

USC EE450 Fall 2020

Lab #2 Report: TCP

Zeyu Wang

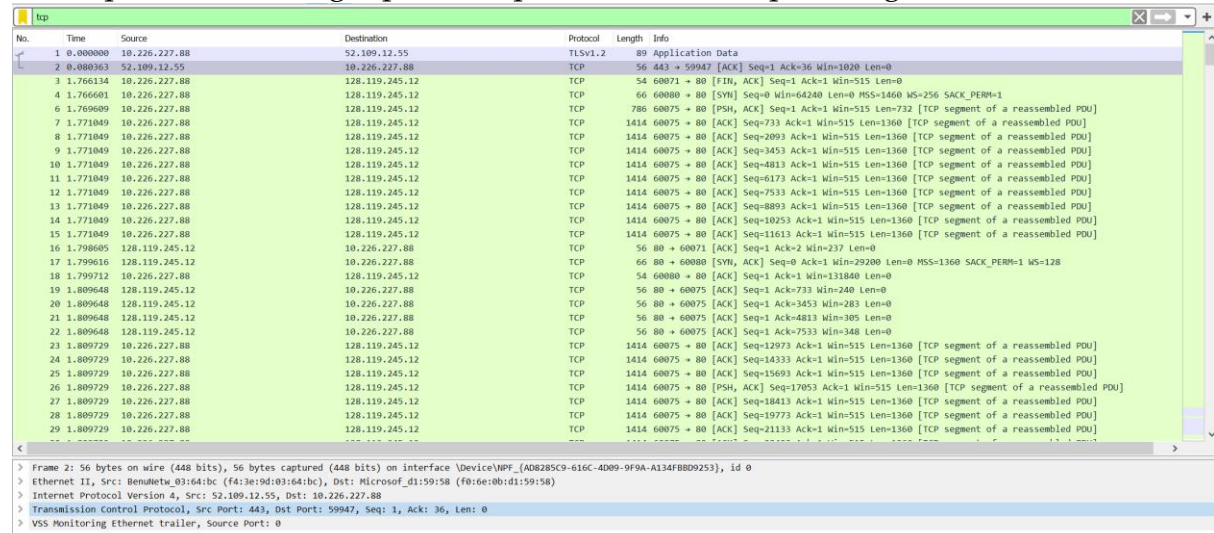
Session 2

1. Abstract

In this lab, I examined and analyzed the use of TCP on a public network by using the Wireshark packet analyzer that runs on Windows, this examination process including the trace of TCP segments, TCP sequence and acknowledgement numbers, and TCP congestion & flow control mechanisms.

Retrieve alic.txt and upload it on <http://gaia.cs.umass.edu/wireshark-labs/TCP-wireshark-file1.html>. Record the trace of TCP & HTTP exchange information.

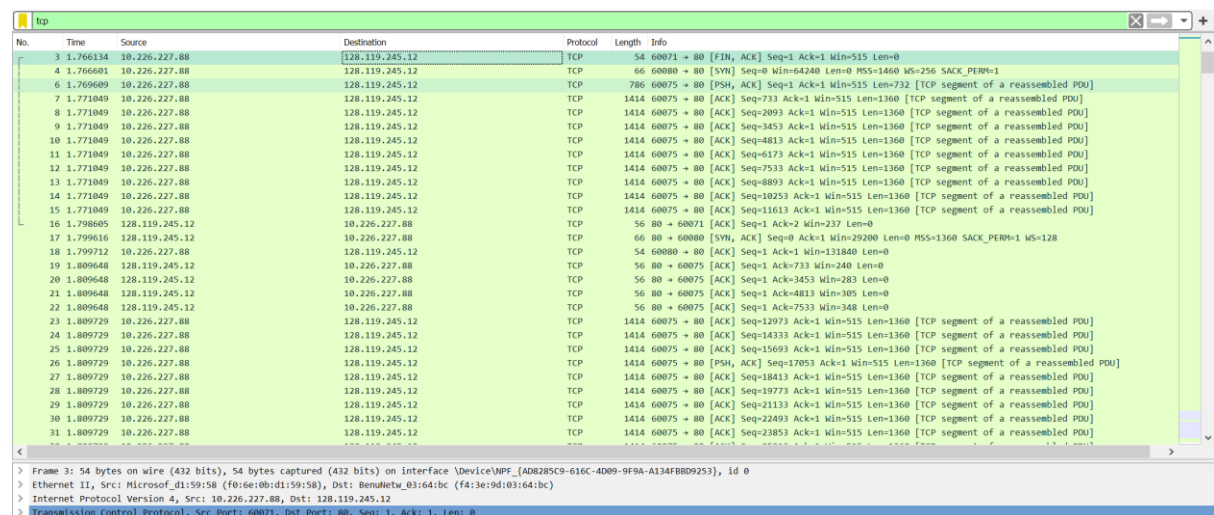
Boot up Wireshark, begin packet capture, and filter tcp messages.



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	10.226.227.88	52.109.12.55	TLSv1.2	89	Application Data
2	0.000363	52.109.12.55	10.226.227.88	TCP	56	443 → 59947 [ACK] Seq=1 Ack=36 Win=1020 Len=0
3	1.766134	10.226.227.88	128.119.245.12	TCP	54	60071 → 80 [FIN, ACK] Seq=1 Ack=1 Win=515 Len=0
4	1.766601	10.226.227.88	128.119.245.12	TCP	66	60080 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
6	1.769609	10.226.227.88	128.119.245.12	TCP	786	60075 → 80 [PSH, ACK] Seq=1 Ack=1 Win=515 Len=732 [TCP segment of a reassembled PDU]
7	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=733 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
8	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=2093 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
9	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=3453 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
10	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=4813 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
11	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=6173 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
12	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=7533 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
13	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=8893 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
14	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=10253 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
15	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=11613 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
16	1.798605	128.119.245.12	10.226.227.88	TCP	56	80 → 60071 [ACK] Seq=1 Ack=2 Win=237 Len=0
17	1.799616	128.119.245.12	10.226.227.88	TCP	66	80 → 60080 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1360 SACK_PERM=1 WS=128
18	1.799712	10.226.227.88	128.119.245.12	TCP	54	60080 → 80 [ACK] Seq=1 Ack=1 Win=131840 Len=0
19	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075 [ACK] Seq=1 Ack=733 Win=240 Len=0
20	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075 [ACK] Seq=1 Ack=3453 Win=283 Len=0
21	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075 [ACK] Seq=1 Ack=4813 Win=305 Len=0
22	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075 [ACK] Seq=1 Ack=7533 Win=348 Len=0
23	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=12973 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
24	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=14333 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
25	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=15693 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
26	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [PSH, ACK] Seq=17053 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
27	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=18413 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
28	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=19773 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
29	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=21133 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
30	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=22493 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
31	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=23853 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]

> Frame 2: 56 bytes on wire (448 bits), 56 bytes captured (448 bits) on interface \Device\NPF_{AD82B5C9-616C-4D09-9FA9-A134F8B09253}, id 0
> Ethernet II, Src: BenuMetw_03:64:bc (f4:3e:9d:03:64:bc), Dst: Microsof_d1:59:58 (f0:6e:0b:d1:59:58)
> Internet Protocol Version 4, Src: 52.109.12.55, Dst: 10.226.227.88
> Transmission Control Protocol, Src Port: 443, Dst Port: 59947, Seq: 1, Ack: 36, Len: 0
> VSS Monitoring Ethernet trailer, Source Port: 0

Cumulative Acknowledgments:



No.	Time	Source	Destination	Protocol	Length	Info
3	1.766134	10.226.227.88	128.119.245.12	TCP	54	60071 → 80 [FIN, ACK] Seq=1 Ack=1 Win=515 Len=0
4	1.766601	10.226.227.88	128.119.245.12	TCP	66	60080 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
6	1.769609	10.226.227.88	128.119.245.12	TCP	786	60075 → 80 [PSH, ACK] Seq=1 Ack=1 Win=515 Len=732 [TCP segment of a reassembled PDU]
7	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=733 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
8	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=2093 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
9	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=3453 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
10	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=4813 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
11	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=6173 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
12	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=7533 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
13	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=8893 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
14	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=10253 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
15	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=11613 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
16	1.798605	128.119.245.12	10.226.227.88	TCP	56	80 → 60071 [ACK] Seq=1 Ack=2 Win=237 Len=0
17	1.799616	128.119.245.12	10.226.227.88	TCP	66	80 → 60080 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1360 SACK_PERM=1 WS=128
18	1.799712	10.226.227.88	128.119.245.12	TCP	54	60080 → 80 [ACK] Seq=1 Ack=1 Win=131840 Len=0
19	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075 [ACK] Seq=1 Ack=733 Win=240 Len=0
20	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075 [ACK] Seq=1 Ack=3453 Win=283 Len=0
21	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075 [ACK] Seq=1 Ack=4813 Win=305 Len=0
22	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075 [ACK] Seq=1 Ack=7533 Win=348 Len=0
23	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=12973 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
24	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=14333 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
25	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=15693 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
26	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [PSH, ACK] Seq=17053 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
27	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=18413 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
28	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=19773 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
29	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=21133 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
30	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=22493 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
31	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=23853 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]

> Frame 3: 54 bytes on wire (432 bits), 54 bytes captured (432 bits) on interface \Device\NPF_{AD82B5C9-616C-4D09-9FA9-A134F8B09253}, id 0
> Ethernet II, Src: Microsof_d1:59:58 (f0:6e:0b:d1:59:58), Dst: BenuMetw_03:64:bc (f4:3e:9d:03:64:bc)
> Internet Protocol Version 4, Src: 10.226.227.88, Dst: 128.119.245.12
> Transmission Control Protocol, Src Port: 60071, Dst Port: 80, Seq: 1, Ack: 1, Len: 0

2. Answers to questions in lab

- 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?

Client IP address: 192.168.1.102 | TCP port number: 1161

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN, ACK] 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 [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 [TCP segment of a reassembled PDU]
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 [TCP segment of a reassembled PDU]
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	0.054826	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=2026 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
8	0.054900	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=3486 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
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 [TCP segment of a reassembled PDU]
11	0.078157	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=6406 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
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 [TCP segment of a reassembled PDU]
14	0.169118	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=4946 Win=14080 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=20480 Len=0
17	0.304807	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=9013 Win=23360 Len=0
18	0.305040	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=9013 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
19	0.305813	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=10473 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
20	0.306692	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=11933 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
21	0.307571	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=13393 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
22	0.308699	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=14853 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
23	0.309553	192.168.1.102	128.119.245.12	TCP	946	1161 → 80 [PSH, ACK] Seq=16313 Ack=1 Win=17520 Len=892 [TCP segment of a reassembled PDU]
24	0.356437	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=10473 Win=26280 Len=0

- 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?

IP address of gaia.cs.umass.edu is 128.119.245.12

Port number is 80 that is sending and receiving TCP segments.

- 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?

Client IP address is 10.226.227.88

TCP port number is 80 to transfer file to umass.

- 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?

Sequence number of the TCP SYN segment is 0.

SYN flag is set to 1 to identifies the SYN segment.

4	1.766601	10.226.227.88	128.119.245.12	TCP	66	60080 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
6	1.769609	10.226.227.88	128.119.245.12	TCP	786	60075 → 80 [PSH, ACK] Seq=1 Ack=1 Win=515 Len=732 [TCP segment of a reassembled PDU]
7	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=733 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
8	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=2093 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
9	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=3453 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
10	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=4813 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
11	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=6173 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
12	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=7533 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
13	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=8893 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
14	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=10253 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
15	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=11613 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]

Transmission Control Protocol, Src Port: 60080, Dst Port: 80, Seq: 0, Len: 0	
Source Port:	60080
Destination Port:	80
[Stream index:]	2
[TCP Segment len:]	0
Sequence number:	0 (relative sequence number)
Sequence number (raw):	4190244932
[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...	ECH-Echo: Not set
....0...	Urgent: Not set
....0...	Acknowledgment: Not set
....0...	Push: Not set
....0...	Reset: Not set
>0...	SYN: Set
....0...	FIN: Not set

- 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?

Sequence number of SYNACK segment sent by gaia.cs.umass.edu to the client computer in reply to the SYN is 0. The value of the Acknowledgement field in the SYNACK segment is 1, which is determined by the web server. The web server adds 1 to the initial sequence number of the SYN segment that sent from the client. Flag is in the segment

that identifies the segment as a SYNACK segment. If both flag of SYN and ACK are set to 1, then it's a SYNACK segment.

17	1.799616	128.119.245.12	10.226.227.88	TCP	66	60800	[SYN, ACK]	Seq=0 Ack=1 Win=29200 Len=0 MSS=1360 SACK_PERM=1 WS=128	
18	1.799712	10.226.227.88	128.119.245.12	TCP	54	60800	+ 80	[ACK]	Seq=1 Ack=1 Win=131840 Len=0
19	1.809648	128.119.245.12	10.226.227.88	TCP	56	80	+ 60075	[ACK]	Seq=1 Ack=733 Win=240 Len=0
20	1.809648	128.119.245.12	10.226.227.88	TCP	56	80	+ 60075	[ACK]	Seq=1 Ack=3453 Win=283 Len=0
21	1.809648	128.119.245.12	10.226.227.88	TCP	56	80	+ 60075	[ACK]	Seq=1 Ack=4813 Win=305 Len=0
22	1.809648	128.119.245.12	10.226.227.88	TCP	56	80	+ 60075	[ACK]	Seq=1 Ack=7533 Win=348 Len=0
23	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=12973 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
24	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=14333 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
25	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=15693 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
26	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[PSH, ACK]	Seq=17053 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
27	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=18413 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
28	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=19773 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
29	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=21133 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
30	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=22493 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
31	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=23853 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]

Transmission Control Protocol, Src Port: 80, Dst Port: 60800, Seq: 0, Ack: 1, Len: 0

Source Port: 80
Destination Port: 60800
[Stream index: 2]
[TCP Segment Len: 0]
Sequence number: 0 (relative sequence number)
Sequence number (raw): 487676125
[Next sequence number: 1 (relative sequence number)]
Acknowledgment number: 1 (relative ack number)
Acknowledgment number (raw): 419024933
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... = ECH-Echo: Not set
....0... = Urgent: Not set
....1... = Acknowledgment: Set
....0... = Push: Not set
....0... = Reset: Not set
> = Syn: Set

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

6	1.769609	10.226.227.88	128.119.245.12	TCP	786	60075	+ 80	[PSH, ACK]	Seq=1 Ack=1 Win=515 Len=732 [TCP segment of a reassembled PDU]	
7	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=733 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]	
8	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=2093 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]	
9	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=3453 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]	
10	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=4813 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]	
11	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=6173 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]	
12	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=7533 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]	
13	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=8893 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]	
14	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=10253 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]	
15	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075	+ 80	[ACK]	Seq=11613 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]	
16	1.798605	128.119.245.12	10.226.227.88	TCP	56	80	+ 60071	[ACK]	Seq=1 Ack=2 Win=237 Len=0	
17	1.799616	128.119.245.12	10.226.227.88	TCP	66	80	+ 60800	[SYN, ACK]	Seq=0 Ack=1 Win=29200 Len=0 MSS=1360 SACK_PERM=1 WS=128	
18	1.799712	10.226.227.88	128.119.245.12	TCP	54	60800	+ 80	[ACK]	Seq=1 Ack=1 Win=131840 Len=0	

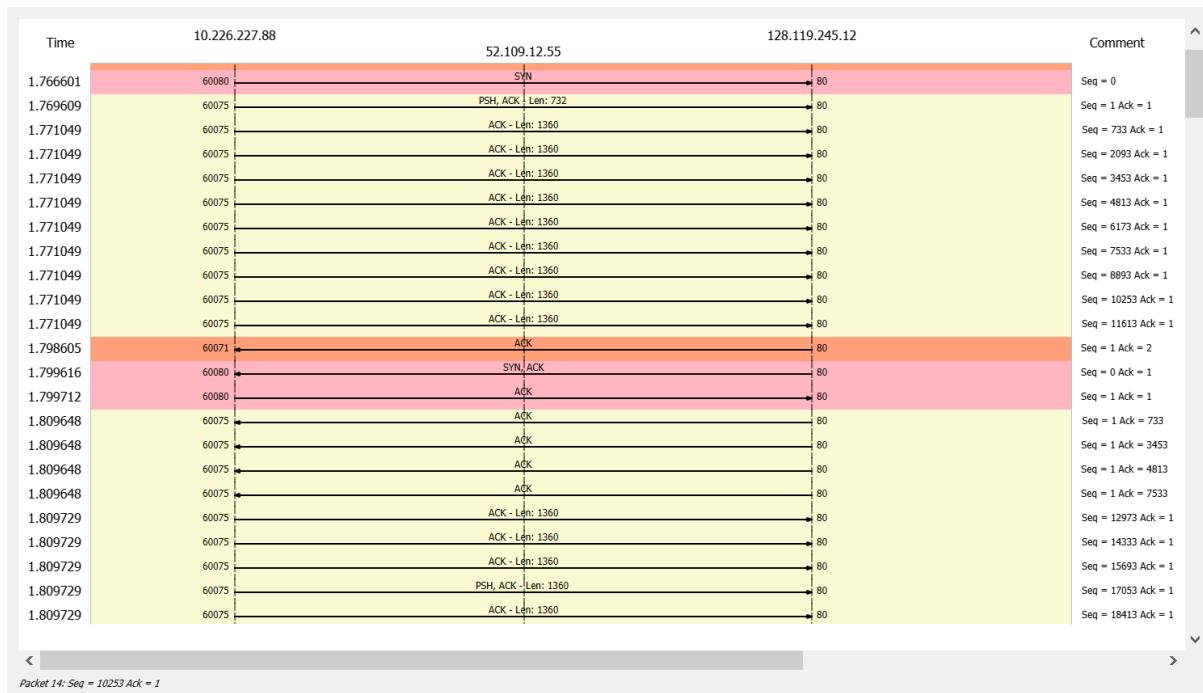
Frame 6: 786 bytes on wire (6288 bits), 786 bytes captured (6288 bits) on interface \Device\NPF_{AD8285C9-616C-4D09-9F9A-A134FB809253}, id 0	
Ethernet II, Src: Microsoft_d1:50:58 (f8:6e:0b:d1:50:58), Dst: BenhuaTw_03:64:bc (f4:3e:9d:03:64:bc)	
Internet Protocol Version 4, Src: 10.226.227.88, Dst: 128.119.245.12	
Transmission Control Protocol, Src Port: 60075, Dst Port: 80, Seq: 1, Ack: 1, Len: 732	

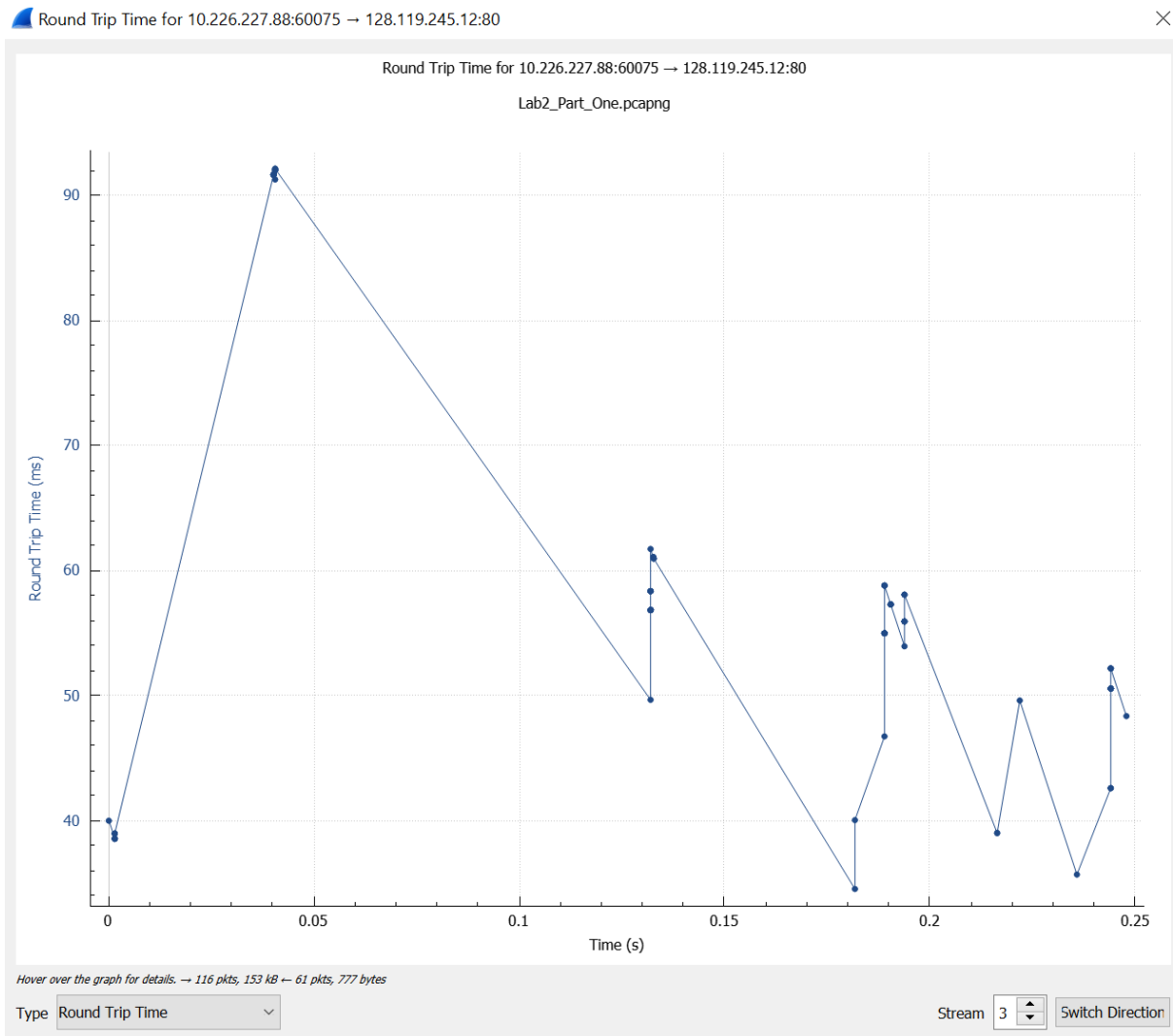
0020	f5 0c ea ab 00 50 15 7d a7 39 1e 92 1a f7 50 18	.....P.....P
0030	02 03 a1 3d 00 00 00 00 00 00 00 00 00 00 00 00	.....P.....P
0040	71 68 61 72 68 20 6c 61 62 73 2f 6c 61 62 11 30	.....P.....P
0050	31 2d 72 65 78 6c 79 2e 68 7a 6d 20 4b 54 54 50	.....P.....P
0060	2f 31 2e 71 6d 0a 4a 6f 72 7a 3a 20 67 61 69 61	.....P.....P
0070	2a 63 71 2e 75 6d 61 71 71 2e 65 64 75 8d 8a 43	.....P.....P

- 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 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.

First Six Segments in the TCP connection, ACK received time, RTT:

- Seq = 1 sent at 1.769609; ACK received at 1.809648; RTT = 0.40039 second
- Seq = 733 sent at 1.771049; ACK received at 0.809648; RTT = 0.38599 second
- Seq = 2093 sent at 1.771049; ACK received at 1.809648; RTT = 0.038599 second
- Seq = 3453 sent at 1.771049; ACK received at 1.809648; RTT = 0.038599 second
- Seq = 4813 sent at 1.771049; ACK received at 1.809648; RTT = 0.038599 second
- Seq = 6173 sent at 1.771049; ACK received at 1.809648; RTT = 0.038599 second





$$\text{EstimatedRTT} = 0.875 * \text{EstimatedRTT} + 0.125 * \text{SampleRTT}$$

- a) EstimatedRTT (Segment 1) = RTT for Segment 1 = 0.40039 second
- b) EstimatedRTT (Segment 2) = $0.875 * 0.40039 + 0.125 * 0.38599 = 0.35909862$ second
- c) EstimatedRTT (Segment 3) = $0.875 * 0.35909862 + 0.125 * 0.38599 = 0.36246005$ second
- d) EstimatedRTT (Segment 4) = $0.875 * 0.36246005 + 0.125 * 0.38599 = 0.36797488$ second
- e) EstimatedRTT (Segment 5) = $0.875 * 0.36797488 + 0.125 * 0.38599 = 0.37022677$ second
- f) EstimatedRTT (Segment 6) = $0.875 * 0.37022677 + 0.125 * 0.38599 = 0.37219717$ second

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

Segment	Length
1	732
2	1360
3	1360
4	1360
5	1360
6	1360

- 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?

The minimum amount of buffer space advertised at the received for the entire trace is 237 bytes. The send will not throttle since the lack of receiver buffer space. The maximum receiver buffer size is 29200 bytes.

16	1.798605	128.119.245.12	10.226.227.88	TCP	56	80 → 60071	[ACK] Seq=1 Ack=2 Win=237 Len=0
17	1.799616	128.119.245.12	10.226.227.88	TCP	66	80 → 60080	[SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1360 SACK_PE
18	1.799712	10.226.227.88	128.119.245.12	TCP	54	60080 → 80	[ACK] Seq=1 Ack=1 Win=131840 Len=0
19	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK] Seq=1 Ack=733 Win=240 Len=0
20	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK] Seq=1 Ack=3453 Win=283 Len=0
21	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK] Seq=1 Ack=4813 Win=305 Len=0
22	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK] Seq=1 Ack=7533 Win=348 Len=0
23	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK] Seq=12973 Ack=1 Win=515 Len=1360 [TCP segment of
24	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK] Seq=14333 Ack=1 Win=515 Len=1360 [TCP segment of

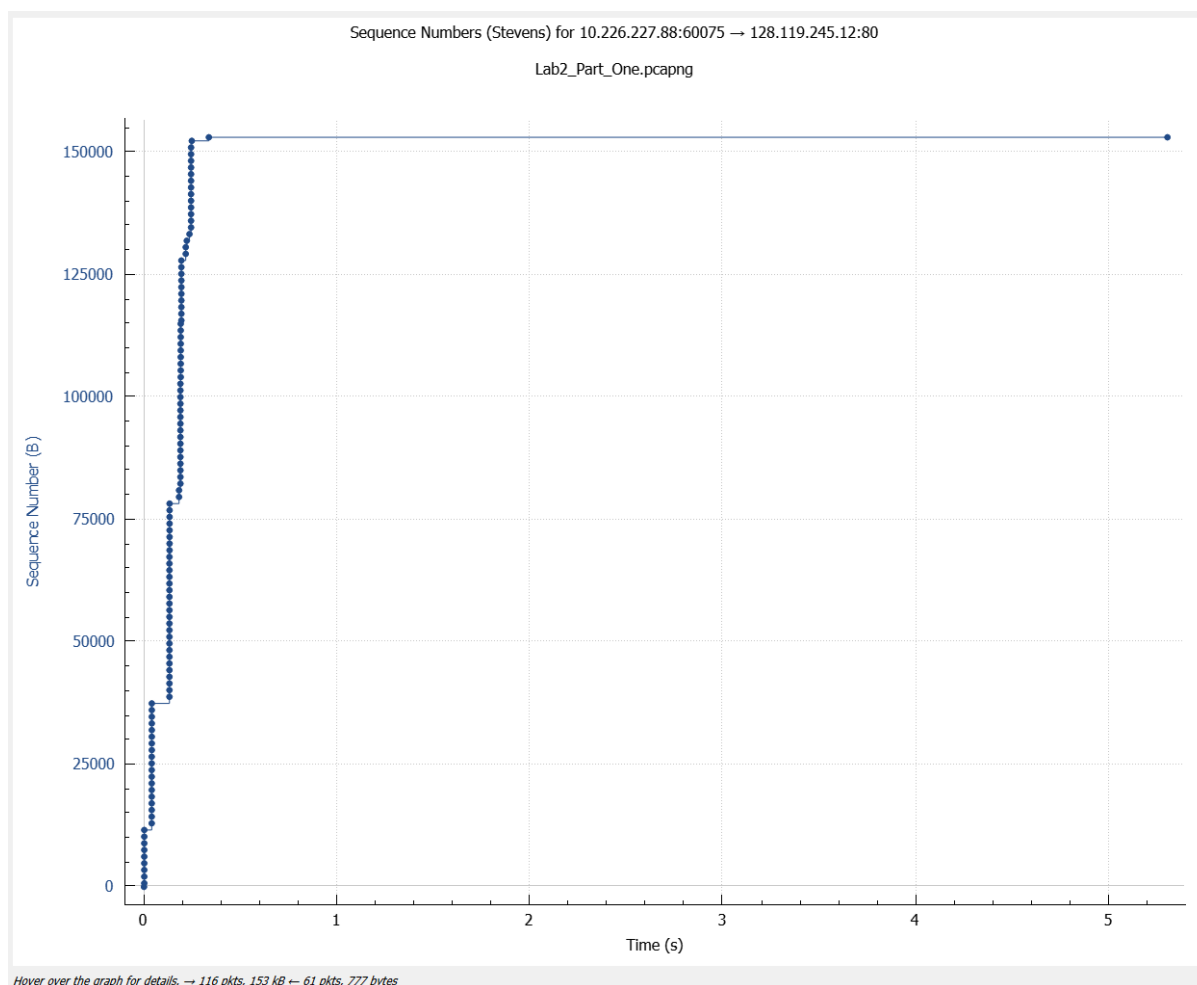
...0 ....	....	= Nonce: Not set
...0 ....	....	= Congestion Window Reduced (CWR): Not set
...0 ..	....	= ECH-Echo: Not set
...0 ..	....	= Urgent: Not set
...0 ..1	....	= Acknowledgment: Set
...0	0...	= Push: Not set
...0	0..	= Reset: Not set
...0	0.	= Syn: Not set
...0	0	= Fin: Not set
[TCP Flags: .....A....]		
window size value: 237		

17	1.799616	128.119.245.12	10.226.227.88	TCP	66	80 → 60080	[SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1360 SACK_PE
18	1.799712	10.226.227.88	128.119.245.12	TCP	54	60080 → 80	[ACK] Seq=1 Ack=1 Win=131840 Len=0
19	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK] Seq=1 Ack=733 Win=240 Len=0
20	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK] Seq=1 Ack=3453 Win=283 Len=0
21	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK] Seq=1 Ack=4813 Win=305 Len=0
22	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK] Seq=1 Ack=7533 Win=348 Len=0
23	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK] Seq=12973 Ack=1 Win=515 Len=1360 [TCP segment of
24	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK] Seq=14333 Ack=1 Win=515 Len=1360 [TCP segment of
25	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK] Seq=15693 Ack=1 Win=515 Len=1360 [TCP segment of
26	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[PSH, ACK] Seq=17053 Ack=1 Win=515 Len=1360 [TCP segment of
27	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK] Seq=18413 Ack=1 Win=515 Len=1360 [TCP segment of
28	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK] Seq=19773 Ack=1 Win=515 Len=1360 [TCP segment of
29	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK] Seq=21133 Ack=1 Win=515 Len=1360 [TCP segment of
30	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK] Seq=22493 Ack=1 Win=515 Len=1360 [TCP segment of
31	1.809729	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK] Seq=23853 Ack=1 Win=515 Len=1360 [TCP segment of

....	....	0	= Fin: Not set
[TCP Flags: .....A..S.]			
window size value: 29200			

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

There are no retransmitted segments in the trace file. I checked the sequence number of the TCP segments in the trace file. The Time-Sequence graph showed that the time increased steadily and didn't change suddenly. If retransmitted segment occurred, then the sequence number of this retransmitted segment should be smaller than its neighboring segments. Thus, there are no retransmitted sequence.



- 11) How much data does the receiver typically acknowledge in an ACK? Can you identify cases where the receiver is ACK'ing every other received segment (see Table 3.2 on page 250 in the text)?

The receiver typically acknowledges 1360 bytes in an ACK. (In the graph below, the difference between each consecutive ACK is 1360 bytes.)

115	1.959900	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK]	Seq=1 Ack=59213 Win=1177 Len=0
116	1.959900	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK]	Seq=1 Ack=61933 Win=1220 Len=0
117	1.959900	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK]	Seq=1 Ack=63293 Win=1243 Len=0
118	1.959900	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK]	Seq=1 Ack=64653 Win=1265 Len=0
119	1.959900	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK]	Seq=1 Ack=66013 Win=1288 Len=0
120	1.959900	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK]	Seq=1 Ack=67373 Win=1311 Len=0

The receiver is ACKing every other segment. For instance, segment #20 is acking #8 and #9 two segments.

6	1.789809	10.226.227.88	128.119.245.12	TCP	786	60075 → 80	[PSH, ACK]	Seq=1 Ack=1 Win=515 Len=772 [TCP segment of a reassembled PDU]
7	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK]	Seq=733 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
8	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK]	Seq=2093 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
9	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK]	Seq=3453 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
10	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK]	Seq=4813 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
11	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK]	Seq=6173 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
12	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK]	Seq=7533 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
13	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK]	Seq=8893 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
14	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK]	Seq=10253 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
15	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80	[ACK]	Seq=11613 Ack=1 Win=515 Len=1360 [TCP segment of a reassembled PDU]
16	1.798605	128.119.245.12	10.226.227.88	TCP	56	80 → 60071	[ACK]	Seq=1 Ack=2 Win=237 Len=0
17	1.799616	128.119.245.12	10.226.227.88	TCP	66	80 → 60080	[SYN, ACK]	Seq=0 Ack=1 Win=29200 Len=0 MSS=1360 SACK_PERM=1 WS=128
18	1.799712	10.226.227.88	128.119.245.12	TCP	54	60080 → 80	[ACK]	Seq=1 Ack=1 Win=131840 Len=0
19	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK]	Seq=1 Ack=733 Win=240 Len=0
20	1.809648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075	[ACK]	Seq=1 Ack=3453 Win=283 Len=0

- 12) What is the throughput (bytes transferred per unit time) for the TCP connection? Explain how you calculated this value.

$$\text{Average throughput for the TCP connection} = \frac{\text{Total amount data (bits)}}{\text{Total transmission time (seconds)}}$$

Thus, Total amount of transmitted data = (Sequence # of the first TCP segment) - (ACKed Sequence # of the last ACK) = 153054 - 1 = 153053 bytes.

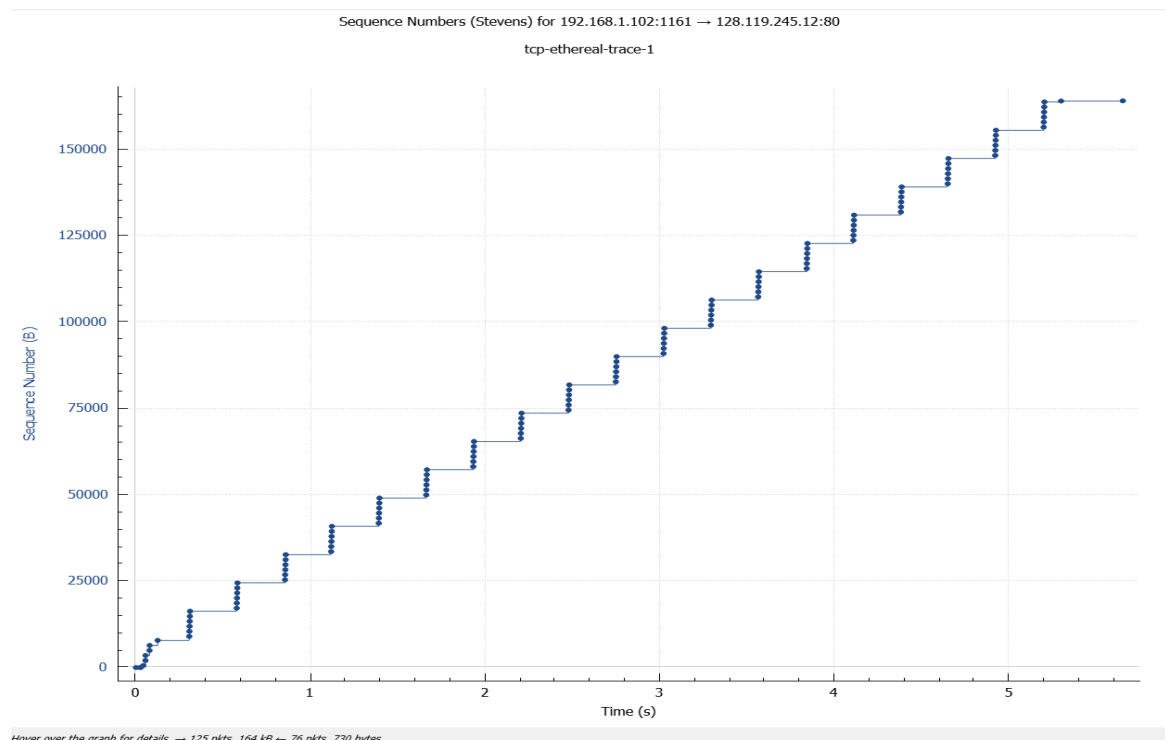
The whole transmission time = | Time (1st TCP segment) - Time (Last TCP segment) | = | 1.798605 - 7.072243 | = 5.273638 seconds. Hence, the Throughput = 153053/5.273638 = 29.022KBps

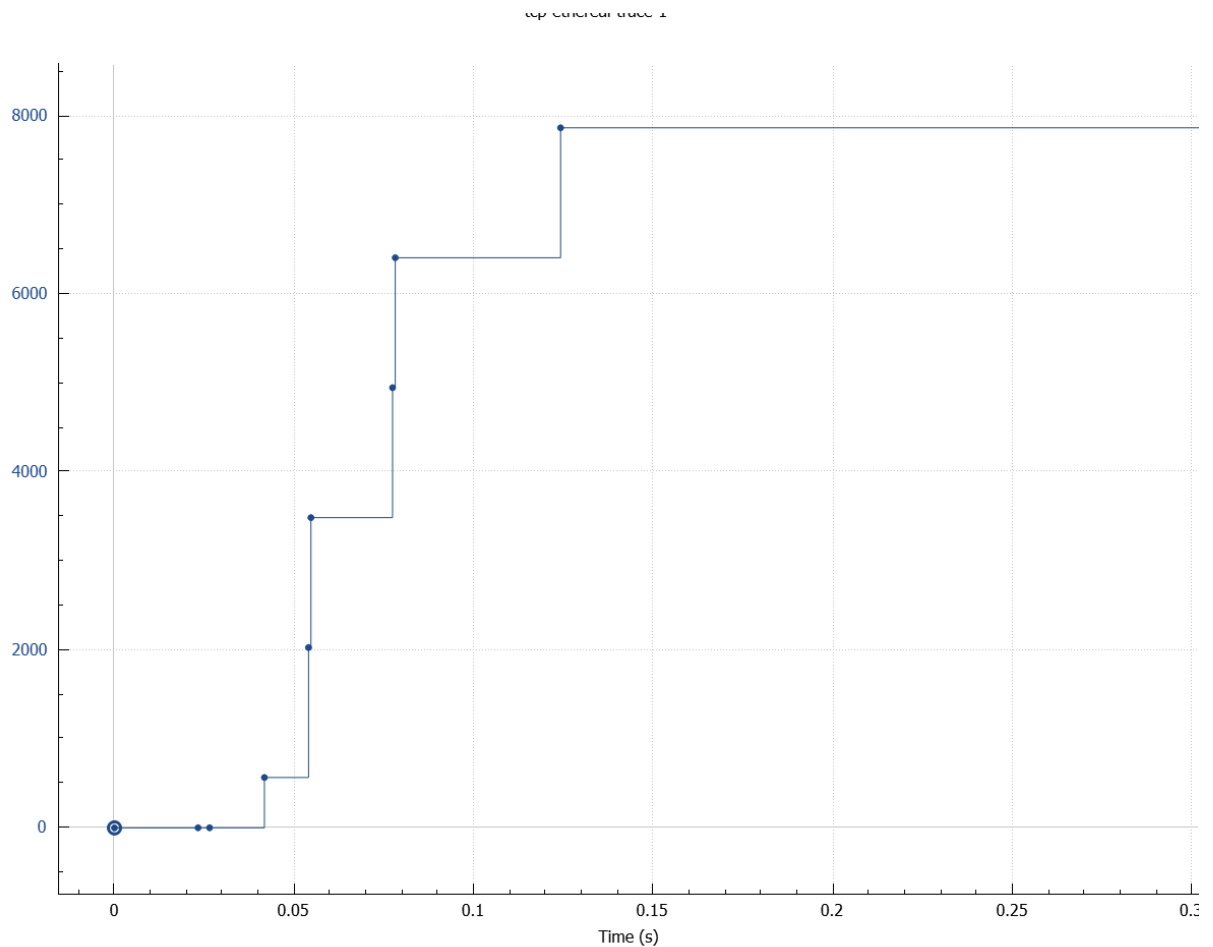
15	1.771049	10.226.227.88	128.119.245.12	TCP	1414	60075 → 80 [ACK] Seq=11613 Ack=1 Win=515 Len=1360 [TCP segment of
16	1.798605	128.119.245.12	10.226.227.88	TCP	56	80 → 60071 [ACK] Seq=1 Ack=2 Win=237 Len=0
17	1.799616	128.119.245.12	10.226.227.88	TCP	66	80 → 60080 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1360 SACK_PE
18	1.799712	10.226.227.88	128.119.245.12	TCP	54	60080 → 80 [ACK] Seq=1 Ack=1 Win=131840 Len=0
19	1.800648	128.119.245.12	10.226.227.88	TCP	56	80 → 60075 [ACK] Seq=1 Ack=733 Win=240 Len=0
203	7.072243	10.226.227.88	128.119.245.12	TCP	54	60075 → 80 [ACK] Seq=153054 Ack=779 Win=512 Len=0

Frame 203: 54 bytes on wire (432 bits), 54 bytes captured (432 bits) on interface \Device\NPF_{A08285C9-616C-4D09-9F9A-A134F8BD9253}, id 0
 Ethernet II, Src: Microsoft_d1:59:58 (f8:6e:0b:d1:59:58), Dst: Benetw_03:64:bc (f4:3e:9d:03:64:bc)
 Internet Protocol Version 4, Src: 10.226.227.88, Dst: 128.119.245.12
 Transmission Control Protocol, Src Port: 60075, Dst Port: 80, Seq: 153054, Ack: 779, Len: 0

- 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. **(Given Trace File)**

TCP's slow start phase begins around zero and ends around 0.15 seconds according to the graph below. Congestion avoidance takes over at around 0.19 seconds because it cut down the amount of data that being sent.





- 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`.

3. Conclusion (Discussion of the result & Evaluation of the tool)

In this lab, I have studied and analyzed the performance of TCP Error/Flow Control, Throughput, and Round-Trip Time (RRT). I traced the TCP segments by observing TCP sequence number and acknowledgment number. I also explored and demonstrated how the TCP is capable of providing reliable and dedicated data transmission between my computer and the remote server.

As a packet analyzer, Wireshark are capable of capturing and decoding every packet that are currently-being-transmitted between clients and servers over a real-time network. It also provides practical functionalities such as timing datagram, flow graph, protocols filter, time display formatters, file I/O, and data import/export. On top of that, it's a human-friendly tool for network administrators due to its colorful GUI interface and other interactive built-in statistic toolboxes.