

# COMP9331 Lab Exercise 4: Exploring TCP

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## Exercise 1: Understanding TCP using Wireshark

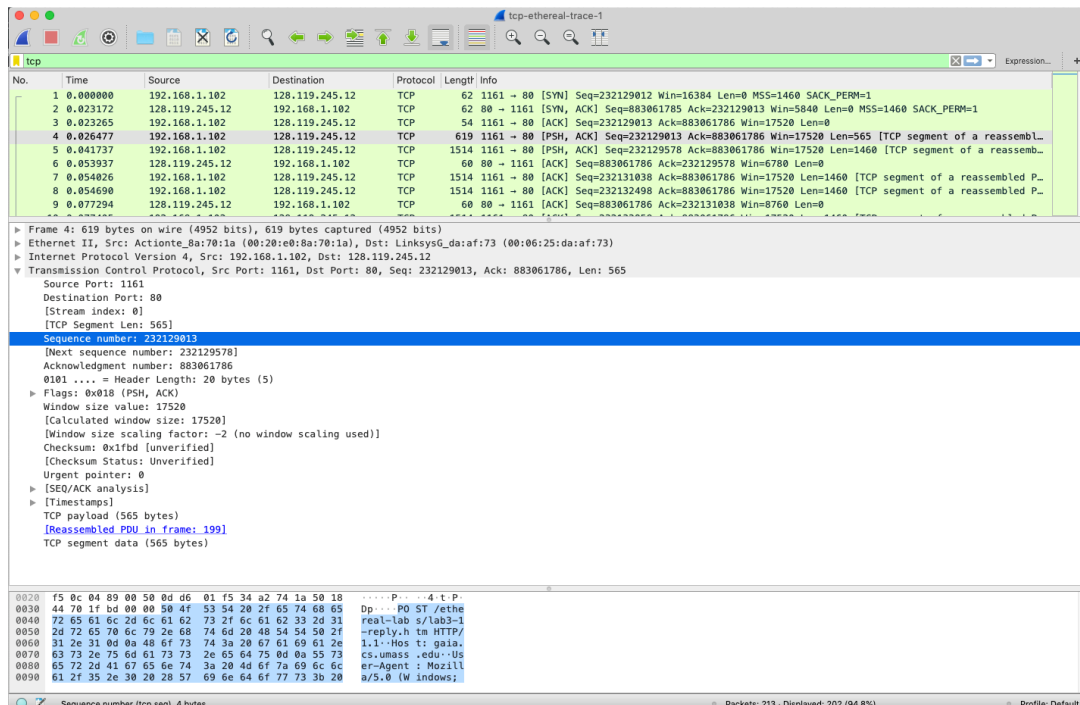
### Question 1.

The IP address of gaia.cs.umass.edu is **128.119.245.12**, its port number for sending TCP segments and receiving at is **80**.

The IP address and TCP port number used by the client computer (source) that is transferring the file to gaia.cs.umass.edu are **192.168.1.102** and **1161**.

### Question 2.

The sequence number of the TCP segment containing the HTTP POST command is **232129013**.



**Question 3.**  $\text{EstimatedRTT} = (1 - 0.125) * \text{EstimatedRTT} + 0.125 * \text{SampleRTT}$

Sequence number	Time sent	ACK received time	RTT	EstimatedRTT
232129013	0.026477	0.053937	0.027460	0.027460
232129578	0.041737	0.077294	0.035557	0.028472
232131038	0.054026	0.124085	0.070059	0.033670
232132498	0.054690	0.169118	0.114428	0.043765
232133958	0.077405	0.217299	0.139894	0.055781
232135418	0.078157	0.267802	0.189645	0.072514

#### Question 4.

The length of first six TCP segments are **565,1460,1460,1460,1460,1460** respectively.

#### Question 5.

The image shows a Wireshark packet capture of a TCP connection. The top pane displays a list of 21 packets. The first six packets are TCP segments with lengths 565, 1460, 1460, 1460, 1460, and 1460 bytes respectively. The details pane for the selected packet (No. 1) shows the following information:

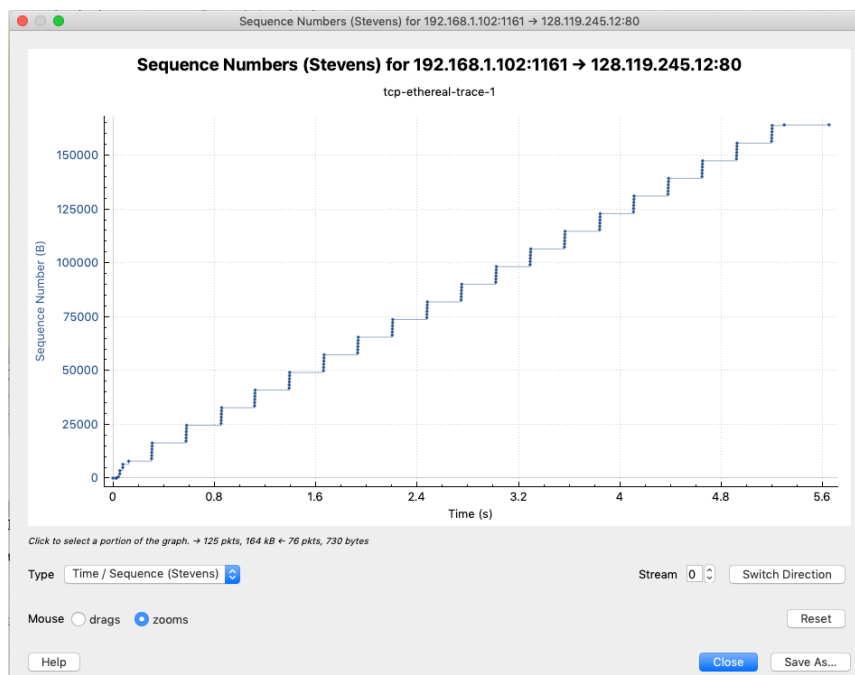
- Stream index: 0
- [TCP Segment Len: 0]
- Sequence number: 883061785
- [Next sequence number: 883061785]
- Acknowledgment number: 232129013
- 0111 .... = Header Length: 28 bytes (7)
- Flags: 0x012 [SYN, ACK]
- Window size value: 5840
- [Calculated window size: 5840]
- Checksum: 0x774d [unverified]
- [Checksum Status: Unverified]
- Urgent pointer: 0
- Options: (8 bytes), Maximum segment size, No-Operation (NOP), No-Operation (NOP), SACK permitted
- [SEQ/ACK analysis]
- [Timestamps]

The bottom pane shows the raw packet data in hexadecimal and ASCII format.

The minimum amount of available buffer space advertised at the receiver for the entire trace is **5840**.

**No**, the window sizes are bigger than the segment sizes at any time in this given trace, so it was not lack of receiver buffer space, hence didn't throttle the sender.

#### Question 6.



**No**, there is no retransmitted segments in the trace file.

From the time sequence number graph above plotted using Wireshark, we can see that the sequence number kept increasing as the time goes by after connection established, if retransmitted ever occurs, there must be a same sequence number occurred at two different times. Since there's no this situation, no retransmission occurred.

### Question 7.

The receiver typically acknowledge one segment in an ACK, the size of one segment is usually 1460 bytes.

No.	Time	Source	Destination	Protocol	Length	Info
86	1.935586	192.168.1.102	128.119.245.12	TCP	946	1161 → 80 [PSH, ACK] Seq=2322194477 Ack=883061786 Win=17520 Len=892 [TCP segment of a r...]
85	1.934770	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322193017 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
84	1.933636	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322191557 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
83	1.932757	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322190097 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
82	1.931879	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322188637 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
81	1.931099	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322187177 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
77	1.665151	192.168.1.102	128.119.245.12	TCP	946	1161 → 80 [PSH, ACK] Seq=2322186285 Ack=883061786 Win=17520 Len=892 [TCP segment of a r...]
76	1.665254	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322184025 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
75	1.664198	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322183365 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
74	1.663315	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322181905 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
73	1.662474	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322180445 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
72	1.661734	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322178985 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
68	1.394202	192.168.1.102	128.119.245.12	TCP	946	1161 → 80 [PSH, ACK] Seq=2322178093 Ack=883061786 Win=17520 Len=892 [TCP segment of a r...]
67	1.393390	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322176633 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
66	1.392594	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322175173 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
65	1.391603	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322173713 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
64	1.390824	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322172253 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
63	1.390110	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322170793 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
58	1.121891	192.168.1.102	128.119.245.12	TCP	946	1161 → 80 [PSH, ACK] Seq=2322169901 Ack=883061786 Win=17520 Len=892 [TCP segment of a r...]
57	1.120902	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322168441 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
56	1.119858	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322166981 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
55	1.119029	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322165521 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
54	1.118133	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322164061 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
53	1.117333	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322162601 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
47	0.857683	192.168.1.102	128.119.245.12	TCP	946	1161 → 80 [PSH, ACK] Seq=2322161709 Ack=883061786 Win=17520 Len=892 [TCP segment of a r...]
46	0.856802	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322160249 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
45	0.855878	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322158789 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
44	0.855036	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322157329 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
43	0.854076	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322155869 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
42	0.853405	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322154409 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
35	0.581074	192.168.1.102	128.119.245.12	TCP	946	1161 → 80 [PSH, ACK] Seq=2322153517 Ack=883061786 Win=17520 Len=892 [TCP segment of a r...]
34	0.580149	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322152057 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
33	0.579185	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322150597 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
32	0.578329	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322149137 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
31	0.577385	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322147677 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
30	0.576671	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322146217 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
23	0.309553	192.168.1.102	128.119.245.12	TCP	946	1161 → 80 [PSH, ACK] Seq=2322145325 Ack=883061786 Win=17520 Len=892 [TCP segment of a r...]
22	0.308699	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322143865 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
21	0.307571	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322142405 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
20	0.306692	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322140945 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
10	0.305813	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2322139485 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]

The receiver is ACKing two received segment in the one ACK at No. 142 transaction shown below. The two segments with sequence number 232240709 and 232242169 are a acked by the No. 142 transaction acking 232242169 as a single cumulative ack. According to TCP ACK generation rules provided at pg 35 in the Transport layer Part 2's, if one in-order segment(seq = 232240709 in this example) arrives, and all segments before it has been acked, then, delayed ACK triggered, wait up to 500ms, the next segment(seq = 232242169) arrives, immediately send a single cumulative ACK acking both seq=232240709 and seq=232242169 segments.

134	3.562531	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=883061786 Ack=232236329 Win=62780 Len=0
135	3.562737	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=232236329 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
136	3.563561	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=232237789 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
137	3.564458	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=232239249 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
138	3.565426	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=232240709 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
139	3.566442	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=232242169 Ack=883061786 Win=17520 Len=1460 [TCP segment of a r...]
140	3.567324	192.168.1.102	128.119.245.12	TCP	946	1161 → 80 [PSH, ACK] Seq=232243629 Ack=883061786 Win=17520 Len=892 [TCP segment of a r...]
141	3.668330	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=883061786 Ack=232239249 Win=62780 Len=0
142	3.768417	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=883061786 Ack=232242169 Win=62780 Len=0

### Question 8.

The throughput for the TCP connection

= total bytes transfered / total time taken

= (last Ack number - Seq number when sending first segment) / (last Ack received time - time sent first segment)

= (232293103 - 232129013) / (5.455830 - 0.026477)

= 164090 / 5.429353

= **30.22KB/s**

First segment sent at No. 4 transaction, last ACK received at No. 202 transaction shown below.

1	0.000000	192.168.1.102	128.119.245.12	TCP	62	80 → 1161	[SYN]	Seq=232129013 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=883061785 Ack=232129013 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=232129013 Ack=883061786 Win=17520 Len=0
4	0.026477	192.168.1.102	128.119.245.12	TCP	619	1161 → 80	[PSH, ACK]	Seq=232129013 Ack=883061786 Win=17520 Len=565 [TCP segment of data set 0x00000000: 0x00000000 0x00000000 0x00000000 0x00000000]
5	0.041737	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80	[PSH, ACK]	Seq=232129578 Ack=883061786 Win=17520 Len=1460 [TCP segment of data set 0x00000000: 0x00000000 0x00000000 0x00000000 0x00000000]
...								
200	5.389471	128.119.245.12	192.168.1.102	TCP	60	80 → 1161	[ACK]	Seq=883061786 Ack=232291321 Win=62780 Len=0
201	5.447887	128.119.245.12	192.168.1.102	TCP	60	80 → 1161	[ACK]	Seq=883061786 Ack=232293053 Win=62780 Len=0
202	5.455830	128.119.245.12	192.168.1.102	TCP	60	80 → 1161	[ACK]	Seq=883061786 Ack=232293103 Win=62780 Len=0
203	5.461175	128.119.245.12	192.168.1.102	HTTP	784	HTTP/1.1	200 OK	(text/html)
204	5.561141	192.168.1.102	128.119.245.12	TCP	54	1161 → 80	[ACK]	Seq=232293103 Ack=883061786 Win=17520 Len=0

## Exercise 2: TCP connection management

### Question 1.

The sequence number of the TCP SYN segment that is used to initiate the TCP connection between the client computer and server is: **2818463618**.

### Question 2.

The sequence number of the SYNACK segment sent by the server to the client computer in reply to the SYN is **1247095790**.

The value of the Acknowledgement field in the SYNACK segment is **2818463619**.

For the sequence number, it is randomly chosen by the server from all numbers can be represented in 32 bits range.

For the ACK number, it is incremented one by the sequence no. received from the client in the SYN message because no data received at this stage.

### Question 3.

The sequence number of the ACK segment sent by the client computer in response to the SYNACK is **2818463619**.

The value of the Acknowledgment field in this ACK segment is **1247095791**.

Yes.

Data sent

= (No. 301)Ack number of server receiving this segment - (No. 297/298)Seq number of this sending ACK segment

= 2818463652 - 2818463619

= 33 Bytes

**Question 4.**

The client and server have both done the active close.

This is determined according to the transactions No. 304, FINACK sent from client to server, and No.305, FINACK sent from server to client. Since 304's sequence number equals to 305's ack number, and 305's sequence number equals to 304's ack number, this shows that these two segments are sent simultaneously before receiving the other side's FINACK. Therefore, both sides did the active close.

Simultaneous closure has been performed.

**Question 5.****Client to the server:**

Data bytes transferred from the client to the server

= 2818463652 - 2818463619

= 33 Bytes

final ACK received from the server - Initial Sequence Number of client

= 2818463653 - 2818463618

= 35 Bytes

**Server to the client:**

Data bytes transferred from the server to the client

= 1247095831 - 1247095791

= 40 Bytes

final ACK received from the client - Initial Sequence Number of server

= 1247095832 - 1247095790

= 42 Bytes

(final ACK received from the other side - Initial Sequence Number) is close to the amount of data transferred from one side to another. However, the difference between final ACK and ISN also included the initial three way handshake bytes (SYN, SYNACK, ACK) and finishing bytes (FIN), and these bytes are empty, just to indicate the state, so the actual number of data bytes are 33 and 42 from client to server and server to client respectively.