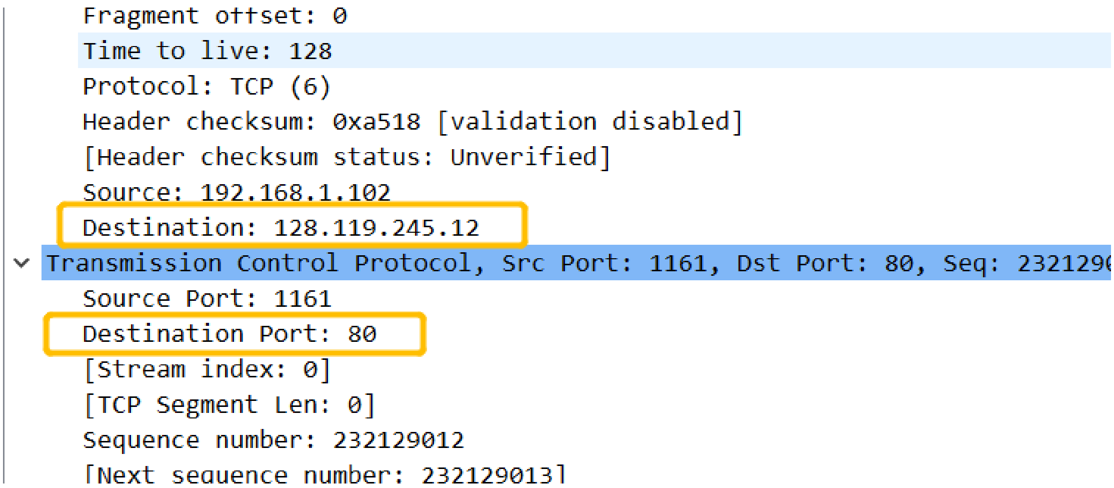
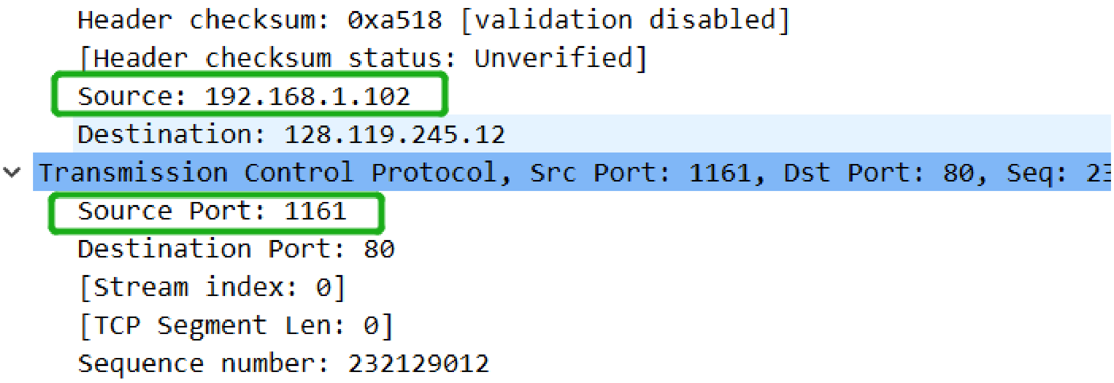
Exercise 1

Question 1 . What is the IP address of gaia.cs.umass.edu? On what port number is it sending and receiving TCP segments for this connection? 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?



```
    Fragment offset: 0
    Time to live: 128
    Protocol: TCP (6)
    Header checksum: 0xa518 [validation disabled]
    [Header checksum status: Unverified]
    Source: 192.168.1.102
    Destination: 128.119.245.12
v Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 232129
    Source Port: 1161
    Destination Port: 80
    [Stream index: 0]
    [TCP Segment Len: 0]
    Sequence number: 232129012
    [Next sequence number: 232129013]
```

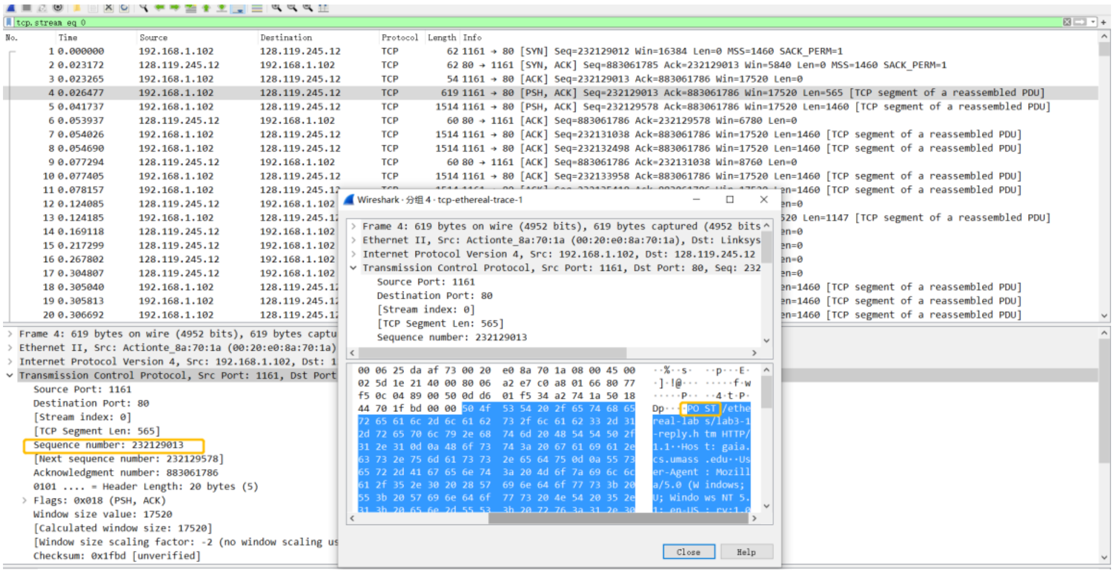
The IP address of gaia.cs.umass.edu is 128.119.245.12 and port number is 80 for this connection.



```
    Header checksum: 0xa518 [validation disabled]
    [Header checksum status: Unverified]
    Source: 192.168.1.102
    Destination: 128.119.245.12
v Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 2
    Source Port: 1161
    Destination Port: 80
    [Stream index: 0]
    [TCP Segment Len: 0]
    Sequence number: 232129012
```

The IP address and TCP port number used by the client computer (source) is 192.168.1.102 and 1161.

Question 2. 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
   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                                                            en=1460 [TCP segment of a reassembled PDU]
  12 0.124085   128.119.245.12  192.168.1.102                                                             en=0
  13 0.124185   192.168.1.102   128.119.245.12                                                            520 Len=1147 [TCP segment of a reassembled PDU]
  14 0.169118   128.119.245.12  192.168.1.102                                                             en=0
  15 0.217299   128.119.245.12  192.168.1.102                                                             en=0
  16 0.267802   128.119.245.12  192.168.1.102                                                             en=0
  17 0.304807   128.119.245.12  192.168.1.102                                                             en=0
  18 0.305040   192.168.1.102   128.119.245.12                                                            en=1460 [TCP segment of a reassembled PDU]
  19 0.305813   192.168.1.102   128.119.245.12                                                            en=1460 [TCP segment of a reassembled PDU]
  20 0.306692   192.168.1.102   128.119.245.12                                                            en=1460 [TCP segment of a reassembled PDU]
```

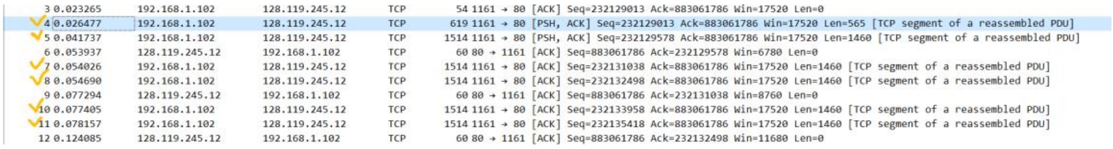
```
> Frame 4: 619 bytes on wire (4952 bits), 619 bytes captu
> Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a)
> Internet Protocol Version 4, Src: 192.168.1.102, Dst: 1
v Transmission Control Protocol, Src Port: 1161, Dst Port
    Source Port: 1161
    Destination Port: 80
    [Stream index: 0]
    [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 size value: 17520
    [Calculated window size: 17520]
    [Window size scaling factor: -2 (no window scaling us
    Checksum: 0x1fbd [unverified]
```

```
> Frame 4: 619 bytes on wire (4952 bits), 619 bytes captured (4952 bits
> Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a), Dst: Linksys
> Internet Protocol Version 4, Src: 192.168.1.102, Dst: 128.119.245.12
v Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 232
    Source Port: 1161
    Destination Port: 80
    [Stream index: 0]
    [TCP Segment Len: 565]
    Sequence number: 232129013
```

```
00 06 25 da af 73 00 20  e0 8a 70 1a 08 00 45 00   ··%··s·  ··p···E·
02 5d 1e 21 40 00 80 06  a2 e7 c0 a8 01 66 80 77   ·]·!@···  ·····f·w
f5 0c 04 89 00 50 0d d6  01 f5 34 a2 74 1a 50 18   ·····P··  ··4·t·P·
44 70 1f bd 00 00 50 4f  53 54 20 2f 65 74 68 65   Dp····PO ST /ethe
72 65 61 6c 2d 6c 61 62  73 2f 6c 61 62 33 2d 31   real-lab s/lab3-1
2d 72 65 70 6c 79 2e 68  74 6d 20 48 54 54 50 2f   -reply.h tm HTTP/
31 2e 31 0d 0a 48 6f 73  74 3a 20 67 61 69 61 2e   1.1··Hos t: gaia.
63 73 2e 75 6d 61 73 73  2e 65 64 75 0d 0a 55 73   cs.umass .edu··Us
65 72 2d 41 67 65 6e 74  3a 20 4d 6f 7a 69 6c 6c   er-Agent : Mozill
61 2f 35 2e 30 20 28 57  69 6e 64 6f 77 73 3b 20   a/5.0 (W indows;
55 3b 20 57 69 6e 64 6f  77 73 20 4e 54 20 35 2e   U; Windo ws NT 5.
```

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

Question 3. 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) sent from the client to the web server (Do not consider the ACKs received from the server as part of these six segments)? 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 relevant parts of Section 3.5 or lecture slides) after the receipt of each ACK? Assume that the initial value of *EstimatedRTT* is equal to the measured RTT (*SampleRTT*) for the first segment, and then is computed using the *EstimatedRTT* equation for all subsequent segments. Set alpha to 0.125.



```
   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
```

There are 4th ,5th ,7th ,8th ,10th and 11th .

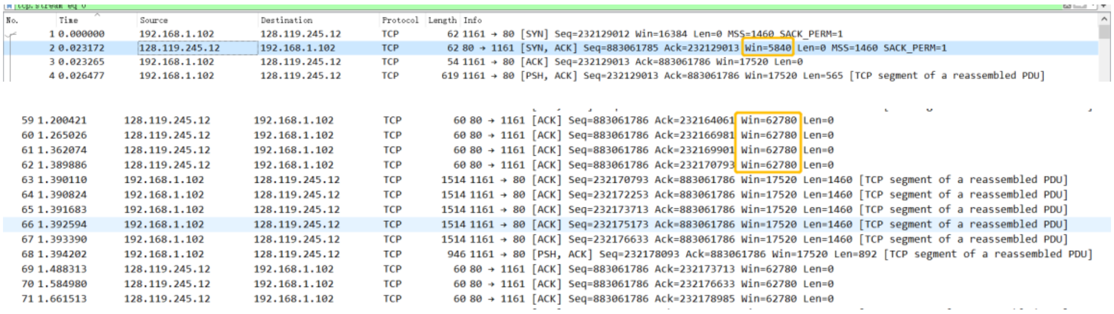
Sequence number	Sent time(s)	Time of Acks received(s)	RTT(s)	EstimatedRTT(s)
232129013	0.026477	0.53937	0.027460	0.027460000
232129578	0.041737	0.77294	0.035557	0.028472125
232131038	0.054026	0.124085	0.070059	0.03367048438

232132498	0.054690	0.169118	0.114428	0.04376517383
232133958	0.077405	0.217299	0.139894	0.0557812771
232135418	0.078157	0.267802	0.189645	0.07251424246

Question 4. What is the length of each of the first six TCP segments?

Sequence number	Length(bytes)
232129013	565
232129578	1460
232131038	1460
232132498	1460
232133958	1460
232135418	1460

Question 5. 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?

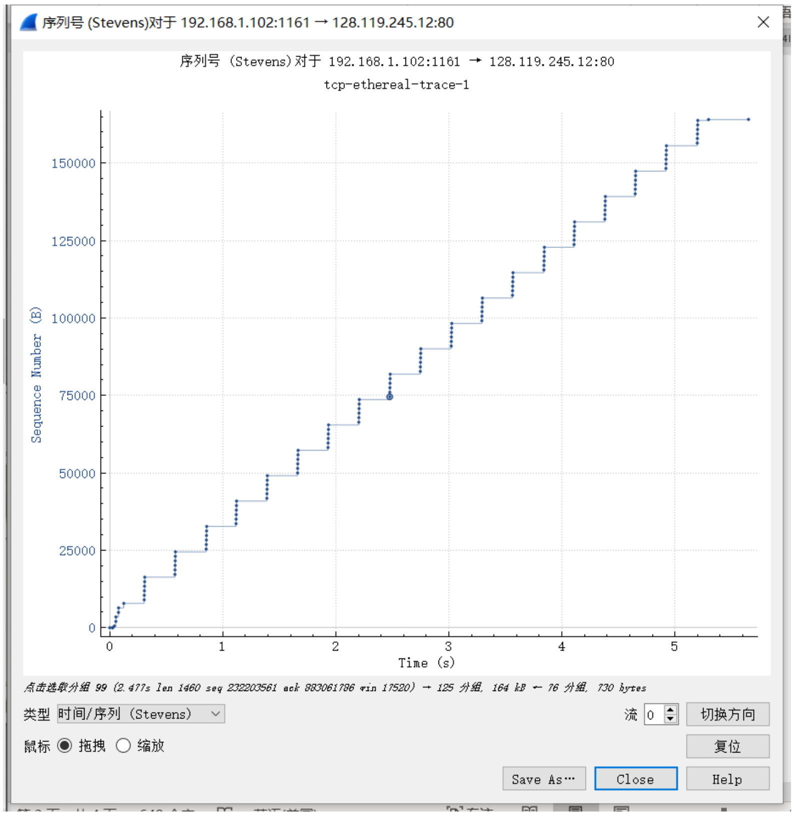


```
tcp.stream eq 0
No.   Time        Source            Destination       Protocol  Length Info
    1 0.000000    192.168.1.102     128.119.245.12    TCP         62 1161 → 80 [SYN] Seq=232129012 Win=16384 Len=0 MSS=1460 SACK_PERM=1
    2 0.023172    128.119.245.12    192.168.1.102     TCP         62 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]

  59 1.200421    128.119.245.12    192.168.1.102     TCP         60 80 → 1161 [ACK] Seq=883061786 Ack=232164061 Win=62780 Len=0
  60 1.265026    128.119.245.12    192.168.1.102     TCP         60 80 → 1161 [ACK] Seq=883061786 Ack=232166981 Win=62780 Len=0
  61 1.362074    128.119.245.12    192.168.1.102     TCP         60 80 → 1161 [ACK] Seq=883061786 Ack=232169901 Win=62780 Len=0
  62 1.389886    128.119.245.12    192.168.1.102     TCP         60 80 → 1161 [ACK] Seq=883061786 Ack=232170793 Win=62780 Len=0
  63 1.390110    192.168.1.102     128.119.245.12    TCP       1514 1161 → 80 [ACK] Seq=232170793 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
  64 1.390824    192.168.1.102     128.119.245.12    TCP       1514 1161 → 80 [ACK] Seq=232172253 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
  65 1.391683    192.168.1.102     128.119.245.12    TCP       1514 1161 → 80 [ACK] Seq=232173713 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
  66 1.392594    192.168.1.102     128.119.245.12    TCP       1514 1161 → 80 [ACK] Seq=232175173 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
  67 1.393390    192.168.1.102     128.119.245.12    TCP       1514 1161 → 80 [ACK] Seq=232176633 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
  68 1.394202    192.168.1.102     128.119.245.12    TCP        946 1161 → 80 [PSH, ACK] Seq=232178093 Ack=883061786 Win=17520 Len=892 [TCP segment of a reassembled PDU]
  69 1.488313    128.119.245.12    192.168.1.102     TCP         60 80 → 1161 [ACK] Seq=883061786 Ack=232173713 Win=62780 Len=0
  70 1.584980    128.119.245.12    192.168.1.102     TCP         60 80 → 1161 [ACK] Seq=883061786 Ack=232176633 Win=62780 Len=0
  71 1.661513    128.119.245.12    192.168.1.102     TCP         60 80 → 1161 [ACK] Seq=883061786 Ack=232178985 Win=62780 Len=0
```

The minimum amount of available buffer space advertised at the receiver for the entire trace is 5840 bytes and the maximum of that buffer space is 62780 bytes, so it is not likely to throttle the sender, because the buffer space is always bigger that the segment size.

Question 6. Are there any retransmitted segments in the trace file? What did you check for (in the trace) in order to answer this question?



序列号 (Stevens)对于 192.168.1.102:1161 → 128.119.245.12:80
序列号 (Stevens)对于 192.168.1.102:1161 → 128.119.245.12:80
tcp-ethereal-trace-1
Sequence Number (B)
150000
125000
100000
75000
50000
25000
0
0
1
2
3
4
5
Time (s)
切换方向
复位
Save As…
Close
Help

点击选取分组 99 (2.477s len 1460 seq 232203561 ack 883061786 win 17520) → 125 分组, 164 kB ← 76 分组, 730 bytes

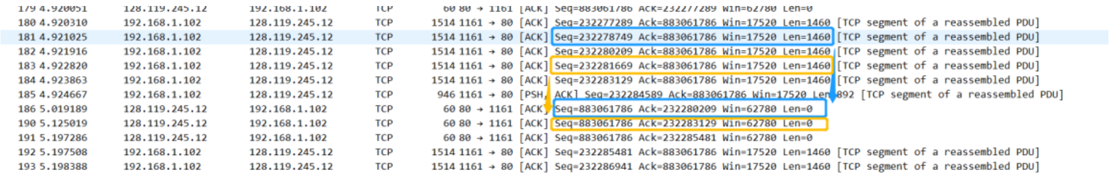
类型 时间/序列 (Stevens)

流 0

鼠标 ● 拖拽 ○ 缩放

According to this graph, we can see that there is no same sequence number with different time stamps, which means that no retransmit segments.

Question 7. How much data does the receiver typically acknowledge in an ACK? Can you identify cases where the receiver is ACKing every other received segment (recall the discussion about delayed acks from the lecture notes or Section 3.5 of the text).

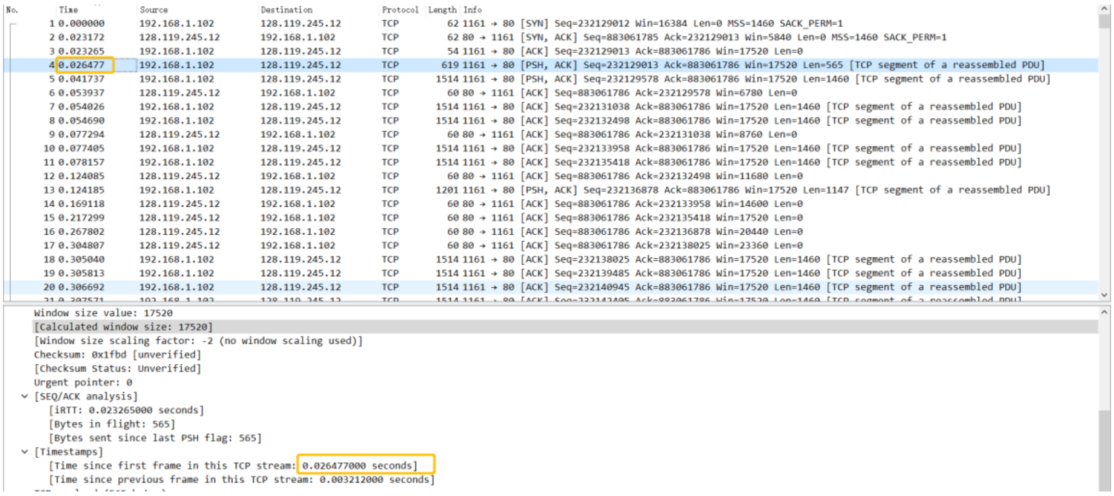


```
179 4.920051  128.119.245.12  192.168.1.102   TCP    60 80 → 1161 [ACK] Seq=883061786 Ack=232277289 Win=62780 Len=0
180 4.920310  192.168.1.102   128.119.245.12  TCP  1514 1161 → 80 [ACK] Seq=232277289 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
181 4.921025  192.168.1.102   128.119.245.12  TCP  1514 1161 → 80 [ACK] Seq=232278749 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
182 4.921916  192.168.1.102   128.119.245.12  TCP  1514 1161 → 80 [ACK] Seq=232280209 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
183 4.922820  192.168.1.102   128.119.245.12  TCP  1514 1161 → 80 [ACK] Seq=232281669 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
184 4.923863  192.168.1.102   128.119.245.12  TCP  1514 1161 → 80 [ACK] Seq=232283129 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
185 4.924667  192.168.1.102   128.119.245.12  TCP   946 1161 → 80 [PSH, ACK] Seq=232284589 Ack=883061786 Win=17520 Len=892 [TCP segment of a reassembled PDU]
186 5.019189  128.119.245.12  192.168.1.102   TCP    60 80 → 1161 [ACK] Seq=883061786 Ack=232280209 Win=62780 Len=0
190 5.125019  128.119.245.12  192.168.1.102   TCP    60 80 → 1161 [ACK] Seq=883061786 Ack=232283129 Win=62780 Len=0
191 5.197286  128.119.245.12  192.168.1.102   TCP    60 80 → 1161 [ACK] Seq=883061786 Ack=232285481 Win=62780 Len=0
192 5.197508  192.168.1.102   128.119.245.12  TCP  1514 1161 → 80 [ACK] Seq=232285481 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
193 5.198388  192.168.1.102   128.119.245.12  TCP  1514 1161 → 80 [ACK] Seq=232286941 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
```

The data that the receiver typically acknowledge in an ACK is 1460 bytes.

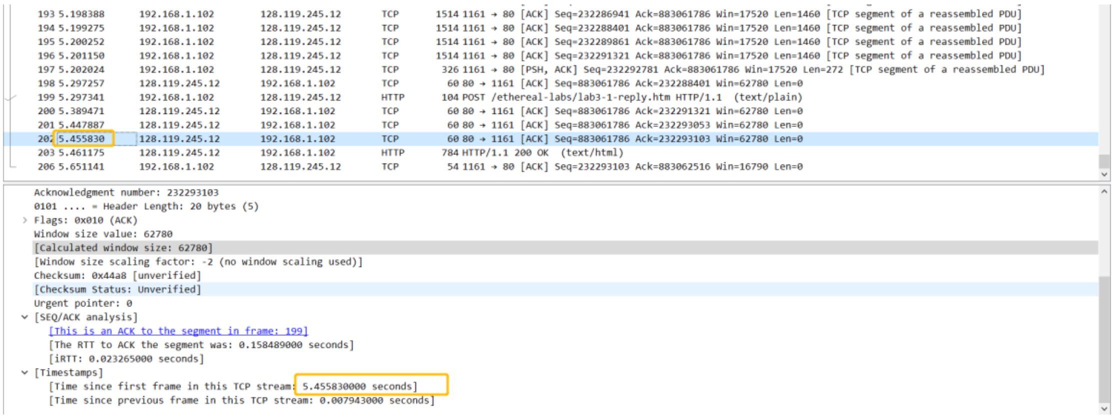
I can identify cases where the receiver is ACKing every other received segment, for example, as the above picture, 181st is acknowledged by 186th and 183rd is acknowledged by 190th

Question 8. What is the throughput (bytes transferred per unit time) for the TCP connection? Explain how you calculated this value.



```
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 0.304807   128.119.245.12   192.168.1.102    TCP       60 80 → 1161 [ACK] Seq=883061786 Ack=232138025 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]

    Window size value: 17520
    [Calculated window size: 17520]
    [Window size scaling factor: -2 (no window scaling used)]
    Checksum: 0x1fbd [unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
  ⌄ [SEQ/ACK analysis]
      [iRTT: 0.023265000 seconds]
      [Bytes in flight: 565]
      [Bytes sent since last PSH flag: 565]
  ⌄ [Timestamps]
      [Time since first frame in this TCP stream: 0.026477000 seconds]
      [Time since previous frame in this TCP stream: 0.003212000 seconds]
```



```
   193 5.198388   192.168.1.102    128.119.245.12   TCP     1514 1161 → 80 [ACK] Seq=232286941 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   194 5.199275   192.168.1.102    128.119.245.12   TCP     1514 1161 → 80 [ACK] Seq=232288401 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   195 5.200252   192.168.1.102    128.119.245.12   TCP     1514 1161 → 80 [ACK] Seq=232289861 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   196 5.201150   192.168.1.102    128.119.245.12   TCP     1514 1161 → 80 [ACK] Seq=232291321 Ack=883061786 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   197 5.202024   192.168.1.102    128.119.245.12   TCP      326 1161 → 80 [PSH, ACK] Seq=232292781 Ack=883061786 Win=17520 Len=272 [TCP segment of a reassembled PDU]
   198 5.297257   128.119.245.12   192.168.1.102    TCP       60 80 → 1161 [ACK] Seq=883061786 Ack=232288401 Win=62780 Len=0
   199 5.297341   192.168.1.102    128.119.245.12   HTTP     104 POST /ethereal-labs/lab3-1-reply.htm HTTP/1.1  (text/plain)
   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)
   206 5.651141   192.168.1.102    128.119.245.12   TCP       54 1161 → 80 [ACK] Seq=232293103 Ack=883062516 Win=16790 Len=0

    Acknowledgment number: 232293103
    0101 .... = Header Length: 20 bytes (5)
  > Flags: 0x010 (ACK)
    Window size value: 62780
    [Calculated window size: 62780]
    [Window size scaling factor: -2 (no window scaling used)]
    Checksum: 0x44a8 [unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
  ⌄ [SEQ/ACK analysis]
      [This is an ACK to the segment in frame: 199]
      [The RTT to ACK the segment was: 0.158489000 seconds]
      [iRTT: 0.023265000 seconds]
  ⌄ [Timestamps]
      [Time since first frame in this TCP stream: 5.455830000 seconds]
      [Time since previous frame in this TCP stream: 0.007943000 seconds]
```

Due to 203rd shows OK, from 4th to 202nd, we can get:

$$\text{total cost time} = 5.455830 - 0.026477 = 5.429353\text{sec}$$

hence,

$$\text{the number of bytes recevied} = 232293103 - 232129013 = 164090\text{bytes}$$

therefore, the throughput for the TCP connection is computed as:

$$\frac{164090 bytes}{5.429353\text{sec}} = 30222.75398 bytes/sec$$

Exercise 2

Question 1 . What is the sequence number of the TCP SYN segment that is used to initiate the TCP connection between the client computer and server?

The sequence number of the TCP SYN segment is 2818463618.

Question 2. What is the sequence number of the SYNACK segment sent by the server to the client computer in reply to the SYN? What is the value of the Acknowledgement field in the SYNACK segment? How did the server determine that value?

The sequence number of the SYNACK segment is 1247095790 and is the value of the Acknowledgement field in the SYNACK segment is 2818463619. the server determine that value by adding 1 to the last sequence numbers(initial serial number).

Question 3 . What is the sequence number of the ACK segment sent by the client computer in response to the SYNACK? What is the value of the Acknowledgment field in this ACK segment? Does this segment contain any data?

The sequence number of the ACK segment sent by the client computer in response to the SYNACK is 2818463619 and the value of the Acknowledgment field in this ACK segment is 1247095791.

Yes, this segment contain data because 301st ACK is 2818463652 and 298th Seq=2818463619, therefore it contains 2818463652-2818463619= 33 bytes data.

Question 4 . Who has done the active close? client or the server? how you have determined this? What type of closure has been performed? 3 Segment (FIN/FINACK/ACK), 4 Segment (FIN/ACK/FIN/ACK) or Simultaneous close?

Client and server both did the active close. I determined this by 304th and 305th, which both client and server generate the FIN segment before receiving it and the type of closure has been performed is Simultaneous close.

Question 5 . How many data bytes have been transferred from the client to the server and from the server to the client during the whole duration of the connection? What relationship does this have with the Initial Sequence Number and the final ACK received from the other side?

The data bytes have been transferred from the client to the server:

$$2818463652 - 2818463619 = 33\ bytes$$

The data bytes have been transferred from the server to the client:

$$1247095831 - 1247095791 = 40\ bytes$$

The ACK number can track the length of the data being transferred, so the final ACK obtained from the other side minus the initial sequence number is the size of data that has been transmitted.