

CS 372 Lab 2

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Question 1

Q: 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, its 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 youre uncertain about the Wireshark windows.)

A: The IP address of the client is 192.168.1.102, and the port number is 1161.

No.	Time	Source	Destination	Protocol	Length	Info
199	06:44:25.867722	192.168.1.102	128.119.245.12	HTTP	104	POST /ethereal-labs/lab3-1-reply.htm HTTP/1.1 (text/plain)
▶ 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						

Question 2

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

A: The IP address of gaia.cs.umass.edu is 128.119.245.12, and the port number is 80.
(see image from Question 1)

Question 3

Q: If you have been able to create your own trace, answer the following question:
What is the IP address and TCP port number used by your client computer (source) to transfer the file to gaia.cs.umass.edu?

A: The IP address of the client is 192.168.86.104, and the port number is 50903.

No.	Time	Source	Destination	Protocol	Length	Info
186	18:35:44.945452	192.168.86.104	128.119.245.12	HTTP	347	POST /wireshark-labs/lab3-1-reply.htm HTTP/1.1 (text/plain)
▶ Internet Protocol Version 4, Src: 192.168.86.104, Dst: 128.119.245.12						
▶ Transmission Control Protocol, Src Port: 50903, Dst Port: 80, Seq: 152708, Ack: 1, Len: 281						

Question 4

Q: 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?

A: The relative sequence number of the TCP SYN segment is 0 (actual is 0x0dd601f4). The Flags value 0x002 identifies the segment as a SYN segment.

No.	Time	Source	Destination	Protocol	Length	Info
1	06:44:20.570381	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1
Source Port: 1161						
Destination Port: 80						
[Stream index: 0]						
[TCP Segment Len: 0]						
Sequence number: 0 (relative sequence number)						
Acknowledgment number: 0						
Header Length: 28 bytes						
▼ 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	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	.0..@... ..f.w			
0020	f5 0c 04 89 00 50 0d d6	01 f4 00 00 00 00 70 02P..p.			
0030	40 00 f6 e9 00 00 02 04	05 b4 01 01 04 02	@.....			

Question 5

Q: 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?

A: The relative sequence number is 0 (actual is 0x34a27419). The value of the Acknowledgement field is 1. It determines the value by adding 1 to the client's sequence number. The Flags value 0x012 identifies the segment as a SYNACK segment.

No.	Time	Source	Destination	Protocol	Length	Info
2	06:44:20.593553	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
Source Port: 80						
Destination Port: 1161						
[Stream index: 0]						
[TCP Segment Len: 0]						
Sequence number: 0 (relative sequence number)						
Acknowledgment number: 1 (relative ack number)						
Header Length: 28 bytes						
▼ 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.]						
0000	00 20 e0 8a 70 1a 00 06	25 da af 73 08 00 45 00	. .p... %.S..E.			
0010	00 30 00 00 40 00 37 06	0c 36 80 77 f5 0c c0 a8	.0..@.7. .6.w...			
0020	01 66 00 50 04 89 34 a2	74 19 0d d6 01 f5 70 12	.f.P..4. t....p.			
0030	16 d0 77 4d 00 00 02 04	05 b4 01 01 04 02	..wM....			

Question 6

Q: 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.

A: The sequence number is 1.

No.	Time	Source	Destination	Protocol	Length	Info
4	06:44:20.596858	192.168.1.102	128.119.245.12	TCP	619	[TCP segment of a reassembled PDU]
▶ 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: 0]						
[TCP Segment Len: 565]						
Sequence number: 1 (relative sequence number)						
[Next sequence number: 566 (relative sequence number)]						
Acknowledgment number: 1 (relative ack number)						
Header Length: 20 bytes						
▶ Flags: 0x018 (PSH, ACK)						
0020	f5 0c 04 89 00 50 0d d6	01 f5 34 a2 74 1a 50 18P..4.t.P.			
0030	44 70 1f bd 00 00 50 4f	53 54 20 2f 65 74 68 65	Dp...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 20 48 54 54 50 2f	-reply.h tm HTTP/			
0060	31 2e 31 0d 0a 48 6f 73	74 3a 20 67 61 69 61 2e	1.1..Host: 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 (Windows;			
00a0	55 3b 20 57 69 6e 64 6f	77 73 20 4e 54 20 35 2e	U; Windows 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/200302			

Question 7

Q: 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, p. 242 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 242 for all subsequent segments.

Note: Wireshark has a nice feature that allows you to plot the RTT for each of the TCP segments sent. Select a TCP segment in the “listing of captured packets” window that is being sent from the client to the gaia.cs.umass.edu server. Then select: Statistics → TCP Stream Graph → Round Trip Time Graph.

A: **EstimatedRTT** was calculated using the formula:

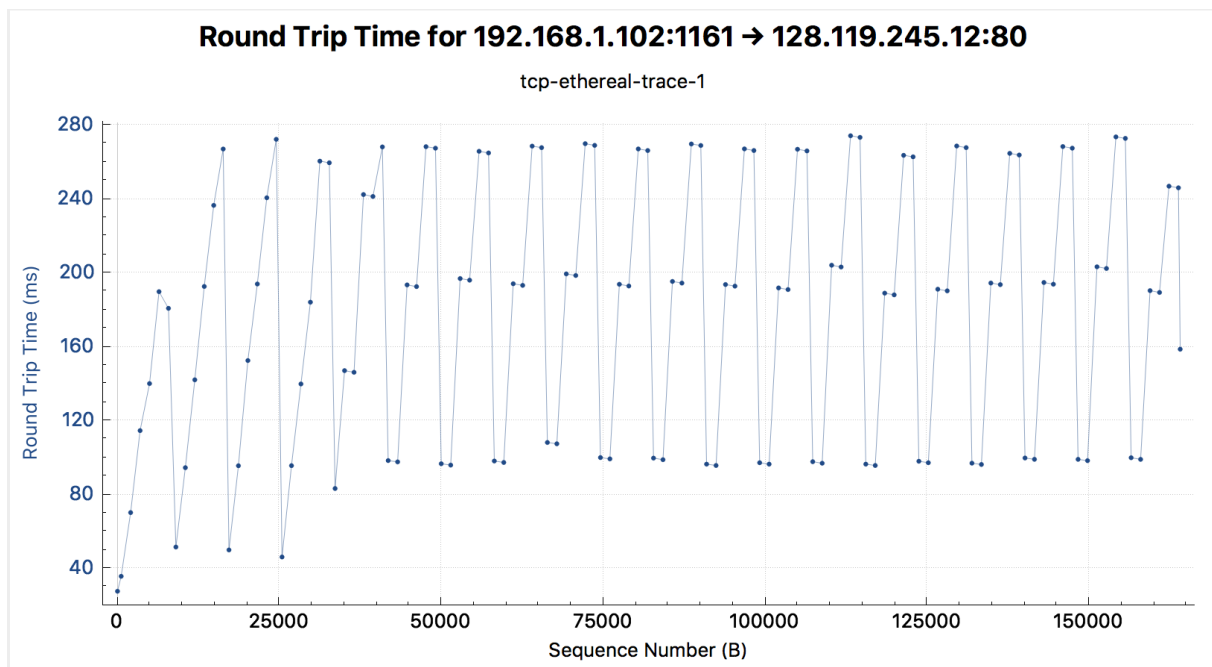
$$\text{EstimatedRTT} = (1 - \alpha) \cdot \text{EstimatedRTT} + \alpha \cdot \text{SampleRTT}$$

where $\alpha = 0.125$

Segment	SEQ Num	Time Sent	ACK received	RTT value	Est. RTT value
1	1	6:44:20.596858	6:44:20.624318	27.46 ms	27.46 ms
2	566	6:44:20.612118	6:44:20.647675	35.56 ms	28.47 ms
3	2026	6:44:20.624407	6:44:20.694466	70.06 ms	33.67 ms
4	3486	6:44:20.625071	6:44:20.739499	114.43 ms	43.77 ms
5	4946	6:44:20.647786	6:44:20.787680	139.90 ms	55.78 ms
6	6406	6:44:20.648538	6:44:20.838183	189.64 ms	72.51 ms

No.	Time	Source	Destination	Protocol	Length	Info
4	06:44:20.596858	192.168.1.102	128.119.245.12	TCP	619	[TCP segment of a reassembled PDU]
5	06:44:20.612118	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
6	06:44:20.624318	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
7	06:44:20.624407	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
8	06:44:20.625071	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
9	06:44:20.647675	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=2026 Win=8760 Len=0
10	06:44:20.647786	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
11	06:44:20.648538	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
12	06:44:20.694466	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=3486 Win=11680 Len=0
13	06:44:20.694566	192.168.1.102	128.119.245.12	TCP	1201	[TCP segment of a reassembled PDU]
14	06:44:20.739499	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=4946 Win=14600 Len=0
15	06:44:20.787680	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=6406 Win=17520 Len=0
16	06:44:20.838183	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=7866 Win=20440 Len=0

▶ Frame 5: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 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: 566, Ack: 1, Len: 1460
 Source Port: 1161
 Destination Port: 80
 [Stream index: 0]
 [TCP Segment Len: 1460]
 Sequence number: 566 (relative sequence number)
 [Next sequence number: 2026 (relative sequence number)]
 Acknowledgment number: 1 (relative ack number)
 Header Length: 20 bytes
 ▶ Flags: 0x018 (PSH, ACK)



Question 8

Q: What is the length of each of the first six TCP segments?

A: The length of the first segment is 565 bytes. The following five segments are each 1460 bytes.

No.	Time	Source	Destination	Protocol	Length	Info
4	06:44:20.596858	192.168.1.102	128.119.245.12	TCP	619	[TCP segment of a reassembled PDU]
▶ 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						

No.	Time	Source	Destination	Protocol	Length	Info
5	06:44:20.612118	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
▶ Frame 5: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 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: 566, Ack: 1, Len: 1460						

Question 9

Q: 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?

A: The minimum buffer space for the entire trace is 5840 bytes. It appears during the first acknowledgement sent by gaia.cs.umass.edu. There is never a lack of receiver buffer space in this trace. The TCP Window grows consistently until it reaches a max of 62,780 bytes, and doesn't dip back down. There are no instances where the TCP Window drops to zero, which would occur if the lack of buffer space was throttling the sender.

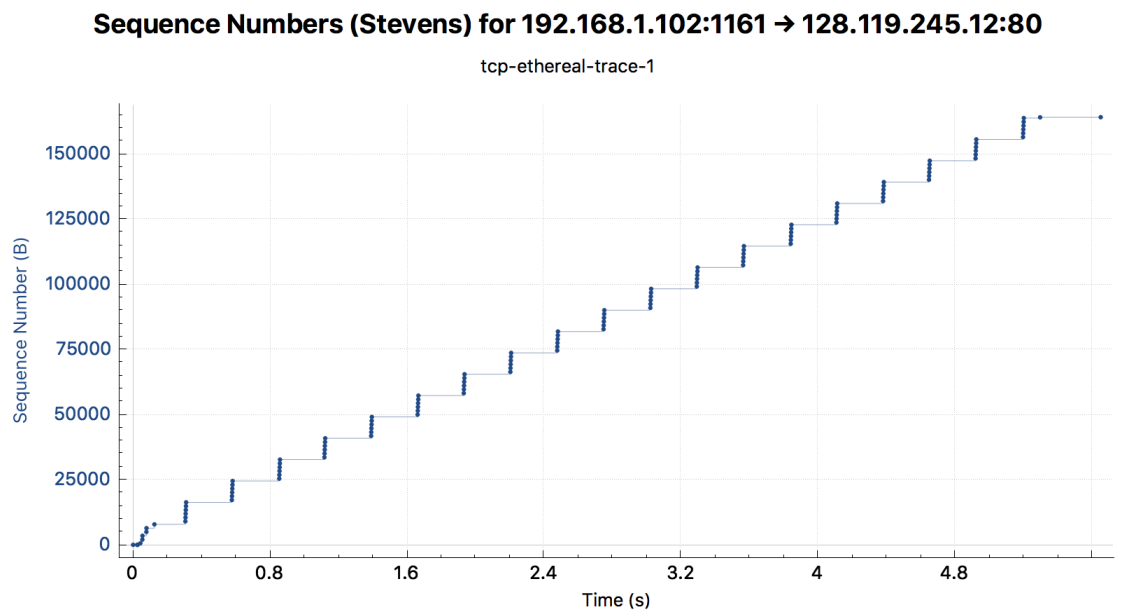
No.	Time	Source	Destination	Protocol	Length	Info
1	06:44:20.570381	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1
2	06:44:20.593553	128.119.245.12	192.168.1.102	TCP	62	80 → 1161 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 SACK_PERM=1
3	06:44:20.593646	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=1 Ack=1 Win=17520 Len=0
4	06:44:20.596858	192.168.1.102	128.119.245.12	TCP	619	[TCP segment of a reassembled PDU]
5	06:44:20.612118	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
6	06:44:20.624318	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
7	06:44:20.624407	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
8	06:44:20.625071	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
9	06:44:20.647675	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=2026 Win=8760 Len=0
10	06:44:20.647786	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
11	06:44:20.648538	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
12	06:44:20.694466	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=3486 Win=11680 Len=0
13	06:44:20.694566	192.168.1.102	128.119.245.12	TCP	1201	[TCP segment of a reassembled PDU]
▼ Transmission Control Protocol, Src Port: 80, Dst Port: 1161, Seq: 0, Ack: 1, Len: 0						
Source Port: 80						
Destination Port: 1161						
[Stream index: 0]						
[TCP Segment Len: 0]						
Sequence number: 0 (relative sequence number)						
Acknowledgment number: 1 (relative ack number)						
Header Length: 28 bytes						
▶ Flags: 0x012 (SYN, ACK)						
Window size value: 5840						
[Calculated window size: 5840]						

Question 10

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

A: No, there aren't any retransmitted segments. We can check by looking at the each segment's data and seeing if any are sent twice. Another way we can check is by plotting the Time-Sequence

Graph (Stevens) and making sure that the sequence number increases at a steady rate over time. If there was a retransmitted packet, then the sequence number of the retransmitted packet should be noticeably smaller than the sequence numbers of the segments near it. Also, if there was a retransmitted segment, Wireshark would also make a note labelled [TCP Retransmit] in the "Info" section.



Question 11

Q: How much data does the receiver typically acknowledge in an ACK? Can you identify cases where the receiver is ACKing every other received segment (see Table 3.2 on p. 250 in the text).

A: The receiver typically acknowledges 1460 bytes of data in an ACK. Segments 60 and 61 ACK every other received segment. The acknowledged data in both segments is 2920, which is 1460 doubled.

No.	Time	Source	Destination	Protocol	Length	Info
6	06:44:20.624318	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
7	06:44:20.624407	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
8	06:44:20.625071	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
9	06:44:20.647675	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=2026 Win=8760 Len=0
10	06:44:20.647786	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
11	06:44:20.648538	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
12	06:44:20.694466	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=3486 Win=11680 Len=0
13	06:44:20.694566	192.168.1.102	128.119.245.12	TCP	1201	[TCP segment of a reassembled PDU]
14	06:44:20.739499	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=4946 Win=14600 Len=0
15	06:44:20.787680	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=6406 Win=17520 Len=0
16	06:44:20.838183	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=7866 Win=20440 Len=0
17	06:44:20.875188	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=9013 Win=23360 Len=0
18	06:44:20.875421	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
58	06:44:21.692272	192.168.1.102	128.119.245.12	TCP	946	[TCP segment of a reassembled PDU]
59	06:44:21.770802	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=35049 Win=62780 Len=0
60	06:44:21.835407	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=37969 Win=62780 Len=0
61	06:44:21.932455	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=40889 Win=62780 Len=0
62	06:44:21.960267	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=41781 Win=62780 Len=0

Num	ACK Number	Data Acknowledged
1	566	566
2	2026	1460
3	3486	1460
4	4946	1460
5	6406	1460
6	7866	1460
7	9013	1147

Question 12

Q: What is the throughput (bytes transferred per unit time) for the TCP connection?

A: The equation for throughput is total bytes transferred over the connection time.

Total bytes transferred = $164091 - 1 = 164090$ bytes = 164.090 KB

Total Time = $6:44:26.026211 - 6:44:20.596858 = 5.42935$ secs

Throughput = $\frac{164.090}{5.42935} = 30.223$ kilobytes/sec

No.	Time	Source	Destination	Protocol	Length	Info
1	06:44:20.570381	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	06:44:20.593553	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	06:44:20.593646	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=1 Ack=1 Win=17520 Len=0
4	06:44:20.596858	192.168.1.102	128.119.245.12	TCP	619	[TCP segment of a reassembled PDU]
202	06:44:26.026211	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=164091 Win=62780 Len=0
203	06:44:26.031556	128.119.245.12	192.168.1.102	HTTP	784	HTTP/1.1 200 OK (text/html)
206	06:44:26.221522	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=164091 Ack=731 Win=16790 Len=0
213	06:44:28.165938	192.168.1.102	199.2.53.206	TCP	62	1162 → 631 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1

Question 13

Q: 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.

A: TCP's slow start begins when the connection begins (Segment 4, when the HTTP POST is sent). However, we cannot identify where TCP's slow start ends and congestion avoidance begins. Congestion avoidance occurs when there is a loss event (i.e. packets dropped, timeout) or the slow state threshold is reached. In the example trace given, the client never sends more data than the server buffer can handle. By inspecting the amount of data outstanding (sent but not yet acknowledged), we can see that the client sends out at most 8192 bytes outstanding. Before the data is acknowledged, the client temporarily stops transmitting data.

The idealized behavior of TCP is that clients should continue to increase their sending rate until they see packets drop. TCP then interprets packet drop as network congestion, and the client's transmission rate slows down. Clients periodically probe the network to check whether more bandwidth is available. The measured data differs since despite not detecting any network congestion or packet loss, the client does not continue to send data, but rather stops.

(see Question 10 for Time-Sequence Graph (Stevens))

Num	SEQ Num	ACK Num	Length	Data Outstanding
18	9013	-	1460	1460
19	10473	-	1460	2920
20	11933	-	1460	4380
21	13393	-	1460	5840
22	14853	-	1460	7300
23	16313	-	892	8192
24	-	10473	-	6732
25	-	11933	-	5272
26	-	13393	-	3812
27	-	14853	-	2352
28	-	16313	-	892
29	-	17205	-	0

No.	Time	Source	Destination	Protocol	Length	Info
18	06:44:20.875421	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
19	06:44:20.876194	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
20	06:44:20.877073	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
21	06:44:20.877952	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
22	06:44:20.879080	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
23	06:44:20.879934	192.168.1.102	128.119.245.12	TCP	946	[TCP segment of a reassembled PDU]
24	06:44:20.926818	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=10473 Win=26280 Len=0
25	06:44:20.970545	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=11933 Win=29200 Len=0
26	06:44:21.018994	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=13393 Win=32120 Len=0
27	06:44:21.070410	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=14853 Win=35040 Len=0
28	06:44:21.115433	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=16313 Win=37960 Len=0
29	06:44:21.146798	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=17205 Win=37960 Len=0
30	06:44:21.147052	192.168.1.102	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
▶ Frame 18: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 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: 9013, Ack: 1, Len: 1460						
Source Port: 1161						
Destination Port: 80						
[Stream index: 0]						
[TCP Segment Len: 1460]						
Sequence number: 9013 (relative sequence number)						
[Next sequence number: 10473 (relative sequence number)]						
Acknowledgment number: 1 (relative ack number)						

Question 14

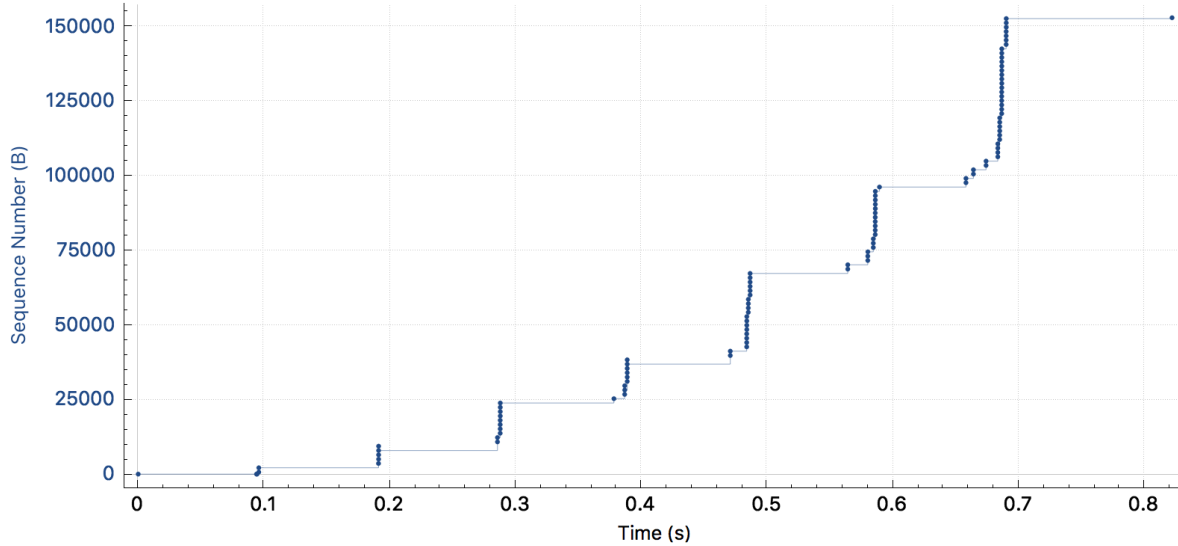
Q: Answer Question 13 for the trace that you captured when you transferred a file from your own computer to gaia.cs.umass.edu

A: TCP's slow start begins when the connection begins, which is Segment 17, when the HTTP POST is sent. Slow start doesn't end before the file is finished transferring. The Time-Sequence (Stevens) graph below shows that doubling of packets sent occurs until the very end of the file transfer process. The ACK statements increase by 1448 (length of each segment), meaning that one ACK statement is being sent for each packet, causing the rate of transmission to grow exponentially.

Since TCP slow start never ends, congestion avoidance doesn't begin.

Sequence Numbers (Stevens) for 192.168.86.104:64625 → 128.119.245.12:80

Wi-Fi: en0



No.	Time	Source	Destination	Protocol	Length	Info
12	00:52:43.044167	192.168.86.104	128.119.245.12	TCP	78	64625 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=32 TSval=1508859767
13	00:52:43.091726	128.119.245.12	192.168.86.104	TCP	66	80 → 64624 [ACK] Seq=1 Ack=2 Win=235 Len=0 TSval=2466138598 TSecr=1508
15	00:52:43.138146	128.119.245.12	192.168.86.104	TCP	74	80 → 64625 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK_PERM=1
16	00:52:43.138221	192.168.86.104	128.119.245.12	TCP	66	64625 → 80 [ACK] Seq=1 Ack=1 Win=131744 Len=0 TSval=1508859860 TSecr=2
17	00:52:43.138672	192.168.86.104	128.119.245.12	TCP	733	[TCP segment of a reassembled PDU]
18	00:52:43.140045	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
19	00:52:43.140047	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
20	00:52:43.235122	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=668 Win=30336 Len=0 TSval=2466138742 TSecr=
21	00:52:43.235128	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=2116 Win=33280 Len=0 TSval=2466138742 TSecr=
22	00:52:43.235129	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=3564 Win=36096 Len=0 TSval=2466138742 TSecr=
23	00:52:43.235228	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
24	00:52:43.235314	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
25	00:52:43.235315	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
26	00:52:43.235317	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
27	00:52:43.235317	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
28	00:52:43.329737	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=5012 Win=39040 Len=0 TSval=2466138837 TSecr=
29	00:52:43.329809	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
30	00:52:43.329810	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
31	00:52:43.331872	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=6460 Win=41984 Len=0 TSval=2466138837 TSecr=
32	00:52:43.331878	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=7908 Win=44800 Len=0 TSval=2466138838 TSecr=
33	00:52:43.331879	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=9356 Win=47744 Len=0 TSval=2466138838 TSecr=
34	00:52:43.331880	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=10804 Win=50688 Len=0 TSval=2466138838 TSecr=
35	00:52:43.331968	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
36	00:52:43.331970	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
37	00:52:43.331970	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
38	00:52:43.331971	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
39	00:52:43.332043	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
40	00:52:43.332044	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
41	00:52:43.332045	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
42	00:52:43.332046	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]

No.	Time	Source	Destination	Protocol	Length	Info
46	00:52:43.422314	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=12252 Win=53504 Len=0 TSval=2466138929 TSecr=
47	00:52:43.422394	128.119.245.12	192.168.86.104	TCP	1514	[TCP segment of a reassembled PDU]
48	00:52:43.430873	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=13700 Win=56448 Len=0 TSval=2466138937 TSecr=
49	00:52:43.430877	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=15148 Win=59264 Len=0 TSval=2466138937 TSecr=
50	00:52:43.430878	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=16596 Win=62208 Len=0 TSval=2466138937 TSecr=
51	00:52:43.430943	128.119.245.12	192.168.86.104	TCP	1514	[TCP segment of a reassembled PDU]
52	00:52:43.430983	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
53	00:52:43.430983	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
54	00:52:43.432781	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=18044 Win=65152 Len=0 TSval=2466138938 TSecr=
55	00:52:43.432784	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=19492 Win=67968 Len=0 TSval=2466138938 TSecr=
56	00:52:43.432785	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=20940 Win=70912 Len=0 TSval=2466138938 TSecr=
57	00:52:43.432786	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=22388 Win=73856 Len=0 TSval=2466138940 TSecr=
58	00:52:43.432786	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=23836 Win=76672 Len=0 TSval=2466138940 TSecr=
59	00:52:43.432787	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=25284 Win=79616 Len=0 TSval=2466138940 TSecr=
60	00:52:43.432975	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
61	00:52:43.432976	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
62	00:52:43.432977	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
63	00:52:43.432977	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
64	00:52:43.432978	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
65	00:52:43.432978	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
66	00:52:43.514874	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=26732 Win=82432 Len=0 TSval=2466139022 TSecr=
67	00:52:43.514928	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
68	00:52:43.514929	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
69	00:52:43.527888	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=28180 Win=85376 Len=0 TSval=2466139035 TSecr=
70	00:52:43.527894	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=29628 Win=88320 Len=0 TSval=2466139035 TSecr=
71	00:52:43.527895	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=31076 Win=91136 Len=0 TSval=2466139035 TSecr=
72	00:52:43.527896	128.119.245.12	192.168.86.104	TCP	66	80 → 64625 [ACK] Seq=1 Ack=32524 Win=94080 Len=0 TSval=2466139036 TSecr=
73	00:52:43.527972	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
74	00:52:43.527974	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
75	00:52:43.527975	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]
76	00:52:43.527976	192.168.86.104	128.119.245.12	TCP	1514	[TCP segment of a reassembled PDU]