	TCP	62	80 → 1161 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 SACK_PERM=1

Flags: 0x012 (SYN, ACK)

- 000... = Reserved: Not set
- ...0... = Nonce: Not set
- ...0... = Congestion Window Reduced (CWR): 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
- ...0... = Fin: Not set

Seq no of SYNACK segment.

Sync and ack flags set.

6. What is the sequence number of the TCP segment containing the HTTP POST command?

Ans:- The sequence number of the TCP segment containing the HTTP POST command is 1.

The image shows a Wireshark packet capture of a TCP connection. The packet list on the left shows the following segments:

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1
2	0.023172	128.119.245.12	192.168.1.102	TCP	62	80 → 1161 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 SACK_PERM=1
3	0.023265	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=1 Ack=1 Win=17520 Len=0
4	0.026477	192.168.1.102	128.119.245.12	TCP	619	1161 → 80 [PSH, ACK] Seq=1 Ack=1 Win=17520 Len=565
5	0.041737	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [PSH, ACK] Seq=566 Ack=1 Win=17520 Len=1460
6	0.053937	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
7	0.054026	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2026 Ack=1 Win=17520 Len=1460
8	0.054690	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=3486 Ack=1 Win=17520 Len=1460
9	0.077294	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=2026 Win=8760 Len=0

The packet details pane for the selected packet (No. 4) shows:

- Ethernet II, Src: PremaxPe\_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG\_da:af:73 (00:06:25:da:af:73)
- Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.119.245.12
- Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 1, Ack: 1, Len: 565
  - Source Port: 1161
  - Destination Port: 80
  - [Stream index: 0]
  - [TCP Segment Len: 565]
  - Sequence number: 1 (relative sequence number)
  - [Next sequence number: 566 (relative sequence number)]
  - Acknowledgment number: 1 (relative ack number)
  - 0101 ... = Header Length: 20 bytes (5)
  - Flags: 0x018 (PSH, ACK)

The packet bytes pane shows the raw data of the POST request, which is highlighted in blue. The content of the HTTP POST command is shown in the text box on the right.

TCP segment containing the post command.

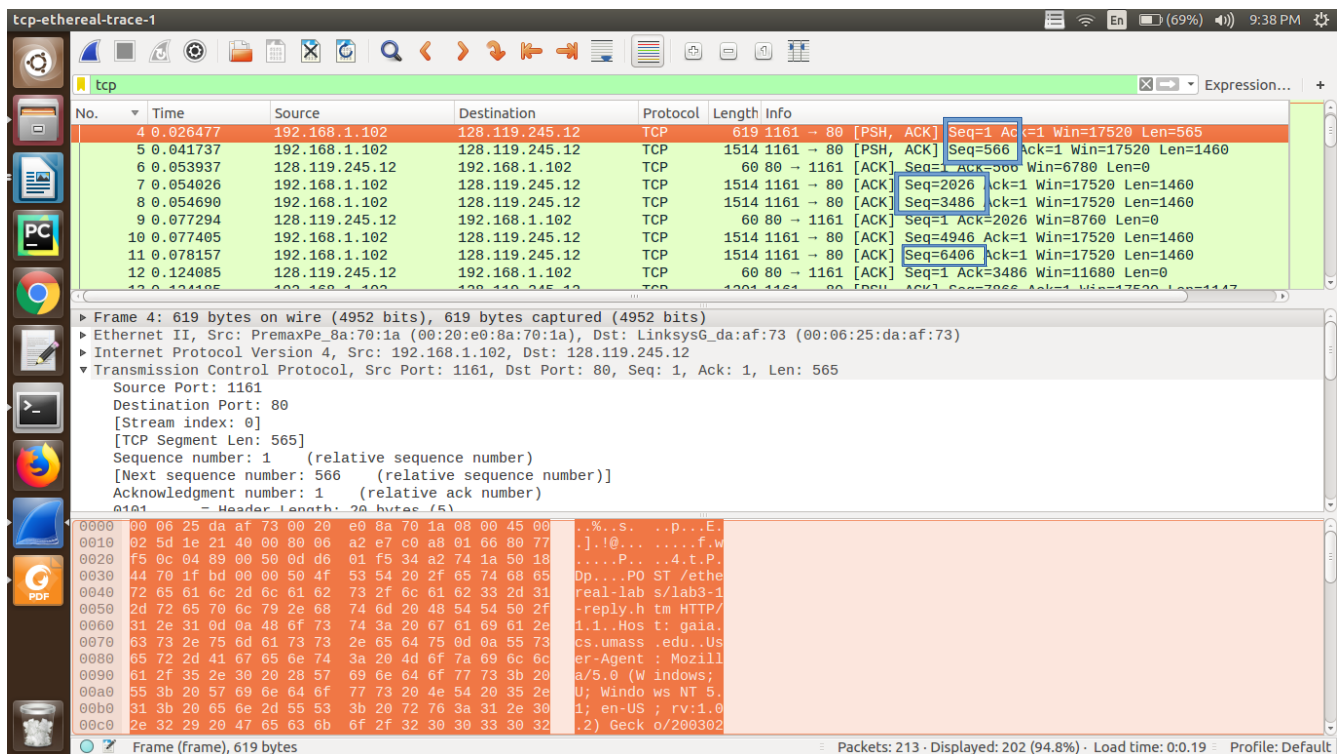
Content of HTTP Post command.

7. Consider the TCP segment containing the HTTP POST as the first segment in the TCP connection. What are the sequence numbers of the first six segments in the TCP connection (including the segment containing the HTTP POST)? At what time was each segment sent? When was the ACK for each segment received? Given the difference between when each TCP segment was sent, and when its acknowledgement was received, what is the RTT value for each of the six segments? What is the EstimatedRTT value (see Section 3.5.3, page 239 in text) after the receipt of each ACK? Assume that the value of the EstimatedRTT is equal to the measured RTT for the first segment, and then is computed using the EstimatedRTT equation on page 239 for all subsequent segments.

Ans:-

1) The sequence number of the first six TCP segments are **1, 566, 2026, 3486, 4946, 6406**.





## 2) Time at which each segment was sent

### 1) Segment 1: Seq num = 1

Time at which it was sent = **0.026477** seconds.

Time at which ACK was recvd = **0.053937** seconds.

### 2) Segment 1: Seq num = 566

Time at which it was sent = **0.041737** seconds.

Time at which ACK was recvd = **0.077294** seconds.

### 3) Segment 1: Seq num = 2026

Time at which it was sent = **0.054026** seconds.

Time at which ACK was recvd = **0.0.124085** seconds.

### 4) Segment 1: Seq num = 3486

Time at which it was sent = **0.054690** seconds.

Time at which ACK was recvd = **0.169118** seconds.

### 5) Segment 1: Seq num = 4946

Time at which it was sent = **0.077405** seconds.

Time at which ACK was recvd = **0.217299** seconds.

### 6) Segment 1: Seq num = 6406

Time at which it was sent = **0.078157** seconds.

Time at which ACK was recvd = **0.267802** seconds.

## 3) RTT value of all six segments

1) Segment 1 RTT1: **0.027460** seconds

2) Segment 2 RTT2: **0.03555700** seconds

3) Segment 3 RTT3: **0.070059000** seconds

4) Segment 4 RTT4: **0.114428000** seconds

5) Segment 5 RTT5: **0.19894000** seconds

6) Segment 6 RTT6: **0.189645000** seconds

4) Estimated RTT for six segments:

- 1)  $ERTT1 = 0.027460$  (We will be taking it same as RTT1 as suggested)
- 2)  $ERTT2 = ((1 - 0.125) * 0.27460) + 0.125 * 0.03555700$   
 $= 0.02847375$
- 3)  $ERTT3 = (0.875 * 0.02847375) + (0.125 * 0.070059000)$   
 $= 0.033671906$
- 4)  $ERTT4 = (0.875 * 0.033671906) + (0.125 * 0.114428000)$   
 $= 0.043766417$
- 5)  $ERTT5 = (0.875 * 0.043766417) + (0.125 * 0.139894000)$   
 $= 0.05582364$
- 6)  $ERTT6 = (0.875 * 0.05582364) + (0.125 * 0.189645000)$   
 $= 0.072515193$

8. What is the length of each of the first six TCP segments?

Ans: Length of first TCP segment is 565(segment which consists of the POST request.). And length of remaining TCP segments is 1460.

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1
2	0.023172	128.119.245.12	192.168.1.102	TCP	62	80 → 1161 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 SACK_PERM=1
3	0.023265	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=1 Ack=1 Win=17520 Len=0
4	0.026477	192.168.1.102	128.119.245.12	TCP	619	1161 → 80 [PSH, ACK] Seq=1 Ack=1 Win=17520 Len=565
5	0.041737	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [PSH, ACK] Seq=566 Ack=1 Win=17520 Len=1460
6	0.053937	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
7	0.054026	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2026 Ack=1 Win=17520 Len=1460
8	0.054690	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=3486 Ack=1 Win=17520 Len=1460
9	0.077294	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=2026 Win=8760 Len=0

Frame 4: 619 bytes on wire (4952 bits), 619 bytes captured (4952 bits)

Ethernet II, Src: PremaxPe\_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG\_da:af:73 (00:06:25:da:af:73)

Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.119.245.12

Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 1, Ack: 1, Len: 565

Source Port: 1161  
Destination Port: 80  
Stream index: 1

0000 00 06 25 da af 73 00 20 e0 8a 70 1a 08 00 45 00 ... .s. .p...E.  
 0010 02 5d 1e 21 40 00 00 06 a2 e7 c0 a8 01 66 80 77 ... .!@... ..f.w  
 0020 f5 0c 04 89 00 50 0d d6 01 f5 34 a2 74 1a 50 18 ... .P. .4.t.P.  
 0030 44 70 1f bd 00 00 50 4f 53 54 29 2f 65 74 68 65 ... .p...PO ST /ethe  
 0040 72 65 61 6c 2d 6c 61 62 73 2f 6c 61 62 33 2d 31 ... real-lab s/lab3-1  
 0050 2d 72 65 70 6c 79 2e 68 74 6d 29 48 54 54 50 2f ... -reply.h tm HTTP/  
 0060 31 2e 31 0d 0a 48 6f 73 74 3a 29 67 61 69 61 2e ... 1.1..Hos t: gaia.  
 0070 63 73 2e 75 6d 61 73 73 2e 65 64 75 0d 0a 55 73 ... cs.umass .edu..Us  
 0080 65 72 2d 41 67 65 6e 74 3a 20 4d 6f 7a 69 6c 6c ... er-Agent : Mozill  
 0090 61 2f 35 2e 30 20 28 57 69 6e 64 6f 77 73 3b 20 ... a/5.0 (W indows;  
 00a0 55 3b 20 57 69 6e 64 6f 77 73 20 4e 54 20 35 2e ... U; Windo ws NT 5.  
 00b0 31 3b 20 65 6e 2d 55 53 3b 20 72 76 3a 31 2e 30 ... 1; en-US ; rv:1.0  
 00c0 2e 32 29 20 47 65 63 6b 6f 2f 32 30 30 33 30 32 ... .2) Gecko o/200302

9. What is the minimum amount of available buffer space advertised at the receiver for the entire trace? Does the lack of receiver buffer space ever throttle the sender?

Ans:- Minimum amount of Buffer space advertised for the entire space is 5480, which is seen when we receive the first acknowledgment from the server. And the maximum is 62870. Also, by inspecting the trace we can observe that the receiver buffer space never throttle the sender.



**\*\*minimum amount of buffer space advertised in the window field in the segment received from the server \*\***

The screenshot shows a Wireshark packet capture of a TCP connection. The packet list on the left shows a SYN segment (Seq=0, Win=5840) from 192.168.1.102 to 128.119.245.12. The packet details pane on the right shows the Transmission Control Protocol section with Source Port: 80, Destination Port: 1161, Seq: 0, Ack: 1, Len: 0. The packet bytes pane at the bottom shows the raw data in hexadecimal and ASCII.

No.	Time	Source	Destination	Protocol	Length	Info
000000	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1	
023172	128.119.245.12	192.168.1.102	TCP	62	80 → 1161 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 SACK_PERM=1	

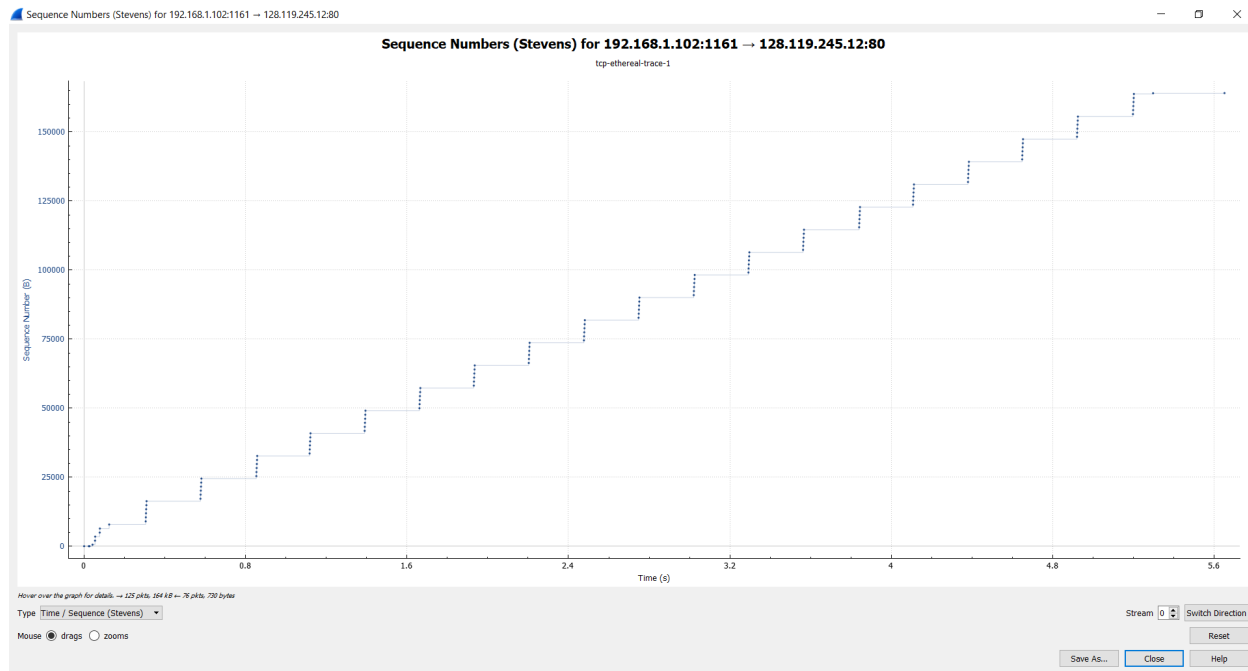
**\*\*maximum amount of buffer space that was advertised in the window field in the segment received from the server \*\***

The screenshot shows a Wireshark packet capture of a TCP connection. The packet list on the left shows a SYN segment (Seq=0, Win=16384) from 192.168.1.102 to 128.119.245.12. The packet details pane on the right shows the Transmission Control Protocol section with Source Port: 80, Destination Port: 1161, Seq: 0, Ack: 1, Len: 0. The packet bytes pane at the bottom shows the raw data in hexadecimal and ASCII.

No.	Time	Source	Destination	Protocol	Length	Info
192	5.197508	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=156469 Ack=1 Win=17520 Len=1460
193	5.198388	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=157929 Ack=1 Win=17520 Len=1460
194	5.199275	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=159389 Ack=1 Win=17520 Len=1460
195	5.200252	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=160849 Ack=1 Win=17520 Len=1460
196	5.201150	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=162309 Ack=1 Win=17520 Len=1460
197	5.202024	192.168.1.102	128.119.245.12	TCP	326	1161 → 80 [PSH, ACK] Seq=163769 Ack=1 Win=17520 Len=272
198	5.297257	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=159389 Win=62780 Len=0
199	5.297341	192.168.1.102	128.119.245.12	TCP	104	1161 → 80 [PSH, ACK] Seq=164041 Ack=1 Win=17520 Len=50
200	5.389471	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=162309 Win=62780 Len=0
201	5.447887	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=164041 Win=62780 Len=0
202	5.455830	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=164991 Win=62780 Len=0
203	5.461175	128.119.245.12	192.168.1.102	TCP	784	80 → 1161 [PSH, ACK] Seq=1 Ack=164091 Win=62780 Len=730
206	5.651141	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=164891 Ack=731 Win=16790 Len=0
213	7.595557	192.168.1.102	199.2.53.206	TCP	62	1162 → 631 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1

10. Are there any retransmitted segments in the trace file? What did you check for (in the trace) in order to answer this question?

Ans:- No, there are no retransmitted segments in the trace file. We can check for the same using time sequence graph. As we observe the sequence numbers of the segments sent from host to server we can see that the sequence numbers are growing with time and there cannot be seen a drop of any previously sent packet. Because, if a segment had been retransmitted its sequence number would have been smaller than the previously sent segment which is not in this case and sequence number of the packets are steadily increasing in ascending order.



11. How much data does the receiver typically acknowledge in an ACK? Can you identify cases where the receiver is ACKing every other received segment ?

Ans:- The receiver typically acknowledges 1460 bytes in an ACK. Yes, we can identify cases where receiver is ACKing every other received segment which can be seen from the example below.

For Segment with sequence no 566 the receiver acknowledges with ACK = 2026 which is the next sequence number expected i.e. it previously acknowledged 2026-566 = 1460 bytes.

Similarly, For segment with sequence no 2026 the receiver acknowledge with ACK = 3486, which determines that it received 1460 bytes.

Similar it is the case for below few segments where for sequence no. 3486 we get an acknowledgement with ACK = 4946 i.e. after 1460 bytes. Similarly, for seq no 4946 we get and acknowledgement with ACK=6406.

Also, when we send segment with sequence number 155577 we receive acknowledgement with ACK=156469. i.e. receiver acknowledges it after receiving 1460 bytes.

tcp-ethereal-trace-1

No.	Time	Source	Destination	Protocol	Length	Info
3	0.023265	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=1 Ack=1 Win=17520 Len=0
4	0.026477	192.168.1.102	128.119.245.12	TCP	619	1161 → 80 [PSH, ACK] Seq=1 Ack=1 Win=17520 Len=565
5	0.041737	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [PSH, ACK] Seq=566 Ack=1 Win=17520 Len=1460
6	0.053937	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
7	0.054026	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2026 Ack=1 Win=17520 Len=1460
8	0.054690	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=3486 Ack=1 Win=17520 Len=1460
9	0.077294	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=2026 Win=8760 Len=0
10	0.077405	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=4946 Ack=1 Win=17520 Len=1460
11	0.078157	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=6406 Ack=1 Win=17520 Len=1460
12	0.124085	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=3486 Win=11680 Len=0
13	0.124185	192.168.1.102	128.119.245.12	TCP	1201	1161 → 80 [PSH, ACK] Seq=7866 Ack=1 Win=17520 Len=1147
14	0.169118	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=4946 Win=14600 Len=0
15	0.217299	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=6406 Win=17520 Len=0
16	0.267802	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=7866 Win=20440 Len=0

Frame 12: 60 bytes on wire (480 bits), 60 bytes captured (480 bits)  
 Ethernet II, Src: LinksysG\_da:af:73 (00:06:25:da:af:73), Dst: PremaxPe\_8a:70:1a (00:20:e0:8a:70:1a)  
 Internet Protocol Version 4, Src: 128.119.245.12, Dst: 192.168.1.102  
 Transmission Control Protocol, Src Port: 80, Dst Port: 1161, Seq: 1, Ack: 3486, Len: 0  
 Source Port: 80  
 Destination Port: 1161  
 [Stream index: 0]

0000 08 20 e0 8a 70 1a 00 06 25 da af 73 08 00 45 00 ...p...%...s...E  
 0010 08 28 58 74 40 00 37 06 b3 c9 80 77 f5 0c c0 a8 (Xt0.7. ...w...  
 0020 01 66 00 50 04 89 34 a2 74 1a 0d d6 0f 92 50 10 f.P..4. t....P.  
 0030 2d a0 7f a4 00 00 7b ec 00 00 5f 33 .....{...3

tcp-ethereal-trace-1

No.	Time	Source	Destination	Protocol	Length	Info
180	4.920310	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=148277 Ack=1 Win=17520 Len=1460
181	4.921025	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=149737 Ack=1 Win=17520 Len=1460
182	4.921916	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=151197 Ack=1 Win=17520 Len=1460
183	4.922820	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=152657 Ack=1 Win=17520 Len=1460
184	4.923863	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=154117 Ack=1 Win=17520 Len=1460
185	4.924667	192.168.1.102	128.119.245.12	TCP	946	1161 → 80 [PSH, ACK] Seq=155577 Ack=1 Win=17520 Len=892
186	5.019189	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=151197 Win=62780 Len=0
190	5.125019	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=154117 Win=62780 Len=0
191	5.197286	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=156469 Win=62780 Len=0
192	5.197508	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=156469 Ack=1 Win=17520 Len=1460
193	5.198388	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=157929 Ack=1 Win=17520 Len=1460
194	5.199275	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=159389 Ack=1 Win=17520 Len=1460
195	5.200252	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=160849 Ack=1 Win=17520 Len=1460
196	5.201150	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=162309 Ack=1 Win=17520 Len=1460

Frame 12: 60 bytes on wire (480 bits), 60 bytes captured (480 bits)  
 Ethernet II, Src: LinksysG\_da:af:73 (00:06:25:da:af:73), Dst: PremaxPe\_8a:70:1a (00:20:e0:8a:70:1a)  
 Internet Protocol Version 4, Src: 128.119.245.12, Dst: 192.168.1.102  
 Transmission Control Protocol, Src Port: 80, Dst Port: 1161, Seq: 1, Ack: 3486, Len: 0  
 Source Port: 80  
 Destination Port: 1161  
 [Stream index: 0]

0000 08 20 e0 8a 70 1a 00 06 25 da af 73 08 00 45 00 ...p...%...s...E  
 0010 08 28 58 74 40 00 37 06 b3 c9 80 77 f5 0c c0 a8 (Xt0.7. ...w...  
 0020 01 66 00 50 04 89 34 a2 74 1a 0d d6 0f 92 50 10 f.P..4. t....P.  
 0030 2d a0 7f a4 00 00 7b ec 00 00 5f 33 .....{...3

12. What is the throughput (bytes transferred per unit time) for the TCP connection?

Explain how you calculated this value.

Ans:- Total Number of bytes transferred to Server = 164090.

As we can see the last ACK received from server was ACK 164091, it determines that we have sent a total of 164090 bytes.

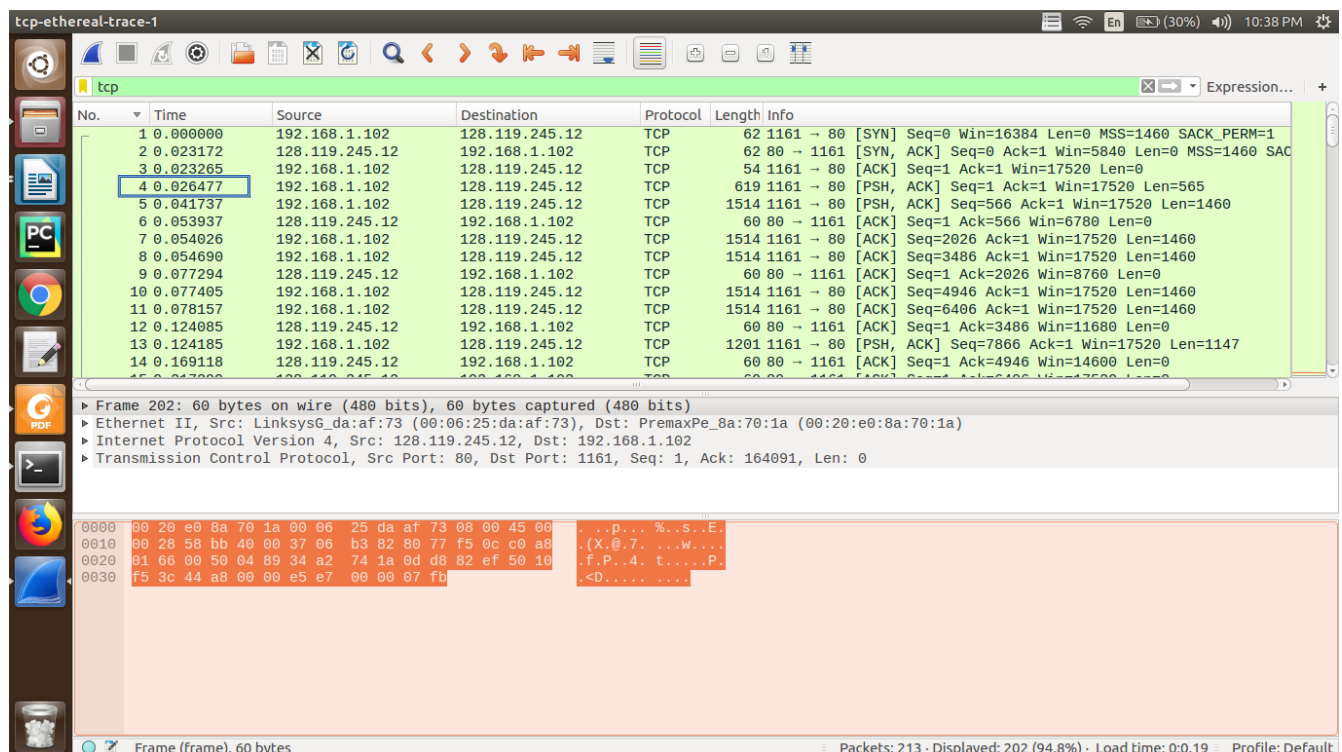
The Time at which acknowledgement was received for the last byte sent was received 5.455830. Time at which first segment was sent 0.026477.

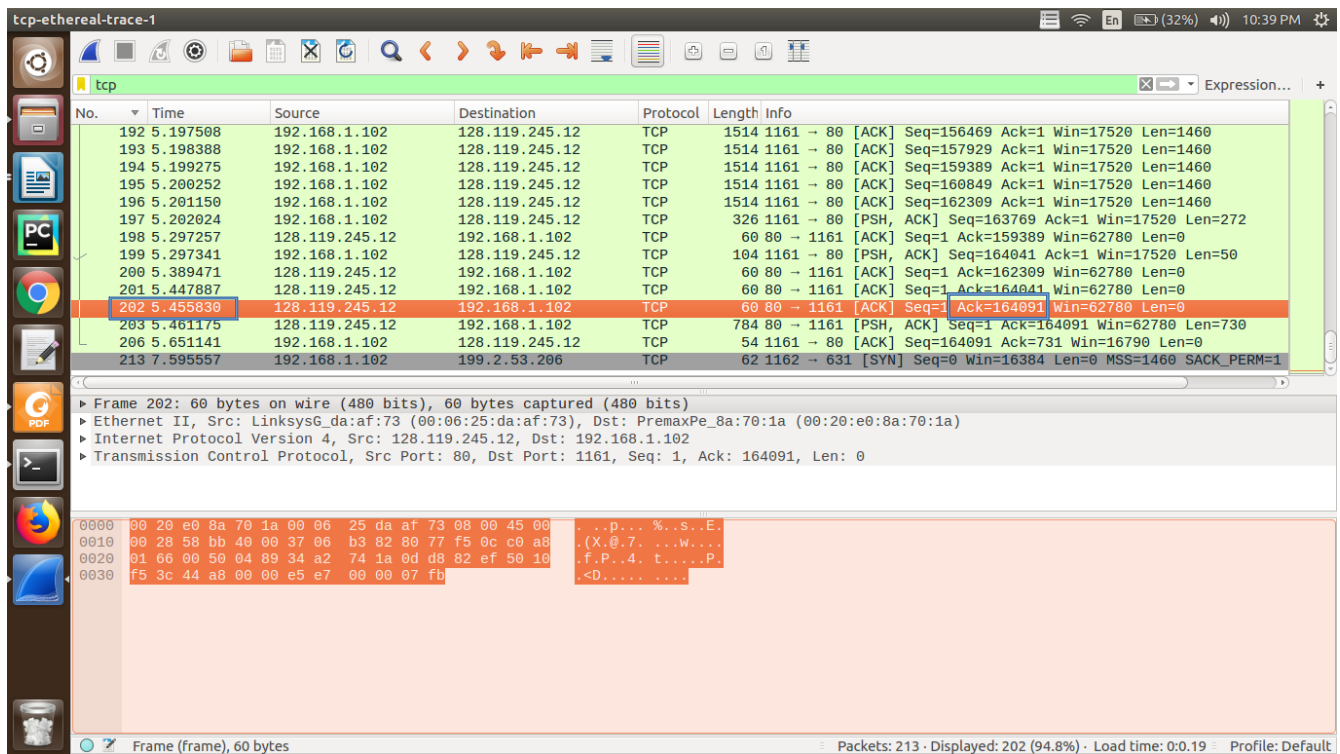
Total time to transfer data from sender to receiver =  $5.455830 - 0.026477$   
= 5.429353 seconds

The Throughput of TCP connection = (Total Bytes transferred)/ (Time taken to transfer those bytes)

Total TCP Throughput =  $(164090 / 5.429353)$  bytes/sec  
= 30222.753 bytes/sec  
= 30.222753 KiloBytes/sec

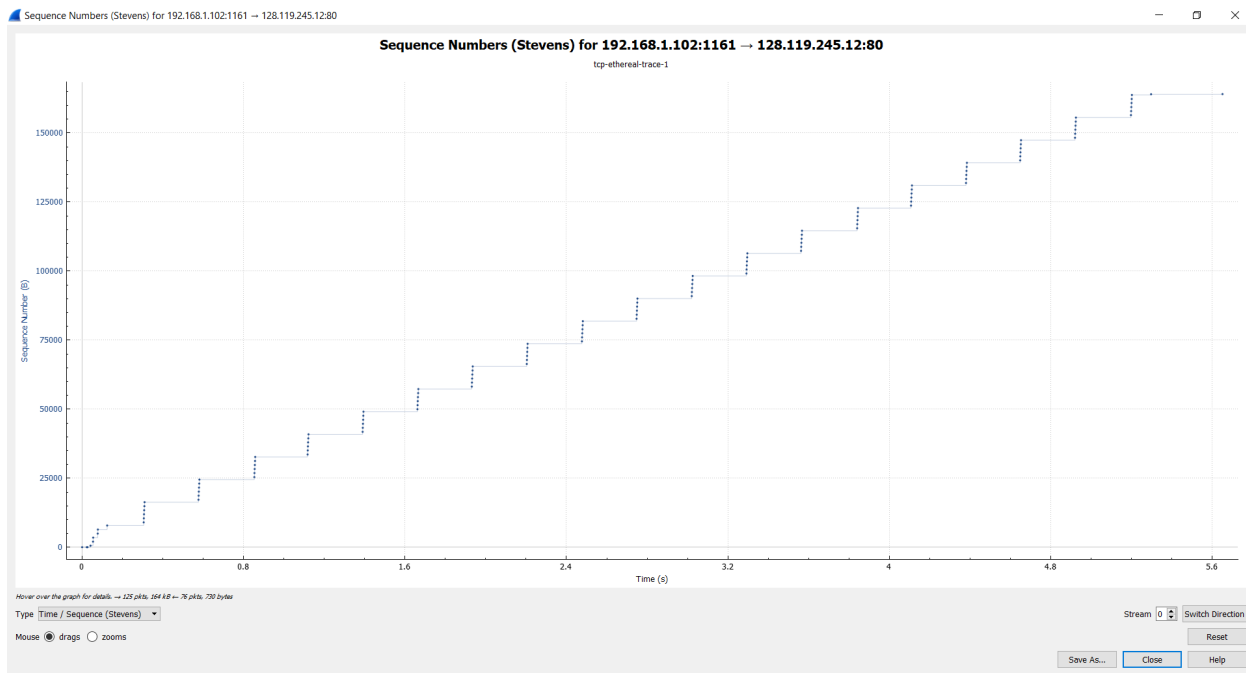
Below Screen Shots shows the times at which the first segment was sent and acknowledgment of the last bytes was received. It also shows the the ACK number received after the last TCP segment was sent which can be used for calculating the total amount that was being transferred from server to client.





13. Use the Time-Sequence-Graph(Stevens) plotting tool to view the sequence number versus time plot of segments being sent from the client to the gaia.cs.umass.edu server. Can you identify where TCP's slow start phase begins and ends, and where congestion avoidance takes over? Comment on ways in which the measured data differs from the idealized behavior of TCP that we've studied in the text.

Ans:- The slow start phase begins at 0.02648 seconds and then it goes on till 0.1242 seconds and thereafter congestion avoidance takes over. The measured data never utilizes the complete capacity of the window size. We can see that the sender sends at the maximum of 6 packets in one burst and the TCP session is constantly in congestion avoidance state thereafter. And thus the measured data just uses 1/4<sup>th</sup> of the window capacity and never makes use of the full capacity which it should do ideally.



14. Answer each of two questions above for the trace that you have gathered when you transferred a file from your computer to gaia.cs.umass.edu?

Ans:- The slow start phase begins at around '0' seconds and goes upto 0.8 seconds and there onwards congestion avoidance takes over. Here as we is the same scenario as mentioned in the 13<sup>th</sup> qns, the sender never sends data to the full capacity of the window and just go on to maximum of 1/4<sup>th</sup> of the window size and never utilized maximum windows size.

