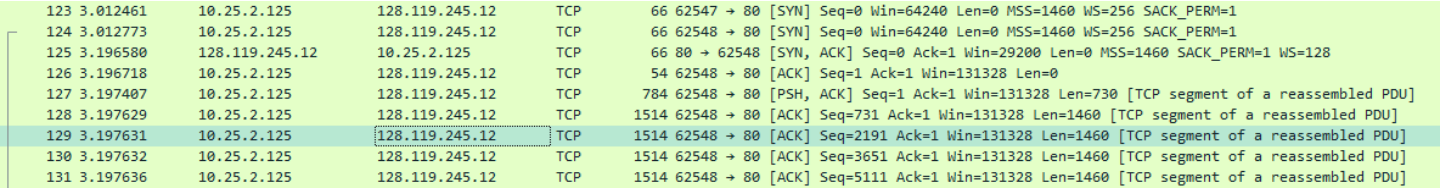
Figure #1



123	3.012461	10.25.2.125	128.119.245.12	TCP	66 62547 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
124	3.012773	10.25.2.125	128.119.245.12	TCP	66 62548 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
125	3.196580	128.119.245.12	10.25.2.125	TCP	66 80 → 62548 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1460 SACK_PERM=1 WS=128
126	3.196718	10.25.2.125	128.119.245.12	TCP	54 62548 → 80 [ACK] Seq=1 Ack=1 Win=131328 Len=0
127	3.197407	10.25.2.125	128.119.245.12	TCP	784 62548 → 80 [PSH, ACK] Seq=1 Ack=1 Win=131328 Len=730 [TCP segment of a reassembled PDU]
128	3.197629	10.25.2.125	128.119.245.12	TCP	1514 62548 → 80 [ACK] Seq=731 Ack=1 Win=131328 Len=1460 [TCP segment of a reassembled PDU]
129	3.197631	10.25.2.125	128.119.245.12	TCP	1514 62548 → 80 [ACK] Seq=2191 Ack=1 Win=131328 Len=1460 [TCP segment of a reassembled PDU]
130	3.197632	10.25.2.125	128.119.245.12	TCP	1514 62548 → 80 [ACK] Seq=3651 Ack=1 Win=131328 Len=1460 [TCP segment of a reassembled PDU]
131	3.197636	10.25.2.125	128.119.245.12	TCP	1514 62548 → 80 [ACK] Seq=5111 Ack=1 Win=131328 Len=1460 [TCP segment of a reassembled PDU]

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" (refer to Figure 2 in the "Getting Started with Wireshark" Lab if you're uncertain about the Wireshark windows.

Answer: from figure #1, source IP address is 10.25.2.125 and port 62548

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?

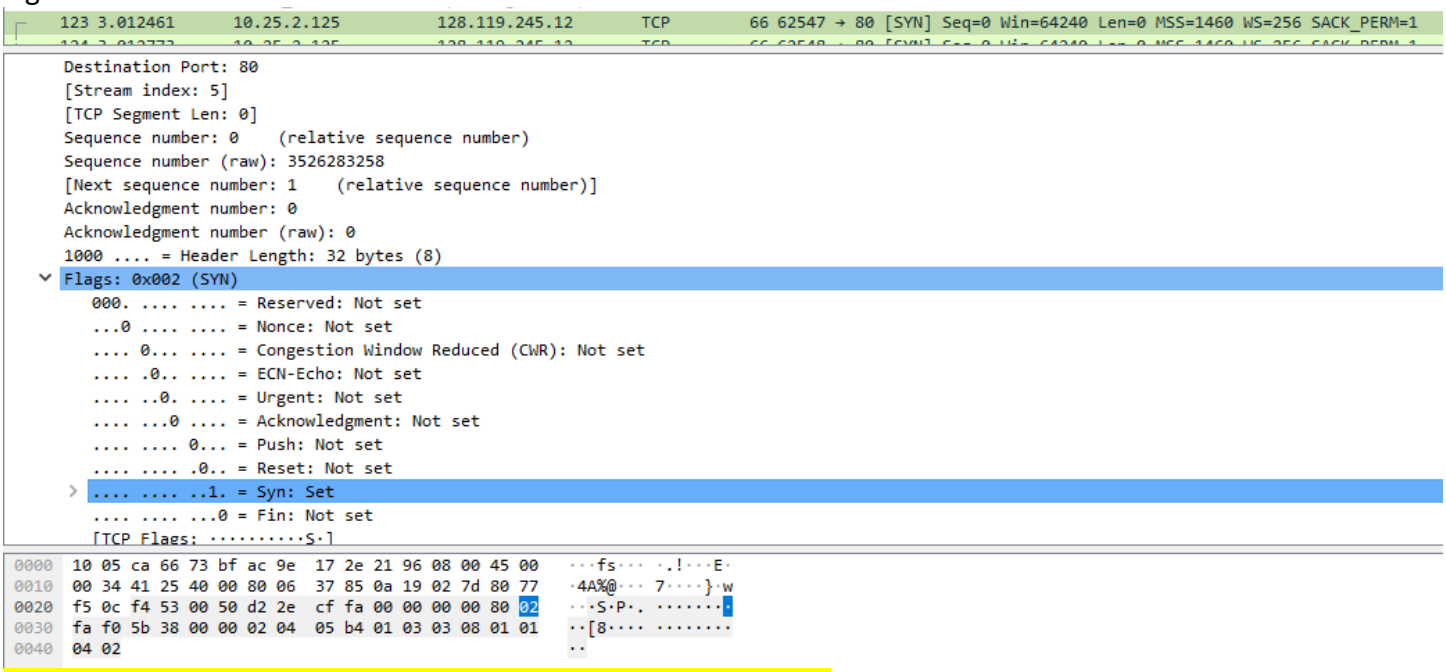
Answer: from figure #1, IP address is 128.119.245.12 and port 80

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?

Answer: from figure #1, source IP address is 10.25.2.125 and port 62548

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?

Figure #2



```
123 3.012461      10.25.2.125          128.119.245.12       TCP        66 62547 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1

Destination Port: 80
[Stream index: 5]
[TCP Segment Len: 0]
Sequence number: 0    (relative sequence number)
Sequence number (raw): 3526283258
[Next sequence number: 1    (relative sequence number)]
Acknowledgment number: 0
Acknowledgment number (raw): 0
1000 .... = Header Length: 32 bytes (8)
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
   .... .... ...0 = Fin: Not set
   [TCP Flags: ··········S·]

0000  10 05 ca 66 73 bf ac 9e  17 2e 21 96 08 00 45 00   ···fs··· ··!···E·
0010  00 34 41 25 40 00 80 06  37 85 0a 19 02 7d 80 77   ·4A%@··· 7····}·w
0020  f5 0c f4 53 00 50 d2 2e  cf fa 00 00 00 00 80 02   ···S·P·. ········
0030  fa f0 5b 38 00 00 02 04  05 b4 01 03 03 08 01 01   ··[8···· ········
0040  04 02                                             ··
```

Answer: from figure #2, Sequence number 0, Flags: 0x002 (SYN)

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?

Figure #3

```
125 3.196580    128.119.245.12    10.25.2.125    TCP    66 80 → 62548 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1460 SACK_PERM=1 WS=128
```

```
Sequence number: 0    (relative sequence number)
Sequence number (raw): 505176859
[Next sequence number: 1    (relative sequence number)]
Acknowledgment number: 1    (relative ack number)
Acknowledgment number (raw): 1894954751
1000 .... = Header Length: 32 bytes (8)
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
   [TCP Flags: ·····A··S·]
Window size value: 29200
```

```
0000  ac 9e 17 2e 21 96 10 05  ca 66 73 bf 08 00 45 00   ····!··· ·fs···E·
0010  00 34 00 00 40 00 2f 06  c9 aa 80 77 f5 0c 0a 19   ·4··@·/· ···w····
0020  02 7d 00 50 f4 54 1e 1c  63 1b 70 f2 b6 ff 80 12   ·}·P·T·· c·p·····
0030  72 10 dd 08 00 00 02 04  05 b4 01 01 04 02 01 03   r·······  ········
0040  03 07                                             ··
```

Answer: from figure #3, Sequence number: 0, Acknowledgment number: 1, Initial sequence number +1, Flag: 0x012(SYN, ACK)

6. What is the sequence number of the TCP segment containing the HTTP POST command? Note that in order to find the POST command, you'll need to dig into the packet content field at the bottom of the Wireshark window, looking for a segment with a "POST" within its DATA field.

Figure #4

```
127 3.197407    10.25.2.125    128.119.245.12    TCP    784 62548 → 80 [PSH, ACK] Seq=1 Ack=1 Win=131328 Len=730 [TCP segment of a reassembled PDU]
```

```
Transmission Control Protocol, Src Port: 62548, Dst Port: 80, Seq: 1, Ack: 1, Len: 730
   Source Port: 62548
   Destination Port: 80
   [Stream index: 6]
   [TCP Segment Len: 730]
   Sequence number: 1    (relative sequence number)
   Sequence number (raw): 1894954751
   [Next sequence number: 731    (relative sequence number)]
   Acknowledgment number: 1    (relative ack number)
   Acknowledgment number (raw): 505176860
   0101 .... = Header Length: 20 bytes (5)
   Flags: 0x018 (PSH, ACK)
```

```
0020  f5 0c f4 54 00 50 70 f2  b6 ff 1e 1c 63 1c 50 18   ···T·Pp· ····c·P·
0030  02 01 d4 bc 00 00 50 4f  53 54 20 2f 77 69 72 65   ·····PO ST /wire
0040  73 68 61 72 6b 2d 6c 61  62 73 2f 6c 61 62 33 2d   shark-la bs/lab3-
0050  31 2d 72 65 70 6c 79 2e  68 74 6d 20 48 54 54 50   1-reply. htm HTTP
0060  2f 31 2e 31 0d 0a 48 6f  73 74 3a 20 67 61 69 61   /1.1··Ho st: gaia
0070  2e 63 73 2e 75 6d 61 73  73 2e 65 64 75 0d 0a 43   .cs.umas s.edu··C
0080  6f 6e 6e 65 63 74 69 6f  6e 3a 20 6b 65 65 70 2d   onnectio n: keep-
0090  61 6c 69 76 65 0d 0a 43  6f 6e 74 65 6e 74 2d 4c   alive··C ontent-L
00a0  65 6e 67 74 68 3a 20 31  35 32 33 30 33 0d 0a 43   ength: 1 52303··C
00b0  61 63 68 65 2d 43 6f 6e  74 72 6f 6c 3a 20 6d 61   ache-Con trol: ma
00c0  78 2d 61 67 65 3d 30 0d  0a 4f 72 69 67 69 6e 3a   x-age=0· ·Origin:
00d0  20 68 74 74 70 3a 2f 2f  67 61 69 61 2e 63 73 2e    http:// gaia.cs.
00e0  75 6d 61 73 73 2e 65 64  75 0d 0a 55 70 67 72 61   umass.ed u··Upgra
00f0  64 65 2d 49 6e 73 65 63  75 72 65 2d 52 65 71 75   de-Insec ure-Requ
```

Answer: from figure #4, sequence number: 1

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.

Figure #5

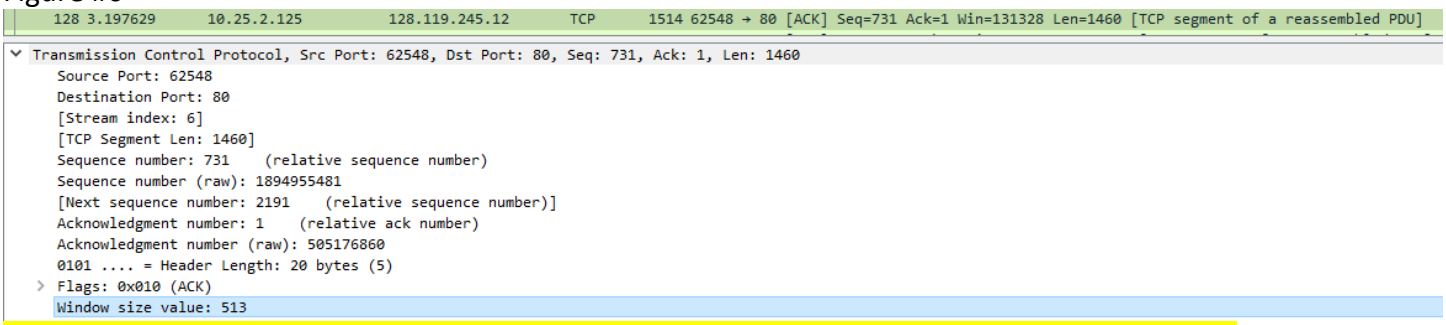
```
127 3.197407    10.25.2.125    128.119.245.12    TCP    784 62548 → 80 [PSH, ACK] Seq=1 Ack=1 Win=131328 Len=730 [TCP segment of a reassembled PDU]
128 3.197629    10.25.2.125    128.119.245.12    TCP   1514 62548 → 80 [ACK] Seq=731 Ack=1 Win=131328 Len=1460 [TCP segment of a reassembled PDU]
129 3.197631    10.25.2.125    128.119.245.12    TCP   1514 62548 → 80 [ACK] Seq=2191 Ack=1 Win=131328 Len=1460 [TCP segment of a reassembled PDU]
130 3.197632    10.25.2.125    128.119.245.12    TCP   1514 62548 → 80 [ACK] Seq=3651 Ack=1 Win=131328 Len=1460 [TCP segment of a reassembled PDU]
131 3.197636    10.25.2.125    128.119.245.12    TCP   1514 62548 → 80 [ACK] Seq=5111 Ack=1 Win=131328 Len=1460 [TCP segment of a reassembled PDU]
132 3.197637    10.25.2.125    128.119.245.12    TCP   1514 62548 → 80 [ACK] Seq=6571 Ack=1 Win=131328 Len=1460 [TCP segment of a reassembled PDU]
```

Answer: from figure #5, Sequence numbers: 1, 731, 2191, 3651, 5111, 6571

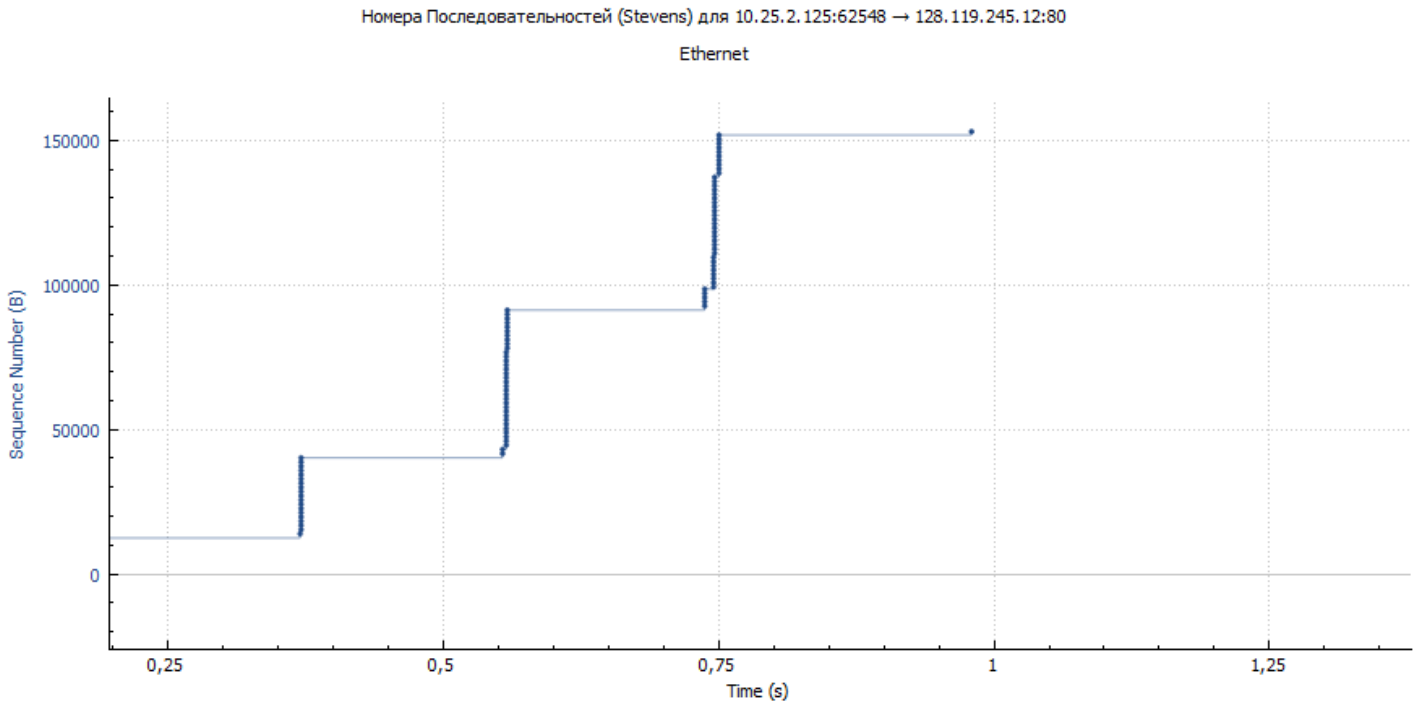
Time each segment sent: 3.197407, 3.197629, 3.197631, 3.197632, 3.197636, 3.197637

Time ACK for each segment received: 3.210314, 3.383281, 3.384168, 3.384169, 3.566954, 3.570233
RTT values: 0.012907, 0.185652, 0.186537, 0.186537, 0.369318, 0.372596
EstimatedRTT = 0.875 * EstimatedRTT + 0.125 * SampleRTT
EstimatedRTT:
1 -> 0.012907
2 ->0.875×0.012907+0.125× 0.185652= 0.0345
3 ->0.875×0.0345+0.125×0.186537= 0.0535
4 ->0.875×0.0535+0.125×0.186537= 0.0701
5 ->0.875×0.0701+0.125×0.369318= 0.1075
6 ->0.875×0.1075+0.125×0.372596= 0.140637

8. What is the length of each of the first six TCP segments?
Answer: from figure#5, 730, 1460, 1460, 1460, 1460, 1460
9. What is the minimum amount of available buffer space advertised at the received for the entire trace? Does the lack of receiver buffer space ever throttle the sender?
Figure #6

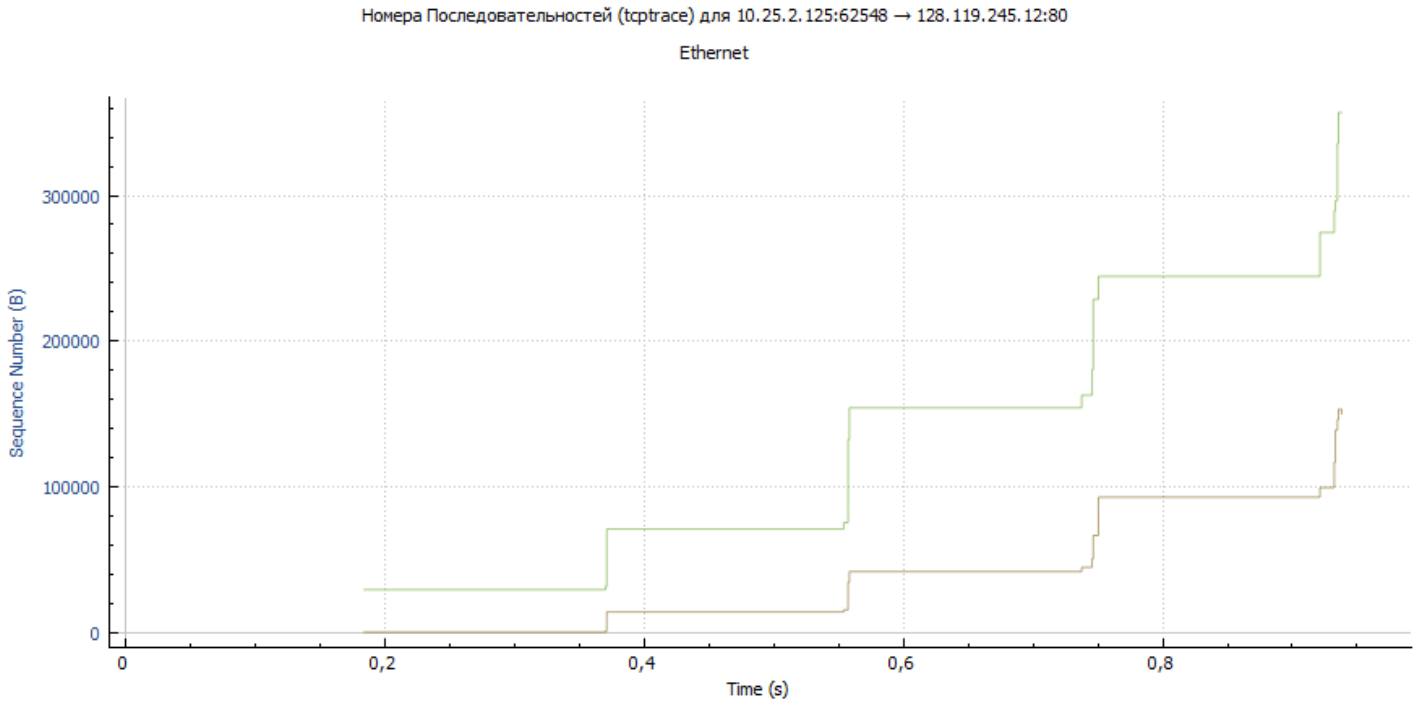


Answer: from figure #6, 513 bytes and the lack of receiver buffer space never throttle the sender
10. Are there any retransmitted segments in the trace file? What did you check for (in the trace) in order to answer this question?
Answer: No retransmitted segments. Sequence number of each TCP is always increasing
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
Answer: The receiver typically acknowledge amount of data equal to the difference between next two acknowledged sequence numbers
12. What is the throughput (bytes transferred per unit time) for the TCP connection? Explain how you calculated this value.
Answer: Throughput is equal to File_Weight divided by time where time is Last ACK time minus time of CP segment with HTTP POST. Thus, throughput = 155648 bytes / (3.763356sec – 3.197407sec) = 275024.1632 bytes/second
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 slowstart 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.



Answer: From 0.01 to 0.32

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



Answer: from 0.95 to 0.38