

**University of Chicago Masters Program in Computer Science**



**Networks 54001**

**Winter 2021**

**Lab 3**

**Yi Nian, Jingjing Xiao, Mo Naveed**

We pledge our honor that we have not violated the University of Chicago code of ethics.

io.	Time	Source	Destination	Protocol	Length	Info
3269	2021-01-20 18:05:33.579620	128.139.245.12	128.139.245.12	TCP	68	80 → 58754 [ACK] Seq=14271917 Win=201728 Len=0 TSV=1347238071 TSecr=1118536361
3270	2021-01-20 18:05:33.579807	128.160.200.85	128.139.245.12	TCP	514	58754 → 80 [ACK] Seq=208369 Ack=131712 Len=0 TSV=1347238071 TSecr=1118536361 (TCP segment of a reassembled PDU)
3272	2021-01-20 18:05:33.579807	128.160.200.85	128.139.245.12	TCP	514	58754 → 80 [ACK] Seq=297557 Ack=131712 Len=4448 TSV=1118536360 TSecr=1347238071 (TCP segment of a reassembled PDU)
3273	2021-01-20 18:05:33.579808	128.160.200.85	128.139.245.12	TCP	514	58754 → 80 [ACK] Seq=297555 Ack=131712 Len=4448 TSV=1118536360 TSecr=1347238071 (TCP segment of a reassembled PDU)
3274	2021-01-20 18:05:33.579809	128.160.200.85	128.139.245.12	TCP	514	58754 → 80 [ACK] Seq=304543 Ack=131712 Len=4448 TSV=1118536360 TSecr=1347238071 (TCP segment of a reassembled PDU)
3275	2021-01-20 18:05:33.579809	128.160.200.85	128.139.245.12	TCP	514	58754 → 80 [ACK] Seq=301984 Ack=131712 Len=4448 TSV=1118536360 TSecr=1347238071 (TCP segment of a reassembled PDU)
3276	2021-01-20 18:05:33.579809	128.160.200.85	128.139.245.12	TCP	514	58754 → 80 [ACK] Seq=303349 Ack=131712 Len=4448 TSV=1118536360 TSecr=1347238071 (TCP segment of a reassembled PDU)
3277	2021-01-20 18:05:33.579809	128.160.200.85	128.139.245.12	TCP	447	POST /minishark-lab/lsmb-1-replay/MinH/TLS.1. (text/plain)
3281	2021-01-20 18:05:33.579866	128.139.245.12	128.160.200.85	HTTP	66	80 → 58754 [ACK] Seq=129365 Win=26848 Len=0 TSV=1347238074 TSecr=1118536364
3287	2021-01-20 18:05:33.596243	99.83.186.201	128.160.200.85	TLSv1.2	112	Application data
3288	2021-01-20 18:05:33.596244	99.83.186.201	128.160.200.85	TLSv1.2	97	Encrypted Alert
3289	2021-01-20 18:05:33.596291	128.160.200.85	99.83.186.201	TCP	66	58715 → 443 [ACK] Seq=4047 Win=2047 Len=0 TSV=1118537138 TSecr=568925273
3290	2021-01-20 18:05:33.596291	128.160.200.85	99.83.186.201	TCP	66	58715 → 443 [ACK] Seq=4078 Win=2048 Len=0 TSV=1118537138 TSecr=568925273
3291	2021-01-20 18:05:33.596411	128.160.200.85	99.83.186.201	TCP	66	58715 → 443 [FIN, ACK] Seq=4078 Win=2048 Len=0 TSV=1118537138 TSecr=568925273
3294	2021-01-20 18:05:33.596335	99.83.186.201	128.160.200.85	TCP	443	58715 (FIN, ACK) Seq=7081 Win=2008 Len=0 TSV=568925273 TSecr=1118524279
3303	2021-01-20 18:05:33.630434	128.139.245.12	128.160.200.85	TCP	68	80 → 58754 [ACK] Seq=14271917 Win=201728 Len=0 TSV=1347238071 TSecr=1118536361
3316	2021-01-20 18:05:33.630474	128.139.245.12	128.160.200.85	TCP	68	80 → 58754 [ACK] Seq=14271917 Win=201728 Len=0 TSV=1347238071 TSecr=1118536361
3317	2021-01-20 18:05:33.630476	128.139.245.12	128.160.200.85	TCP	68	80 → 58754 [ACK] Seq=14271917 Win=201728 Len=0 TSV=1347238071 TSecr=1118536361
3318	2021-01-20 18:05:33.630505	128.139.245.12	128.160.200.85	TCP	68	80 → 58754 [ACK] Seq=14271917 Win=201728 Len=0 TSV=1347238071 TSecr=1118536361
3319	2021-01-20 18:05:33.630478	128.139.245.12	128.160.200.85	TCP	68	80 → 58754 [ACK] Seq=14271917 Win=201728 Len=0 TSV=1347238071 TSecr=1118536361
3320	2021-01-20 18:05:33.630472	128.139.245.12	128.160.200.85	TCP	68	80 → 58754 [ACK] Seq=14271917 Win=201728 Len=0 TSV=1347238071 TSecr=1118536361
3321	2021-01-20 18:05:33.630480	128.139.245.12	128.160.200.85	TCP	68	80 → 58754 [ACK] Seq=14271917 Win=201728 Len=0 TSV=1347238071 TSecr=1118536361
3327	2021-01-20 18:05:33.640713	128.139.245.12	128.160.200.85	TCP	68	80 → 58754 [ACK] Seq=14271917 Win=201728 Len=0 TSV=1347238071 TSecr=1118536361
3328	2021-01-20 18:05:33.640746	128.139.245.12	128.160.200.85	TCP	68	80 → 58754 [ACK] Seq=14271917 Win=201728 Len=0 TSV=1347238071 TSecr=1118536361
3329	2021-01-20 18:05:33.652931	128.139.245.12	128.160.200.85	TCP	68	80 → 58754 [ACK] Seq=14271917 Win=201728 Len=0 TSV=1347238071 TSecr=1118536361
3330	2021-01-20 18:05:33.652933	128.139.245.12	128.160.200.85	TCP</		

```

.... 0000 .... = IG bit: Individual address (unicast)
Type: IPv4 (0x0000)
▼ Internet Protocol Version 4, Src: 192.168.200.85, Dst: 128.119.245.12
0100 .... = Version: 4
.... 0101 = Header Length: 20 bytes (5)
► Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
Total Length: 423
Identification: 0x0000 (0)
► Flags: 0x40, Don't fragment
Fragment Offset: 0
Time to Live: 64
Protocol: TCP (6)
Header Checksum: 0x3ac5 [validation disabled]
[Header checksum status: Unverified]
Source Address: 192.168.200.85
Destination Address: 128.119.245.12
► Transmission Control Protocol, Src Port: 50754, Dst Port: 80, Seq: 304777, Ack: 1, Len: 381
► [212 Reassembled TCP Segments (38517 bytes): #2827(716), #2828(1440), #2829(1440), #2860(1440), #2861(1440), #2862(1440), #2863(1440), #2864(1440), #2890(1440), #2891(1440), #2892(1440), #2893(1440), #2894(1440), #2895(1440), #2896(1440), ]
► Hypertext Transfer Protocol

```

**3. Skipped as per Professor's instructions.**

2792	2021-01-28 18:05:32.887928	192.168.200.85	128.110.245.12	TCP	78	50754 → 80 [SYN] Seq=0 Win=5335 Len=0 MSS=1460 WS=64 TSval=1118583811 TSecr=0 SACK_PERM=1
2793	2021-01-28 18:05:32.887966	192.168.200.85	128.110.245.12	TCP	78	50755 → 80 [SYN] Seq=0 Win=5335 Len=0 MSS=1460 WS=64 TSval=1118583811 TSecr=0 SACK_PERM=1
2823	2021-01-28 18:05:32.962645	128.110.245.12	192.168.200.85	TCP	74	80 → 50754 [SYN, ACK] Seq=0 Ack=1 Wlen=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=3472379658 TSecr=1118583811 WS=128
2824	2021-01-28 18:05:32.962647	128.110.245.12	192.168.200.85	TCP	74	80 → 50755 [SYN, ACK] Seq=0 Ack=1 Wlen=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=3472379660 TSecr=1118583811 WS=128
2825	2021-01-28 18:05:32.962700	192.168.200.85	128.110.245.12	TCP	66	50754 → 80 [ACK] Seq=1 Ack=1 Win=13172 Len=0 TSval=1118583808 TSecr=3472379658
2826	2021-01-28 18:05:32.962708	192.168.200.85	128.110.245.12	TCP	66	50755 → 80 [ACK] Seq=1 Ack=1 Win=13172 Len=0 TSval=1118583808 TSecr=3472379660
2827	2021-01-28 18:05:32.963089	192.168.200.85	128.110.245.12	TCP	782	50754 → 80 [PSH, Seq=1 Ack=1 Win=13172 Len=716 TSval=1118583808 TSecr=3472379658
2828	2021-01-28 18:05:32.963183	192.168.200.85	128.110.245.12	TCP	534	50754 → 80 [ACK] Seq=717 Ack=1 Win=13172 Len=448 TSval=1118583808 TSecr=3472379658
2829	2021-01-28 18:05:32.963184	192.168.200.85	128.110.245.12	TCP	1514	50754 → 80 [ACK] Seq=2165 Ack=1 Win=13172 Len=1448 TSval=1118583808 TSecr=3472379658
2830	2021-01-28 18:05:32.933966	192.168.200.85	128.110.245.12	TCP	66	80 → 50754 [ACK] Seq=1 Ack=717 Win=34864 Len=0 TSval=3472379735 TSecr=1118583808
2831	2021-01-28 18:05:32.933969	192.168.200.85	128.110.245.12	TCP	66	80 → 50754 [ACK] Seq=1 Ack=717 Win=34864 Len=0 TSval=3472379735 TSecr=1118583808
2868	2021-01-28 18:05:33.838568	192.168.200.85	128.110.245.12	TCP	1414	80 → 50754 [ACK] Seq=3073 Ack=1 Win=13173 Len=1448 TSval=1118583819 TSecr=3473767836
<b>PYTHON3 TCP SWI</b>						
Header Checksum: 8bc3c6 (validation disabled)						
[Header checksum status: Unverified]						
Source Address: 192.168.200.85						
Destination Address: 128.110.245.12						
▼ Transmission Control Protocol, Src Port: 50754, Dst Port: 80, Seq: 0, Len: 0						
Source Port: 50754						
Destination Port: 80						
(Stream index) 14:						
[TCP Segment Len: 0]						
Sequence Number: 0 (relative sequence number)						
Sequence Number (raw): 478992246						
[Next Sequence Number: 1 (relative sequence number)]						
Acknowledgment Number: 0						
Acknowledgment Number (raw): 0						
1011 ..... => Header Length: 44 bytes (11)						
▼ Flags: RST, URG						

Sequence number: 478062246

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?

No.	Time	Source	Destination	Protocol	Length	Info
2782	2021-01-28 18:05:32.887928	192.168.200.85	128.119.245.12	TCP	78	58754 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=64 TSval=1118583813 TSecr=0 SACK_PERM=1
2783	2021-01-28 18:05:32.887966	192.168.200.85	128.119.245.12	TCP	78	58755 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=64 TSval=1118583813 TSecr=0 SACK_PERM=1
2823	2021-01-28 18:05:32.962645	128.119.245.12	192.168.200.85	TCP	74	80 → 58755 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=3472379658 TSecr=1118583813 WS=128
2824	2021-01-28 18:05:32.962647	128.119.245.12	192.168.200.85	TCP	74	80 → 58755 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=3472379658 TSecr=1118583813 WS=128
2825	2021-01-28 18:05:32.962780	192.168.200.85	128.119.245.12	TCP	66	58754 → 80 [ACK] Seq=1 Ack=1 Win=131712 Len=0 TSval=1118583808 TSecr=3472379658
2826	2021-01-28 18:05:32.962788	192.168.200.85	128.119.245.12	TCP	66	58755 → 80 [ACK] Seq=1 Ack=1 Win=131712 Len=0 TSval=1118583808 TSecr=3472379658
2827	2021-01-28 18:05:32.963889	192.168.200.85	128.119.245.12	TCP	782	58754 → 80 [PSH, ACK] Seq=1 Ack=1 Win=131712 Len=716 TSval=1118583808 TSecr=3472379658
2828	2021-01-28 18:05:32.963183	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=717 Ack=1 Win=131712 Len=1448 TSval=1118583808 TSecr=3472379658
2829	2021-01-28 18:05:32.963184	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=2169 Ack=1 Win=131712 Len=1448 TSval=1118583808 TSecr=3472379658
2858	2021-01-28 18:05:33.839366	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Ack=717 Win=38464 Len=0 TSval=3472379735 TSecr=1118583808
2859	2021-01-28 18:05:33.839369	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Ack=3613 Win=38224 Len=0 TSval=3472379735 TSecr=1118583808

▼ Transmission Control Protocol, Src Port: 80, Dst Port: 58754, Seq: 8, Ack: 1, Len: 0

Source Port: 80  
Destination Port: 58754  
[Stream index: 14]  
[TCP Segment Len: 0]  
Sequence Number: 8 (relative sequence number)  
Sequence Number (raw): 3765877490  
[Next Sequence Number: 1 (relative sequence number)]  
Acknowledgment Number: 1 (relative ack number)  
Acknowledgment number (raw): 478062247  
1818 ... = Header Length: 40 bytes (10)

▼ Flags: 0x012 (SYN, ACK)

0000 ... = Reserved: Not set  
...0 ... = Nonce: Not set  
...R ... = Congestion Window Reduced (CWR): Not set  
...E ... = ECN-Echo: Not set  
...U ... = Urgent: Not set  
...I ... = Acknowledgment Set  
...R ... = Push: Not set  
...S ... = Reset: Not set  
...S ... = SYN: Set  
...R ... = FIN: Not set  
[TCP Flags: ...A-S-]  
Window: 28960  
[Calculated window size: 28960]  
[Checksum: 0x0000 (unverified)]

0020 c5 58 00 50 c6 42 e8 76 ba f2 1c 7e a6 a7 00 12 U-P-B-v

SYNACK Sequence Number: 478062246

Acknowledgement Field Value: 478062247

Determined by incrementing the original SYN sequence number by 1.

In the segment that identifies the segment as SYNACK, both Acknowledge and SYN have a value of “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.

No.	Time	Source	Destination	Protocol	Length	Info
2827	2021-01-28 18:05:32.963889	192.168.200.85	128.119.245.12	TCP	782	58754 → 80 [PSH, ACK] Seq=1 Ack=1 Win=131712 Len=716 TSval=1118583808 TSecr=3472379658
2828	2021-01-28 18:05:32.963183	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=717 Ack=1 Win=131712 Len=1448 TSval=1118583808 TSecr=3472379658
2829	2021-01-28 18:05:32.963184	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=2169 Ack=1 Win=131712 Len=1448 TSval=1118583808 TSecr=3472379658
2858	2021-01-28 18:05:33.839366	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Ack=717 Win=38464 Len=0 TSval=3472379735 TSecr=1118583808
2859	2021-01-28 18:05:33.839369	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Ack=3613 Win=38224 Len=0 TSval=3472379735 TSecr=1118583808

▼ Hypertext Transfer Protocol

POST / HTTP/1.1

Host: gaia.cs.umass.edu

Content-Length: 34448

Cache-Control: max-age=...

Segment No. 2827 contains the POST at sequence Number 478062247



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.

#### Sequence Numbers:

- Segment 1: 478062247
- Segment 2: 478062963
- Segment 3: 3765877491
- Segment 4: 478065859
- Segment 5: 478067307
- Segment 6: 3765877491

No.	Time	Source	Destination	Protocol	Length	Info
2789	7.239337	192.168.200.85	52.217.45.172	TCP	54	58722 → 443 [RST, ACK] Seq=2 Ack=1 Win=4095 Len=0
2792	7.239562	192.168.200.85	128.119.245.12	TCP	78	58754 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=64 TSval=1118583813 TSecr=0 SACK_PERM=1
2793	7.239680	192.168.200.85	128.119.245.12	TCP	78	58755 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=64 TSval=1118583813 TSecr=0 SACK_PERM=1
2823	7.314279	128.119.245.12	192.168.200.85	TCP	74	80 → 58754 [SYN, ACK] Seq=0 Ack=1 Win=28968 Len=0 MSS=1460 SACK_PERM=1 TSval=3472379658 TSecr=1118583813 WS=128
2824	7.314281	128.119.245.12	192.168.200.85	TCP	74	80 → 58755 [SYN, ACK] Seq=0 Ack=1 Win=28968 Len=0 MSS=1460 SACK_PERM=1 TSval=3472379660 TSecr=1118583813 WS=128
2825	7.314342	192.168.200.85	128.119.245.12	TCP	66	58754 → 80 [ACK] Seq=1 Ack=1 Win=131712 Len=0 TSval=1118583808 TSecr=3472379658
2826	7.314342	192.168.200.85	128.119.245.12	TCP	66	58755 → 80 [ACK] Seq=1 Ack=1 Win=131712 Len=0 TSval=1118583808 TSecr=3472379660
2827	7.314723	192.168.200.85	128.119.245.12	TCP	782	58754 → 80 [PSH, ACK] Seq=1 Ack=1 Win=131712 Len=716 TSval=1118583808 TSecr=3472379658 [TCP segment of a reassembled PDU]
2828	7.314817	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=717 Ack=1 Win=131712 Len=1448 TSval=1118583808 TSecr=3472379658 [TCP segment of a reassembled PDU]
2829	7.314818	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=2185 Ack=1 Win=131712 Len=1448 TSval=1118583808 TSecr=3472379658 [TCP segment of a reassembled PDU]
2858	7.391000	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Ack=717 Win=38464 Len=0 TSval=3472379735 TSecr=1118583808
2859	7.391003	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Ack=3613 Win=36224 Len=0 TSval=3472379735 TSecr=1118583808
2868	7.391084	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=3613 Ack=1 Win=131712 Len=1448 TSval=1118583163 TSecr=3472379735 [TCP segment of a reassembled PDU]
2861	7.391120	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=5861 Ack=1 Win=131712 Len=1448 TSval=1118583163 TSecr=3472379735 [TCP segment of a reassembled PDU]
2862	7.391121	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=6589 Ack=1 Win=131712 Len=1448 TSval=1118583163 TSecr=3472379735 [TCP segment of a reassembled PDU]
2863	7.391121	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=7957 Ack=1 Win=131712 Len=1448 TSval=1118583163 TSecr=3472379735 [TCP segment of a reassembled PDU]
2864	7.391122	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=9485 Ack=1 Win=131712 Len=1448 TSval=1118583163 TSecr=3472379735 [TCP segment of a reassembled PDU]
2889	7.467155	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Ack=18853 Win=58688 Len=0 TSval=3472379811 TSecr=1118583163
2898	7.467222	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=18853 Ack=1 Win=131712 Len=1448 TSval=1118583239 TSecr=3472379811 [TCP segment of a reassembled PDU]
2891	7.467222	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=12381 Ack=1 Win=131712 Len=1448 TSval=1118583239 TSecr=3472379811 [TCP segment of a reassembled PDU]
2892	7.467223	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=13749 Ack=1 Win=131712 Len=1448 TSval=1118583239 TSecr=3472379811 [TCP segment of a reassembled PDU]
2893	7.467223	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=15197 Ack=1 Win=131712 Len=1448 TSval=1118583239 TSecr=3472379811 [TCP segment of a reassembled PDU]
2894	7.467223	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=16645 Ack=1 Win=131712 Len=1448 TSval=1118583239 TSecr=3472379811 [TCP segment of a reassembled PDU]
2895	7.467224	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=18093 Ack=1 Win=131712 Len=1448 TSval=1118583239 TSecr=3472379811 [TCP segment of a reassembled PDU]
2896	7.467224	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=19541 Ack=1 Win=131712 Len=1448 TSval=1118583239 TSecr=3472379811 [TCP segment of a reassembled PDU]
2920	7.541239	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Ack=15197 Win=59392 Len=0 TSval=3472379884 TSecr=1118583239
2921	7.541292	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=28989 Ack=1 Win=131712 Len=1448 TSval=1118583313 TSecr=3472379884 [TCP segment of a reassembled PDU]
2922	7.541292	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=22437 Ack=1 Win=131712 Len=1448 TSval=1118583313 TSecr=3472379884 [TCP segment of a reassembled PDU]
2923	7.541293	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=23885 Ack=1 Win=131712 Len=1448 TSval=1118583313 TSecr=3472379884 [TCP segment of a reassembled PDU]

	Sent time	ACK time	RTT
Segment 1	7.314723	7.391000	0.076277
Segment 2	7.314817	7.391003	0.076186
Segment 3	7.314818	7.467155	0.152337
Segment 4	7.391084	7.541239	0.150155
Segment 5	7.391120	7.546749	0.155629
Segment 6	7.391121	7.616297	0.225176

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

Segment1 EstimateRTT = 0.076277

Segment2 EstimateRTT =  $0.875 \cdot 0.076277 + 0.125 \cdot 0.076186 = \mathbf{0.076266}$

Segment3 EstimateRTT =  $0.875 \cdot 0.076266 + 0.125 \cdot 0.152337 = \mathbf{0.085774}$

Segment4 EstimateRTT =  $0.875 \cdot 0.085774 + 0.125 \cdot 0.150155 = \mathbf{0.093822}$

Segment5 EstimateRTT =  $0.875 \cdot 0.093822 + 0.125 \cdot 0.155629 = \mathbf{0.084040}$

Segment6 EstimateRTT =  $0.875 \cdot 0.08404 + 0.125 \cdot 0.225176 = \mathbf{0.101682}$

The screenshot displays the Wireshark network protocol analyzer interface. The top bar shows the application is running on a Linux system. The main window is divided into three panes:

- Packet List:** Shows a list of captured packets. The first packet is a TCP segment from 192.168.200.85 to 128.119.245.12, sequence number 1, length 66. Subsequent packets show the establishment of the connection and data transfer.
- Packet Details:** Provides a hierarchical view of the selected packet (Packet 1). It shows the Ethernet II header, Internet Protocol Version 4 header, and Transmission Control Protocol header. The TCP header fields are expanded, showing source and destination ports, sequence number, and window size.
- Packet Bytes:** Displays the raw data of the selected packet in hexadecimal and ASCII. The first few bytes are shown, including the Ethernet II header and the start of the TCP segment.

The status bar at the bottom indicates the current capture is on the 'eth0' interface, showing 4077 packets, with 424 displayed and 0 dropped.

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

Segment 1: 716

Segment 2: 1448

Segment 3: 1448

Segment 4: 1448

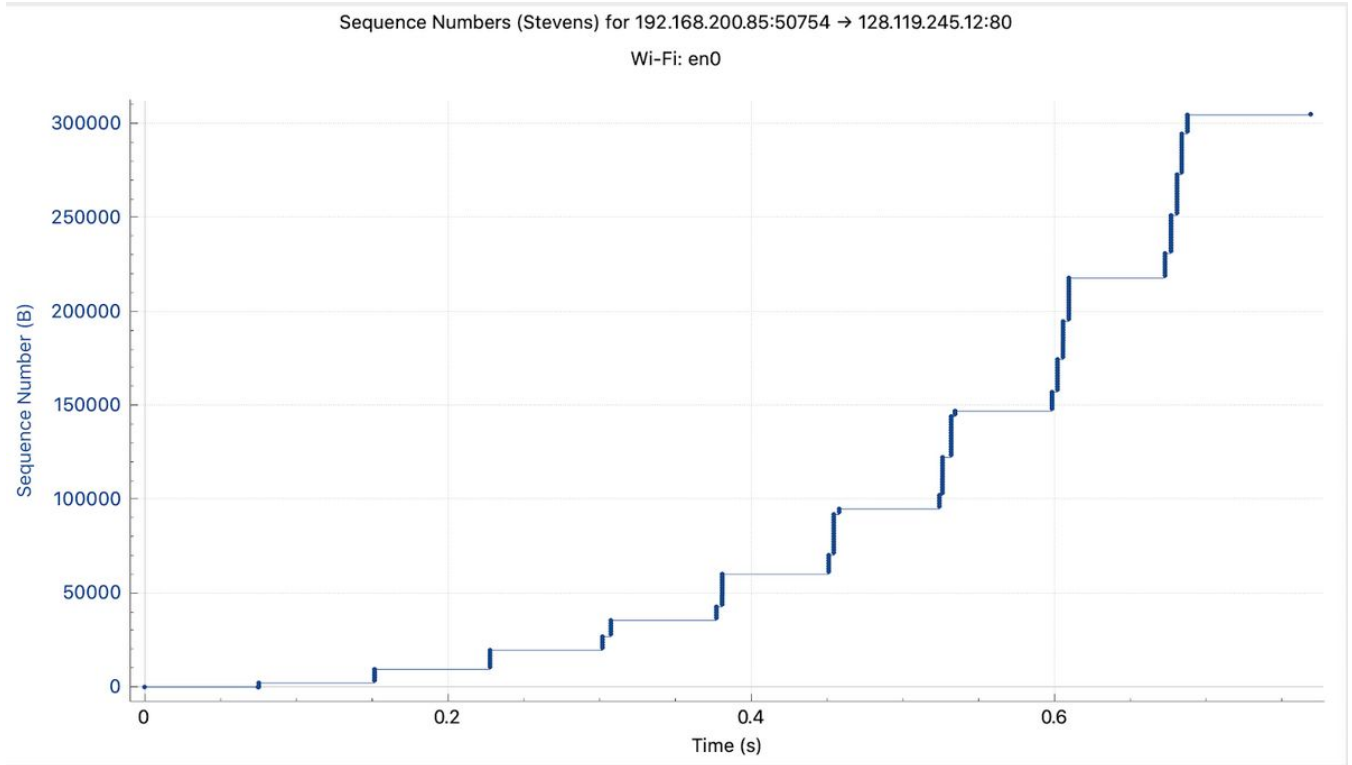
Segment 5: 1448

Segment 6: 1448

28960. No, the lack of receiver buffer space never throttles the sender.

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

There are no retransmitted segments because the sequence numbers only go up in the time sequence graph. For retransmitted segments, we'd expect the sequence numbers to vacillate over time (go down and then go up) as older segments are retransmitted.





**11. How much data does the receiver typically acknowledge in an ACK? Can you identify cases where the receiver is ACKing every other received segment (see Table 3.2 on page 250 in the text or slide 22 in Transmission Control Protocol)?**

The amount of data acknowledged in an ACK is the difference between consecutive ACK sequence numbers. I'm going to take 2 consecutive ACK sequence numbers:

No.	Time	Source	Destination	Protocol	Length	Info
3275	7.926723	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=381901 Ack=1 Win=11712 Len=1448 TSval=1118583698 TSecr=3472388271 (TCP segment of a reassembled PDU)
3276	7.926723	192.168.200.85	128.119.245.12	TCP	1514	58754 → 80 [ACK] Seq=383349 Ack=1 Win=11712 Len=1448 TSval=1118583698 TSecr=3472388271 (TCP segment of a reassembled PDU)
3277	7.926724	192.168.200.85	128.119.245.12	HTTP	447	POST /af/research-lab/1/ab3-1-engl-1.htm HTTP/1.1 (text/plain)
3281	7.930382	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=219365 Win=286848 Len=0 TSval=3472388274 TSecr=1118583614
3287	7.947877	99.83.186.201	192.168.200.85	TLSv1.2	112	Application Data
3288	7.947878	99.83.186.201	192.168.200.85	TLSv1.2	97	Encrypted Alert
3289	7.947925	192.168.200.85	99.83.186.201	TCP	66	58715 → 443 [ACK] Seq=1 Ack=47 Win=2847 Len=0 TSval=1118583710 TSecr=568925273
3290	7.947925	192.168.200.85	99.83.186.201	TCP	66	58715 → 443 [ACK] Seq=1 Ack=78 Win=2846 Len=0 TSval=1118583710 TSecr=568925273
3291	7.948845	192.168.200.85	99.83.186.201	TCP	66	58715 → 443 [FIN, ACK] Seq=78 Ack=78 Win=2846 Len=0 TSval=1118583718 TSecr=568925273
3294	7.949769	99.83.186.201	192.168.200.85	TCP	66	443 → 58715 [FIN, ACK] Seq=78 Ack=1 Win=2800 Len=0 TSval=568925273 TSecr=1118583711
3298	7.952088	99.83.186.201	192.168.200.85	TCP	66	443 → 58715 [ACK] Seq=78 Ack=2 Win=2800 Len=0 TSval=568925274 TSecr=1118583710
3313	7.997189	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=225983 Win=283648 Len=0 TSval=3472388311 TSecr=1118583677
3314	7.997118	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=223937 Win=281728 Len=0 TSval=3472388311 TSecr=1118583677
3317	7.998692	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=241885 Win=284672 Len=0 TSval=3472388335 TSecr=1118583681
3318	7.998694	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=246877 Win=280704 Len=0 TSval=3472388335 TSecr=1118583681
3319	8.001118	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=252500 Win=283648 Len=0 TSval=3472388338 TSecr=1118583684
3320	7.994186	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=257813 Win=283648 Len=0 TSval=3472388342 TSecr=1118583684
3321	7.997804	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=271493 Win=280704 Len=0 TSval=3472388342 TSecr=1118583684
3327	8.001347	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=274389 Win=280846 Len=0 TSval=3472388345 TSecr=1118583684
3328	8.001388	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=285973 Win=280704 Len=0 TSval=3472388345 TSecr=1118583687
3329	8.004050	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=288317 Win=280846 Len=0 TSval=3472388349 TSecr=1118583687
3330	8.004050	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=301981 Win=276688 Len=0 TSval=3472388349 TSecr=1118583687
3331	8.007917	128.119.245.12	192.168.200.85	TCP	66	80 → 58754 [ACK] Seq=1 Aca=305178 Win=286848 Len=0 TSval=3472388352 TSecr=1118583690
3332	8.007920	128.119.245.12	192.168.200.85	HTTP	843	HTTP/1.1 200 OK (text/html)
3334	8.007979	192.168.200.85	128.119.245.12	TCP	66	58754 → 80 [ACK] Seq=385178 Ack=778 Win=130944 Len=0 TSval=1118583767 TSecr=3472388352
3716	9.063187	198.251.236.228	192.168.200.85	TLSv1.2	145	Application Data
3719	9.063252	192.168.200.85	198.251.236.228	TCP	66	58380 → 443 [ACK] Seq=3883 Ack=1483 Win=2846 Len=0 TSval=1118584021 TSecr=3661738516
3726	9.078959	192.168.200.85	198.251.236.228	TLSv1.2	116	Application Data
3753	9.146779	198.251.236.228	192.168.200.85	TCP	66	443 → 58380 [ACK] Seq=1483 Ack=2933 Win=16 Len=0 TSval=3661738800 TSecr=1118584036

Source Address: 128.119.245.12  
Destination Address: 192.168.200.85  
Transmission Control Protocol, Src Port: 80, Dst Port: 58754, Seq: 1, Ack: 252669, Len: 0  
Source Port: 80  
Destination Port: 58754  
[Stream index: 14]  
[TCP Segment Len: 0]  
Sequence Number: 1 (relative sequence number)  
Sequence Number (raw): 290977492  
[Next Sequence Number: 1 (relative sequence number)]  
Acknowledgment Number: 252669 (relative ack number)  
Acknowledgment Number (raw): 421834855  
1000 .... = Header Length: 22 bytes (8)  
Flags: 0x018 (ACK)  
...0 .... = Reserved: Not set  
...0 .... = Nonce: Not set  
...0 .... = Congestion Window Reduced (CWR): Not set  
...0 .... = ECN-Echo: Not set

478319259 - 478314915 = 4344 bytes is the data received by the server between ACK 3319 and 3320.

No, we can not identify cases where the receiver is ACKing every other received segment.

**12. What is the throughput (bytes transferred per unit time) for the TCP connection? Explain how you calculated this value. TCP Congestion Control in Action**

Alice.txt is 304,278 bytes.

Download time: 8.007917 (Last ACK segment) - 7.314342 (first TCP segment) minus = 0.693575 seconds.

=304,278/0.693575 seconds = **438709.5844 bytes/second**

**13. 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.**

Based on the graph in 10, it seems TCP slow start begins around 0.075 seconds and ends a little after 0.2 seconds. It seems that congestion avoidance takes over at multiple points (0.55 seconds, 0.6 seconds, 0.63 seconds), when sequence numbers start incrementing rapidly. From an academic perspective, we should see an exponential graph. However, we are seeing a more graduated rise in sequence numbers, with periods of inactivity intermixed with periods where congestion avoidance takes over and sequence numbers rise dramatically in a short interval.