

Lab Exercise 4: Exploring TCP

Exercise 1: Understanding TCP using Wireshark

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN] Seq=232129012 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 a reassembled PDU]
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 a reassembled PDU]
6	0.053937	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=883061786 Ack=232129578 Win=6780 Len=0
7	0.054026	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=232131038 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
8	0.054690	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=232132498 Ack=883061786 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=883061786 Ack=232131038 Win=8760 Len=0

1. The IP address of gaia.cs.umass.ed is 192.168.1.102. It is sending and receiving TCP segments on port 1161. The IP address of the client computer (source) is 128.119.245.12 and it is transferring the file on port 80.

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN] Seq=232129012 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 a reassembled PDU]
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 a reassembled PDU]
6	0.053937	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=883061786 Ack=232129578 Win=6780 Len=0
7	0.054026	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=232131038 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
8	0.054690	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=232132498 Ack=883061786 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=883061786 Ack=232131038 Win=8760 Len=0
10	0.077405	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=232133958 Ack=883061786 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=232135418 Ack=883061786 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=883061786 Ack=232132498 Win=11680 Len=0
13	0.124185	192.168.1.102	128.119.245.12	TCP	1201	1161 → 80 [PSH, ACK] Seq=232136878 Ack=883061786 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=883061786 Ack=232133958 Win=14600 Len=0
15	0.217299	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=883061786 Ack=232135418 Win=17520 Len=0
16	0.267802	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=883061786 Ack=232136878 Win=20440 Len=0
17	0.304087	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=883061786 Ack=232130025 Win=23360 Len=0
18	0.305040	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK] Seq=232138025 Ack=883061786 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=232139485 Ack=883061786 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=232140945 Ack=883061786 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=232142405 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]

Frame 4: 619 bytes on wire (4952 bits), 619 bytes captured (4952 bits) on interface 0
Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a), Dst: Linksys_6:daf:73 (00:06:25:da:f7:73)
Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 232129013, Ack: 883061786, Len: 565
Source Port: 1161
Destination Port: 80
[Stream index: 0]
[Conversation completeness: Incomplete, DATA (15)]
[TCP Segment Len: 565]
Sequence Number: 232129013
[Next Sequence Number: 232129578]
Acknowledgment Number: 883061786
0101 = Header Length: 20 bytes (5)
Flags: 0x018 (PSH, ACK)
Window: 17520
[Calculated window size: 17520]
[Window size scaling factor: -2 (no window scaling used)]
Checksum: 0x1fbd (unverified)
[Checksum status: Unverified]
0020 f5 8c 84 89 00 50 84 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 20 72 65 70 6c 79 2e 60 74 6d 20 40 54 54 50 2f -rsplsh tn HTTP/
0060 31 2e 31 0d 0a 48 6f 73 74 3a 20 6f 61 69 61 2e 1.1 Hos t: gaia.
0070 63 73 2e 75 6d 61 73 73 2e 65 64 75 0d 0a 55 73 cs.umass .edu .Us
0080 65 72 2d 41 67 65 6a 74 3a 20 40 6f 7a 69 6c 6c er-Agent : Mozill
0090 61 2f 35 2e 38 20 28 57 69 6a 64 6f 77 73 30 20 n/5.0 (W indow:
00a0 55 3b 20 57 69 6a 64 6f 77 73 20 4e 54 20 35 2e U; Windo ws NT 5.
00b0 31 30 20 65 6e 2d 55 53 30 20 72 70 3a 31 2e 30 1; en-US ; rv:1.0
00c0 2e 32 29 47 65 63 6b 6f 2f 32 30 30 33 30 32 -) Gecko o/200202
00d0 30 38 20 4e 65 74 73 63 61 70 65 2f 37 2e 30 32 00 Netsc ape/7.02
00e0 0d 0a 61 63 63 65 70 74 3a 20 74 65 78 74 2f 78 'Accept : text/x
00f0 6d 6c 2c 61 70 70 6c 69 63 61 74 69 6f 6e 2f 78 ml,appli cation/x
0100 6d 6c 2c 61 70 70 6c 69 63 61 74 69 6f 6e 2f 78 ml,appli cation/x
0110 68 74 6d 6c 2b 78 6d 6c 2c 74 65 78 74 2f 68 74 html+xml ,text/ht
0120 6d 6c 30 71 3d 30 2e 39 2c 74 65 78 74 2f 70 6c mliq=0.9 ,text/pl
0130 61 69 6e 30 71 3d 30 2e 39 2c 74 65 69 6a 65 6f 2f ainq=0.8 ,video/
0140 78 2d 6d 6e 67 2c 69 6d 61 67 65 2f 70 6e 67 2c x-mng, in age/png,

2. The sequence number is 232129013.
- 3.

No.	Sequence No.	Time sent (s)	ACK received (s)	RTT diff (s)	Est. RTT (s)
4	232129013	0.026477	0.053937	0.02746	0.02746
5	232129578	0.041737	0.077294	0.035557	
7	232131038	0.054026	0.124085	0.070059	
8	232132498	0.054690	0.169118	0.114428	
10	232133958	0.077405	0.217299	0.139894	
11	232135418	0.078157	0.267802	0.189645	

RTT diff = ACK received – Time sent

Est. RTT = $7/8 * (\text{Est. RTT of Prev ACK}) + 1/8 * (\text{RTT diff})$

- 4.

No.	Length (bytes)
4	565

5	1460
7	1460
8	1460
10	1460
11	1460

1	0.000000	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN, Seq=232129012 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, Seq=883061786 Ack=232129013 Win=5840 Len=0 MSS=1460 SACK_PERM=1]
3	0.023255	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 a reassembled PDU]]
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 a reassembled PDU]]

5. The minimum amount of available buffer space is 5840 bytes (Window) in segment 2. The lack of receiver buffer space does not throttle the sender.

No.	Time	Source	Destination	Protocol	Length	Info
tcp.analysis.retransmission						
51	1.039820	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK, Seq=883061786 Ack=232162601 Win=62780 Len=0]
52	1.117097	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK, Seq=883061786 Ack=232162601 Win=62780 Len=0]
53	1.117333	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK, Seq=232162601 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]]

No.	Time	Source	Destination	Protocol	Length	Info
tcp.analysis.fast_retransmission						

6. No, there are no retransmitted segments. I used **tcp.analysis.retransmission** and **tcp.analysis.fast_retransmission** and neither yielded anything.

51	1.039820	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK, Seq=883061786 Ack=232162601 Win=62780 Len=0]
52	1.117097	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK, Seq=883061786 Ack=232162601 Win=62780 Len=0]
53	1.117333	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK, Seq=232162601 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]]

7. In an ACK, the receiver typically acknowledging 1460 bytes of data.
A case where the receiver is ACKing every other received segment is approximately segment 52.

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 a reassembled PDU]]
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 a reassembled PDU]]
6	0.053937	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK, Seq=883061786 Ack=232129578 Win=6780 Len=0]
7	0.054826	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK, Seq=232131038 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]]
8	0.054690	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK, Seq=232132498 Ack=883061786 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=883061786 Ack=232131038 Win=8760 Len=0]
10	0.077485	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK, Seq=232133958 Ack=883061786 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=232135418 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]]
12	0.124805	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK, Seq=883061786 Ack=232132498 Win=11680 Len=0]
13	0.124185	192.168.1.102	128.119.245.12	TCP	1781	1161 → 80 [PSH, ACK, Seq=232136878 Ack=883061786 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=883061786 Ack=232133958 Win=14600 Len=0]
15	0.217299	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK, Seq=883061786 Ack=232135418 Win=17520 Len=0]
16	0.267802	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK, Seq=883061786 Ack=232136878 Win=20440 Len=0]
17	0.304807	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK, Seq=883061786 Ack=232138025 Win=23360 Len=0]
18	0.305840	192.168.1.102	128.119.245.12	TCP	1514	1161 → 80 [ACK, Seq=232138025 Ack=883061786 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=232139485 Ack=883061786 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=232140945 Ack=883061786 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=232142405 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]]


```

[... tcp.analysis.lenr_ack ...]
Sequence Number: 232129013
[Next Sequence Number: 232129578]
Acknowledgment Number: 883061786
0101 .... = Header Length: 20 bytes (5)
Flags: 0x010 (PSH, ACK)
Window: 17520
[Calculated window size: 17520]
[Window size scaling factor: -2 (no window scaling used)]
Checksum: 0x1fbd [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0
[... Timestamps ...]
[Time since first frame in this TCP stream: 0.026477800 seconds]
[Time since previous frame in this TCP stream: 0.003212000 seconds]

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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)
206	5.651141	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=232293103 Ack=883062516 Win=16790 Len=0
213	7.595557	192.168.1.102	199.2.53.206	TCP	62	1162 → 631 [SYN] Seq=234862521 Win=16384 Len=0 MSS=1460 SACK_PERM=1


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00000000: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
[Stream index: 0]
[Conversation completeness: Incomplete, DATA (15)]
[TCP Segment Len: 0]
Sequence Number: 883061786
[Next Sequence Number: 883061786]
Acknowledgment Number: 232293103
0101 .... = Header Length: 20 bytes (5)
Flags: 0x010 (ACK)
Window: 62780
[Calculated window size: 62780]
[Window size scaling factor: -2 (no window scaling used)]
Checksum: 0x44a8 [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0
[Timestamps]
[Time since first frame in this TCP stream: 5.455830000 seconds]
[Time since previous frame in this TCP stream: 0.802043000 seconds]

```

8. Throughput = data (bytes) / transmission time (seconds)
data = 232293103 (bytes) – 232129013 (bytes) = 164090 (bytes)
transmission time = 5.45583 (seconds) – 0.026477 (seconds) = 5.429353 (seconds)
Therefore, Throughput = 164090 (bytes) / 5.429353 (seconds) = 30222.75 (bytes/second)

Exercise 2: TCP Connection Management

No	Source IP	Destination IP	Protocol	Info
295	10.9.16.201	10.99.6.175	TCP	50045 > 5000 [SYN] Seq=2818463618 win=8192 MSS=1460
296	10.99.6.175	10.9.16.201	TCP	5000 > 50045 [SYN, ACK] Seq=1247095790 Ack=2818463619 win=262144 MSS=1460
297	10.9.16.201	10.99.6.175	TCP	50045 > 5000 [ACK] Seq=2818463619 Ack=1247095791 win=65535
298	10.9.16.201	10.99.6.175	TCP	50045 > 5000 [PSH, ACK] Seq=2818463619 Ack=1247095791 win=65535
301	10.99.6.175	10.9.16.201	TCP	5000 > 50045 [ACK] Seq=1247095791 Ack=2818463652 win=262096
302	10.99.6.175	10.9.16.201	TCP	5000 > 50045 [PSH, ACK] Seq=1247095791 Ack=2818463652 win=262144
303	10.9.16.201	10.99.6.175	TCP	50045 > 5000 [ACK] Seq=2818463652 Ack=1247095831 win=65535
304	10.9.16.201	10.99.6.175	TCP	50045 > 5000 [FIN, ACK] Seq=2818463652 Ack=1247095831 win=65535
305	10.99.6.175	10.9.16.201	TCP	5000 > 50045 [FIN, ACK] Seq=1247095831 Ack=2818463652 win=262144
306	10.9.16.201	10.99.6.175	TCP	50045 > 5000 [ACK] Seq=2818463652 Ack=1247095832 win=65535
308	10.99.6.175	10.9.16.201	TCP	5000 > 50045 [ACK] Seq=1247095831 Ack=2818463653 win=262144

1. The sequence number is: 2818463618
2. The sequence number is: 1247095790
Value of acknowledgement field is: 2818463619
The server determined that value by adding 1 to the client sequence number.
3. The sequence number is: 2818463619
Value of acknowledgement field is: 1247095791
This segment does not contain any data since the sequence number is the same as the previous ACK.
4. The active close was done by both the client and the server. This can be seen as they sent FIN,ACK to each other, meaning it was simultaneous close.
5. Data Client to Server = $\text{Seq}_{304} - \text{Seq}_{295} - 1 = 2818463652 \text{ (bytes)} - 2818463618 \text{ (bytes)} = 33 \text{ (bytes)}$
Data Server to Client = $\text{Seq}_{305} - \text{Seq}_{296} - 1 = 1247095831 \text{ (bytes)} - 1247095790 \text{ (bytes)} = 40 \text{ (bytes)}$
Initial sequence number will be added with sent data to result in the final ACK which can be used to calculate the total data transmitted between the client and server.