

# Computer Networks Lab 5

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```
/tmp/wireshark_wlp660_20200428150903_DU47Mbps.pcapng 514 total packets, 439 shown

No.    Time           Source            Destination        Protocol Length Info
359    68.788426965    192.168.0.4       128.119.245.12     TCP              66      53278 -- 80 [ACK] Seq=1 Ack=1 Win=64256
Len=0 TSval=1886734169 TSecr=3498533228
Frame 359: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
Ethernet II, Src: AskeyCom_49:ad:62 (e8:d1:1b:49:ad:62), Dst: Technico_06:60:74 (b4:2a:0e:06:60:74)
Internet Protocol Version 4, Src: 192.168.0.4, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 53278, Dst Port: 80, Seq: 1, Ack: 1, Len: 0
Source Port: 53278
Destination Port: 80
[Stream index: 28]
[TCP Segment Len: 0]
Sequence number: 1 (relative sequence number)
[Next sequence number: 1 (relative sequence number)]
Acknowledgment number: 1 (relative ack number)
1000 .... = Header Length: 32 bytes (8)
Flags: 0x010 (ACK)
Window size value: 502
[Calculated window size: 64256]
[Window size scaling factor: 128]
Checksum: 0x3657 [unverified]
[Checksum Status: Unverified]
Urgent pointer: 0
Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
[SEQ/ACK analysis]
[Timestamps]
```

Figure 1: IP address and TCP port number used by the client computer

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?

According to figure 1, the IP address is 192.168.0.4 and the port number is 53278.

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?

According to figure 1, the destination IP is 128.119.245.12 and the destination port is 80.

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?

According to figure 1, the IP address is 192.168.0.4 and the port number is 53278.

## 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?

According to figure 2, the sequence number of the TCP SYN segment that is used to initiate the TCP connection is 0. This segment is identified by the SYN tag being set to 1.

```
/tmp/wireshark_wlp60_20200428150903_DU47Mb.pcapng 514 total packets, 439 shown

No.    Time            Source                Destination            Protocol Length Info
356 60.747999827  192.168.0.4          128.119.245.12        TCP 74 53278 -- 80 [SYN] Seq=0 Win=64240 Len=0
MSS=1460 SACK_PERM=1 TSval=1086734120 TSecr=0 WS=128
Frame 356: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface 0
Ethernet II, Src: AskeyCom_40:ad:62 (e8:d1:1b:49:ad:62), Dst: Technico_06:60:74 (b4:2a:0e:06:60:74)
Internet Protocol Version 4, Src: 192.168.0.4, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 53278, Dst Port: 80, Seq: 0, Len: 0
  Source Port: 53278
  Destination Port: 80
  [Stream index: 28]
  [TCP Segment Len: 0]
  Sequence number: 0 (relative sequence number)
  [Next sequence number: 0 (relative sequence number)]
  Acknowledgment number: 0 (relative ack number)
  1010 .... = Header Length: 40 bytes (10)
  Flags: 0x002 (SYN)
  Window size value: 64240
  [Calculated window size: 64240]
  Checksum: 0x365f (unverified)
  [Checksum Status: Unverified]
  Urgent pointer: 0
  Options: (20 bytes), Maximum segment size, SACK permitted, Timestamps, No-Operation (NOP), Window scale
  [Timestamps]
```

Figure 2: TCP SYN segment that is used to initiate the TCP connection

## 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?

According to figure 3, the sequence number of the SYNACK segment sent by gaia.cs.umass.edu to the client computer is 0. The value of the ACK is 1. This number is determined by adding 1 to the initial sequence number of the SYN segment from the client to the computer. The SYN flag and ACK flag are set to 1 and they indicate that this segment is an SYNACK segment.

```
/tmp/wireshark_wlp60_20200428150903_DU47Mb.pcapng 514 total packets, 439 shown

No.    Time            Source                Destination            Protocol Length Info
358 60.788411666  128.119.245.12        192.168.0.4          TCP 74 80 -- 53278 [SYN, ACK] Seq=0 Ack=1
Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=3498533228 TSecr=1086734120 WS=128
Frame 358: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface 0
Ethernet II, Src: Technico_06:60:74 (b4:2a:0e:06:60:74), Dst: AskeyCom_40:ad:62 (e8:d1:1b:49:ad:62)
Internet Protocol Version 4, Src: 128.119.245.12, Dst: 192.168.0.4
Transmission Control Protocol, Src Port: 80, Dst Port: 53278, Seq: 0, Ack: 1, Len: 0
  Source Port: 80
  Destination Port: 53278
  [Stream index: 28]
  [TCP Segment Len: 0]
  Sequence number: 0 (relative sequence number)
  [Next sequence number: 0 (relative sequence number)]
  Acknowledgment number: 1 (relative ack number)
  1010 .... = Header Length: 40 bytes (10)
  Flags: 0x012 (SYN, ACK)
  Window size value: 28960
  [Calculated window size: 28960]
  Checksum: 0xad88 (unverified)
  [Checksum Status: Unverified]
  Urgent pointer: 0
  Options: (20 bytes), Maximum segment size, SACK permitted, Timestamps, No-Operation (NOP), Window scale
  [SEQ/ACK analysis]
  [Timestamps]
```

Figure 3: SYNACK segment sent by gaia.cs.umass.edu

## 6

What is the sequence number of the TCP segment containing the HTTP POST command?

According to figure 4, the sequence number of the TCP segment containing the HTTP POST command is 149145.

```
/tmp/wireshark_wireshark_20200428150903_DU47Mh.pcapng 514 total packets, 439 shown

No.    Time                Source                Destination            Protocol Length Info
492 60.940888723 192.168.0.4          128.119.245.12        HTTP      283    POST /wireshark-labs/lab3-1-reply.htm
HTTP/1.1 (text/plain)
Frame 492: 283 bytes on wire (2264 bits), 283 bytes captured (2264 bits) on interface 0
Ethernet II, Src: Askeycom_49:ad:62 (e8:d1:1b:49:ad:62), Dst: Technico_06:60:74 (b4:2a:0e:06:60:74)
Internet Protocol Version 4, Src: 192.168.0.4, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 53278, Dst Port: 80, Seq: 149145, Ack: 1, Len: 217
  Source Port: 53278
  Destination Port: 80
  [Stream index: 28]
  [TCP Segment Len: 217]
  Sequence number: 149145 (relative sequence number)
  [Next sequence number: 149362 (relative sequence number)]
  Acknowledgment number: 1 (relative ack number)
  1600 .... = Header Length: 32 bytes (8)
  Flags: 0x018 (PSH, ACK)
  Window size value: 502
  [Calculated window size: 64256]
  [Window size scaling factor: 128]
  Checksum: 0x3730 [unverified]
  [Checksum Status: Unverified]
  Urgent pointer: 0
  Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
  [SEQ/ACK analysis]
  [Timestamps]
  TCP payload (217 bytes)
  TCP segment data (217 bytes)
[104 Reassembled TCP Segments (149361 bytes): #360(1448), #361(1448), #362(1448), #363(1448), #364(1448), #365(1448),
#366(1448), #367(1448), #368(1448), #369(1448), #371(1448), #372(1448), #374(1448), #375(1448), #377(1448), #378(1448),
#3]
Hypertext Transfer Protocol
MIME Multipart Media Encapsulation, Type: multipart/form-data, Boundary:
"-----d7716306d3578437781326740b7650"
```

Figure 4: Sequence number of the TCP segment containing the HTTP POST command

## 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 after the receipt of each ACK?

According to figure 5, the sequence numbers of the first 6 segments are 1, 579, 716, 2164, 3612, 5060. Figure 6 shows the send time, received (ACK) time and RTT.

The required formula is  $EstimatedRTT_s = 0.875 * EstimatedRTT + 0.125 * SampleRTT$ .

$$EstimatedRTT_1 = 0.0956$$

$$EstimatedRTT_2 = 0.0956$$

$$EstimatedRTT_3 = 0.0958$$

$$EstimatedRTT_4 = 0.0961$$

$$EstimatedRTT_5 = 0.0982$$

$$EstimatedRTT_6 = 0.1001$$

No.	Time	Source	Destination	Protocol	Length	Info
5	0.26960900	192.168.1.8	128.119.245.12	TCP	66	60706 > http [ACK] Seq=1 Ack=1 win=131760 Len=0 TSval=85
7	0.27142500	192.168.1.8	128.119.245.12	TCP	203	60706 > http [PSH, ACK] Seq=579 Ack=1 win=131760 Len=137
8	0.27179700	192.168.1.8	128.119.245.12	TCP	1514	60706 > http [ACK] Seq=716 Ack=1 win=131760 Len=1448 TSV
9	0.27179800	192.168.1.8	128.119.245.12	TCP	1514	60706 > http [ACK] Seq=2164 Ack=1 win=131760 Len=1448 TS
10	0.36693100	128.119.245.12	192.168.1.8	TCP	66	http > 60706 [ACK] Seq=1 Ack=579 win=7040 Len=0 TSval=22
11	0.36708100	192.168.1.8	128.119.245.12	TCP	1514	60706 > http [ACK] Seq=3612 Ack=1 win=131760 Len=1448 TS
12	0.36728900	128.119.245.12	192.168.1.8	TCP	66	http > 60706 [ACK] Seq=1 Ack=716 win=8192 Len=0 TSval=22
13	0.36861700	128.119.245.12	192.168.1.8	TCP	66	http > 60706 [ACK] Seq=1 Ack=2164 win=11008 Len=0 TSval=
14	0.36871100	192.168.1.8	128.119.245.12	TCP	1514	60706 > http [ACK] Seq=5060 Ack=1 win=131760 Len=1448 TS
Frame 6: 644 bytes on wire (5152 bits), 644 bytes captured (5152 bits) on interface 0						
Ethernet II, Src: Apple_1f:d4:56 (b8:e8:56:1f:d4:56), Dst: Tp-LinkT_f8:6d:f9 (a0:f3:c1:f8:6d:f9)						
Internet Protocol Version 4, Src: 192.168.1.8 (192.168.1.8), Dst: 128.119.245.12 (128.119.245.12)						
Transmission Control Protocol, Src Port: 60706 (60706), Dst Port: http (80), Seq: 1, Ack: 1, Len: 578						
Source port: 60706 (60706)						
Destination port: http (80)						
[Stream index: 0]						
Sequence number: 1 (relative sequence number)						
[Next sequence number: 579 (relative sequence number)]						
Acknowledgment number: 1 (relative ack number)						
Header length: 32 bytes						
Flags: 0x018 (PSH, ACK)						
000. .... = Reserved: Not set						
...0 .... = Nonce: Not set						
....0. .... = Congestion Window Reduced (CWR): Not set						
....0. .... = ECN-Echo: Not set						
0000	a0 f3 c1 f8 6d f9 b8 e8 56 1f d4 56 08 00 45 00	...m... V..V..E.				
0010	02 76 f6 5a 40 00 40 06 0a f3 c0 a8 01 08 80 77	..V28.8. ....w				
0020	f5 0c ed 22 00 50 1f e9 a7 e8 79 47 80 0a 80 18	...".P... ..YG....				
0030	20 2b bf 08 00 00 01 01 08 0a 05 16 f8 ee 86 ca	+..... ..				
0040	ee 56 50 4f 53 54 20 2f 77 69 72 65 73 68 61 72	..VPOST / wireshar				
0050	60 2d 6c 61 62 73 2f 6c 61 62 33 2d 31 2d 72 63	k-labs/1 ab3-1-re				
0060	70 6c 79 2e 68 74 6d 20 48 54 54 50 2f 31 2e 31	ply.htm HTTP/1.1				
0070	0d 0a 48 6f 73 74 3a 20 67 61 69 61 2e 63 73 2e	..Host: gaia.cs.				
0080	75 6d 61 73 73 2e 65 64 75 0d 0a 43 6f 6e 74 65	unass.ed u..Conte				
0090	6e 74 2d 54 79 70 65 3a 20 6d 75 6c 74 69 70 61	nt-type: multipa				
00a0	72 74 2f 66 6f 72 6d 2d 64 61 74 61 3b 20 62 6f	rt-form= data: hn				

Figure 5: First 6 segments

No.	Time	Source	Destination	Protocol	Length	Info
10	0.36693100	128.119.245.12	192.168.1.8	TCP	66	http > 60706 [ACK] Seq=1 Ack=579 win=7040 Len=0 TSval=22
11	0.36708100	192.168.1.8	128.119.245.12	TCP	1514	60706 > http [ACK] Seq=3612 Ack=1 win=131760 Len=1448 TS
12	0.36728900	128.119.245.12	192.168.1.8	TCP	66	http > 60706 [ACK] Seq=1 Ack=716 win=8192 Len=0 TSval=22
13	0.36861700	128.119.245.12	192.168.1.8	TCP	66	http > 60706 [ACK] Seq=1 Ack=2164 win=11008 Len=0 TSval=
14	0.36871100	192.168.1.8	128.119.245.12	TCP	1514	60706 > http [ACK] Seq=5060 Ack=1 win=131760 Len=1448 TS
15	0.36871200	192.168.1.8	128.119.245.12	TCP	1514	60706 > http [ACK] Seq=6508 Ack=1 win=131760 Len=1448 TS
16	0.36995200	128.119.245.12	192.168.1.8	TCP	66	http > 60706 [ACK] Seq=1 Ack=3612 win=13952 Len=0 TSval=
17	0.37006300	192.168.1.8	128.119.245.12	TCP	1514	60706 > http [ACK] Seq=7956 Ack=1 win=131760 Len=1448 TS
18	0.37006400	192.168.1.8	128.119.245.12	TCP	1514	60706 > http [ACK] Seq=9404 Ack=1 win=131760 Len=1448 TS
19	0.47996500	128.119.245.12	192.168.1.8	TCP	66	http > 60706 [ACK] Seq=1 Ack=5060 win=16896 Len=0 TSval=
20	0.48010500	192.168.1.8	128.119.245.12	TCP	1514	60706 > http [ACK] Seq=10852 Ack=1 win=131760 Len=1448 T
21	0.48010600	192.168.1.8	128.119.245.12	TCP	1514	60706 > http [ACK] Seq=12300 Ack=1 win=131760 Len=1448 T
22	0.48249200	128.119.245.12	192.168.1.8	TCP	66	http > 60706 [ACK] Seq=1 Ack=6508 win=19712 Len=0 TSval=
Frame 10: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0						
Ethernet II, Src: Tp-LinkT_f8:6d:f9 (a0:f3:c1:f8:6d:f9), Dst: Apple_1f:d4:56 (b8:e8:56:1f:d4:56)						
Internet Protocol Version 4, Src: 128.119.245.12 (128.119.245.12), Dst: 192.168.1.8 (192.168.1.8)						
Transmission Control Protocol, Src Port: http (80), Dst Port: 60706 (60706), Seq: 1, Ack: 579, Len: 0						
Source port: http (80)						
Destination port: 60706 (60706)						
[Stream index: 0]						
Sequence number: 1 (relative sequence number)						
Acknowledgment number: 579 (relative ack number)						
Header length: 32 bytes						
Flags: 0x010 (ACK)						
000. .... = Reserved: Not set						
...0 .... = Nonce: Not set						
.....0. .... = Congestion Window Reduced (CWR): Not set						

Figure 6: First 6 segments ACKs

	Sent time	ACK received time	RTT
Segment 1	0.271257000	0.366931000	0.095674
Segment 2	0.271425000	0.367289000	0.095864
Segment 3	0.271797000	0.368617000	0.09682
Segment 4	0.271798000	0.369952000	0.098154
Segment 5	0.367081000	0.479965000	0.112884
Segment 6	0.368711000	0.482492000	0.113781

Figure 7: Sending and receiving time of AKCs

## 8

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

According to figure 8, the legnth of the first 6 segments are 74, 74, 66, 1514, 1514, 1514.

```
/tmp/wireshark_wlp660_20200428150903_DU47Mb.pcapng 514 total packets, 439 shown

No.    Time           Source            Destination        Protocol Length Info
356 60.747999827 192.168.0.4       128.119.245.12    TCP               74      53278 -- 80 [SYN] Seq=0 Win=64240 Len=0
MSS=1460 SACK_PERM=1 TSval=1086734120 TSecr=0 WS=128
Frame 356: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface 0
Ethernet II, Src: AskeyCom_49:ad:62 (e8:d1:1b:49:ad:62), Dst: Technico_06:60:74 (b4:2a:0e:06:60:74)
Internet Protocol Version 4, Src: 192.168.0.4, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 53278, Dst Port: 80, Seq: 0, Len: 0
No.    Time           Source            Destination        Protocol Length Info
358 60.788411666 128.119.245.12    192.168.0.4       TCP               74      80 -- 53278 [SYN, ACK] Seq=0 Ack=1
Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=3498533228 TSecr=1086734120 WS=128
Frame 358: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface 0
Ethernet II, Src: Technico_06:60:74 (b4:2a:0e:06:60:74), Dst: AskeyCom_49:ad:62 (e8:d1:1b:49:ad:62)
Internet Protocol Version 4, Src: 128.119.245.12, Dst: 192.168.0.4
Transmission Control Protocol, Src Port: 80, Dst Port: 53278, Seq: 0, Ack: 1, Len: 0
No.    Time           Source            Destination        Protocol Length Info
359 60.788426985 192.168.0.4       128.119.245.12    TCP               66      53278 -- 80 [ACK] Seq=1 Ack=1 Win=64256
Len=0 TSval=1086734160 TSecr=3498533228
Frame 359: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
Ethernet II, Src: AskeyCom_49:ad:62 (e8:d1:1b:49:ad:62), Dst: Technico_06:60:74 (b4:2a:0e:06:60:74)
Internet Protocol Version 4, Src: 192.168.0.4, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 53278, Dst Port: 80, Seq: 1, Ack: 1, Len: 0
No.    Time           Source            Destination        Protocol Length Info
360 60.788530678 192.168.0.4       128.119.245.12    TCP               1514     53278 -- 80 [ACK] Seq=1 Ack=1 Win=64256
Len=1448 TSval=1086734160 TSecr=3498533228 [TCP segment of a reassembled PDU]
Frame 360: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits) on interface 0
Ethernet II, Src: AskeyCom_49:ad:62 (e8:d1:1b:49:ad:62), Dst: Technico_06:60:74 (b4:2a:0e:06:60:74)
Internet Protocol Version 4, Src: 192.168.0.4, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 53278, Dst Port: 80, Seq: 1, Ack: 1, Len: 1448
No.    Time           Source            Destination        Protocol Length Info
361 60.788536333 192.168.0.4       128.119.245.12    TCP               1514     53278 -- 80 [ACK] Seq=1449 Ack=1
Win=64256 Len=1448 TSval=1086734160 TSecr=3498533228 [TCP segment of a reassembled PDU]
Frame 361: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits) on interface 0
Ethernet II, Src: AskeyCom_49:ad:62 (e8:d1:1b:49:ad:62), Dst: Technico_06:60:74 (b4:2a:0e:06:60:74)
Internet Protocol Version 4, Src: 192.168.0.4, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 53278, Dst Port: 80, Seq: 1449, Ack: 1, Len: 1448
No.    Time           Source            Destination        Protocol Length Info
362 60.789999345 192.168.0.4       128.119.245.12    TCP               1514     53278 -- 80 [ACK] Seq=2897 Ack=1
Win=64256 Len=1448 TSval=1086734162 TSecr=3498533228 [TCP segment of a reassembled PDU]
Frame 362: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits) on interface 0
Ethernet II, Src: AskeyCom_49:ad:62 (e8:d1:1b:49:ad:62), Dst: Technico_06:60:74 (b4:2a:0e:06:60:74)
Internet Protocol Version 4, Src: 192.168.0.4, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 53278, Dst Port: 80, Seq: 2897, Ack: 1, Len: 1448
No.    Time           Source            Destination        Protocol Length Info
386 60.841468544 192.168.0.4       128.119.245.12    TCP               1514     53278 -- 80 [ACK] Seq=30409 Ack=1
Win=64256 Len=1448 TSval=1086734213 TSecr=3498533278 [TCP segment of a reassembled PDU]
Frame 386: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits) on interface 0
Ethernet II, Src: AskeyCom_49:ad:62 (e8:d1:1b:49:ad:62), Dst: Technico_06:60:74 (b4:2a:0e:06:60:74)
Internet Protocol Version 4, Src: 192.168.0.4, Dst: 128.119.245.12
Transmission Control Protocol, Src Port: 53278, Dst Port: 80, Seq: 30409, Ack: 1, Len: 1448
```

Figure 8: Length of each of the first six TCP segments

## 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?

According to figure 9, the minimum amount of available buffer space advertised at the received for the entire trace is 28960. Throughout the trace, the window grows until it reaches a max buffer size. Thus the sender is never throttled due to a lack of received buffer space.

```
/tmp/wireshark_wlp660_20200428150903_DU47Mb.pcapng 514 total packets, 439 shown

No.    Time           Source            Destination        Protocol Length Info
358 60.788411666 128.119.245.12    192.168.0.4       TCP               74      80 -- 53278 [SYN, ACK] Seq=0 Ack=1
Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=3498533228 TSecr=1086734120 WS=128
Frame 358: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface 0
Ethernet II, Src: Technico_06:60:74 (b4:2a:0e:06:60:74), Dst: AskeyCom_49:ad:62 (e8:d1:1b:49:ad:62)
Internet Protocol Version 4, Src: 128.119.245.12, Dst: 192.168.0.4
Transmission Control Protocol, Src Port: 80, Dst Port: 53278, Seq: 0, Ack: 1, Len: 0
Source Port: 80
Destination Port: 53278
[Stream index: 28]
[TCP Segment Len: 0]
Sequence number: 0 (relative sequence number)
[Next sequence number: 0 (relative sequence number)]
Acknowledgment number: 1 (relative ack number)
1010 ... = Header Length: 40 bytes (10)
Flags: 0x012 (SYN, ACK)
Window size value: 28960
[Calculated window size: 28960]
Checksum: 0xad88 [unverified]
[Checksum Status: Unverified]
Urgent pointer: 0
Options: (20 bytes), Maximum segment size, SACK permitted, Timestamps, No-Operation (NOP), Window scale
[SEQ/ACK analysis]
[Timestamps]
```

Figure 9: Minimum amount of available buffer space

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

According to figure 10, there are no retransmitted segments in the trace file. This can be checked by observing the sequence numbers of the TCP segments. All the sequence numbers increase monotonically with respect to time.

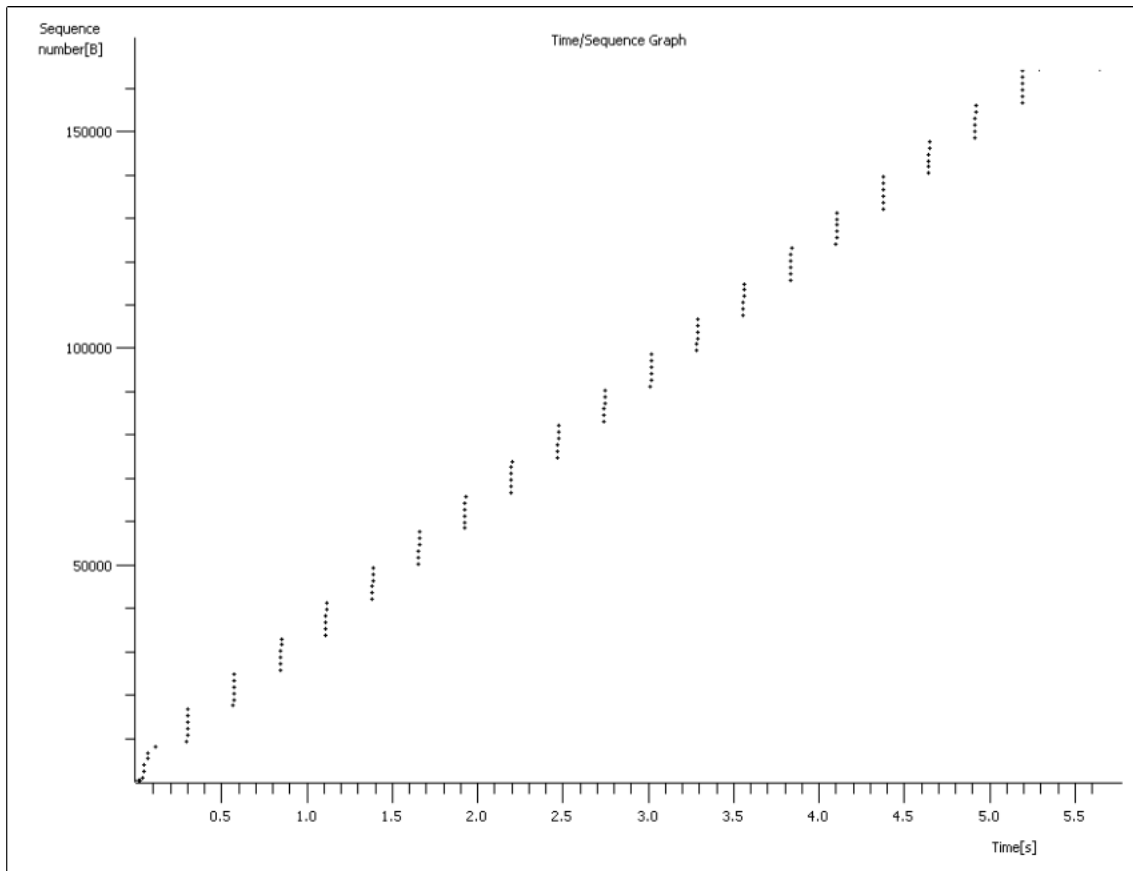


Figure 10: Time sequence graph

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).

The amount of data being transfered can be found by observing the difference of the sequence numbers. It typically acknowledges 1460. According to the table, there are instances where the receiver is ACKing every other segment.

	acknowledged number	acknowledged data
ACK 1	566	566
ACK 2	2026	1460
ACK 3	3486	1460
ACK 4	4946	1460
ACK 5	6406	1460
ACK 6	7866	1460
ACK 7	9013	1147
ACK 8	10473	1460
ACK 9	11933	1460
ACK 10	13393	1460
ACK 11	14853	1460
ACK 12	16313	1460

Figure 11: Table of ACK data

12

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

The throughput can be calculated by dividing the total data by the total time taken. The total data is determined by finding the difference of the first and last sequence number. According to figure 12, the total time taken is 60.987296150 – 60.788426905 = 0.19886924 and the difference of sequence numbers is 149362 – 1 = 149361. Thus the throughput is  $\frac{149361}{0.19886924} = 751051.2938049$ .

```

http://wireshark.wy660_0200428159903_014747Mb.pcapng:514 total packets, 439 shows
No.    Time    Source          Destination      Protocol Length Info
359 60.788426905 192.168.0.4     128.119.245.12  TCP        66      53278 → 80 [ACK] Seq=1 Win=64256
    Len=0 TSval=1086734160 TSecr=3498533228
    Frame 359: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
    Ethernet II, Src: AskeyCom_49:ad:62 (e8:d1:1b:49:ad:62), Dst: Technico_06:60:74 (b4:2a:9e:06:60:74)
    Internet Protocol Version 4, Src: 192.168.0.4, Dst: 128.119.245.12
    Transmission Control Protocol, Src Port: 53278, Dst Port: 80, Seq: 1, Ack: 1, Len: 0
    Source Port: 53278
    Destination Port: 80
    [Stream index: 26]
    [TCP Segment Len: 0]
    Sequence number: 1 (relative sequence number)
    [Next sequence number: 1 (relative sequence number)]
    Acknowledgment number: 1 (relative ack number)
    1000 .... = Header Length: 32 bytes [0]
    Flags: 0x010 (ACK)
    Window size value: 502
    [Calculated window size: 64256]
    [Window size scaling factor: 128]
    Checksum: 0x3057 [Unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
    Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
    [SEQ/ACK analysis]
    [Timestamps]
    [Time since first frame in this TCP stream: 0.040427078 seconds]
    [Time since previous frame in this TCP stream: 0.000015230 seconds]
514 60.987296150 192.168.0.4     128.119.245.12  TCP        66      53278 → 80 [ACK] Seq=149362 Ack=778
    Win=64128 Len=0 TSval=1086734359 TSecr=3498533427
    Frame 514: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
    Ethernet II, Src: AskeyCom_49:ad:62 (e8:d1:1b:49:ad:62), Dst: Technico_06:60:74 (b4:2a:9e:06:60:74)
    Internet Protocol Version 4, Src: 192.168.0.4, Dst: 128.119.245.12
    Transmission Control Protocol, Src Port: 53278, Dst Port: 80, Seq: 149362, Ack: 778, Len: 0
    Source Port: 53278
    Destination Port: 80
    [Stream index: 26]
    [TCP Segment Len: 0]
    Sequence number: 149362 (relative sequence number)
    [Next sequence number: 149362 (relative sequence number)]
    Acknowledgment number: 778 (relative ack number)
    1000 .... = Header Length: 32 bytes [0]
    Flags: 0x010 (ACK)
    Window size value: 561
    [Calculated window size: 64128]
    [Window size scaling factor: 128]
    Checksum: 0x3057 [Unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
    Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
    [SEQ/ACK analysis]
    [Timestamps]
    [Time since first frame in this TCP stream: 0.239296323 seconds]
    [Time since previous frame in this TCP stream: 0.000008080 seconds]
```

Figure 12: First and last packet data

## 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 slowstart 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.

According to figure 13, TCP appears to begin at 0.27 seconds and ends at 10.35 seconds. Congestion avoidance begins at about 0.7 seconds. We know this is occurring because there is a reduced quantity of packets being dispatched. We expect the sequence numbers to increase linearly. Here we can see that packets are sent in batches of 6, also, there is clearly non-linear behavior, especially at the start of the graph.

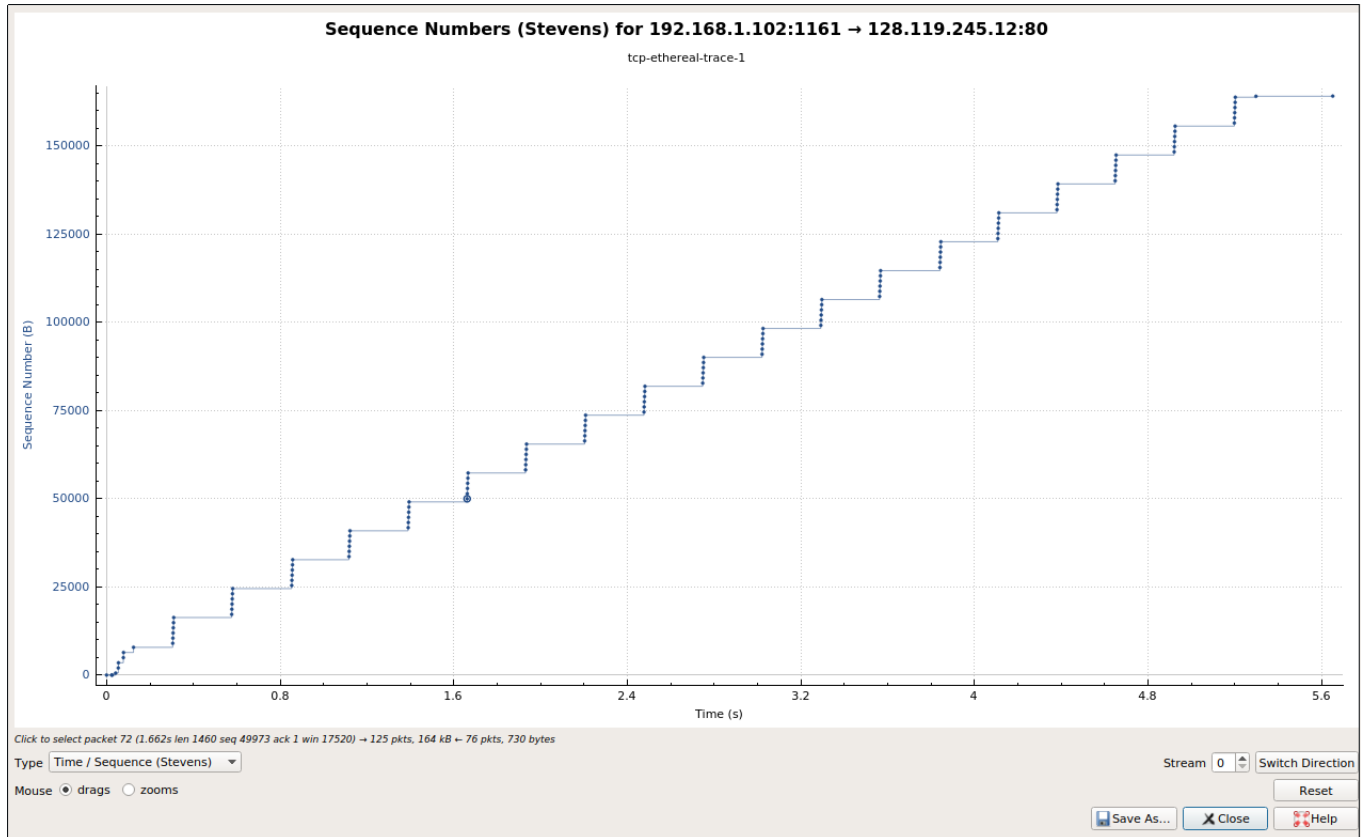


Figure 13: Time sequence graph



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.

According to figure 14, it appears to begin at 0.04 seconds and ends at 0.2 seconds. Congestion avoidance begins at 0.8 seconds when it begins changing the window size. This graph is more linear than the previous example with some gaps inbetween the batches. The ideal case is a perfectly linear graph.

According to figure 15, it appears to begin at 0.04 seconds and ends at 0.24 seconds. Congestion avoidance begins at about 0.9 seconds when the window size begins to increase. The figure does not resemble the ideal graph at all. It has large spikes of sequence numbers and the flattens with the next batch.

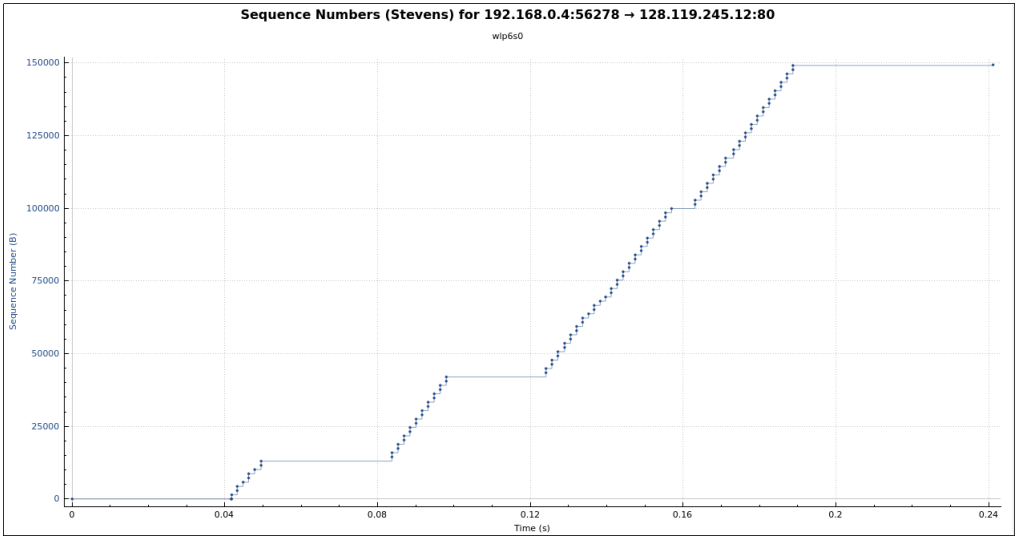


Figure 14: Time sequence graph

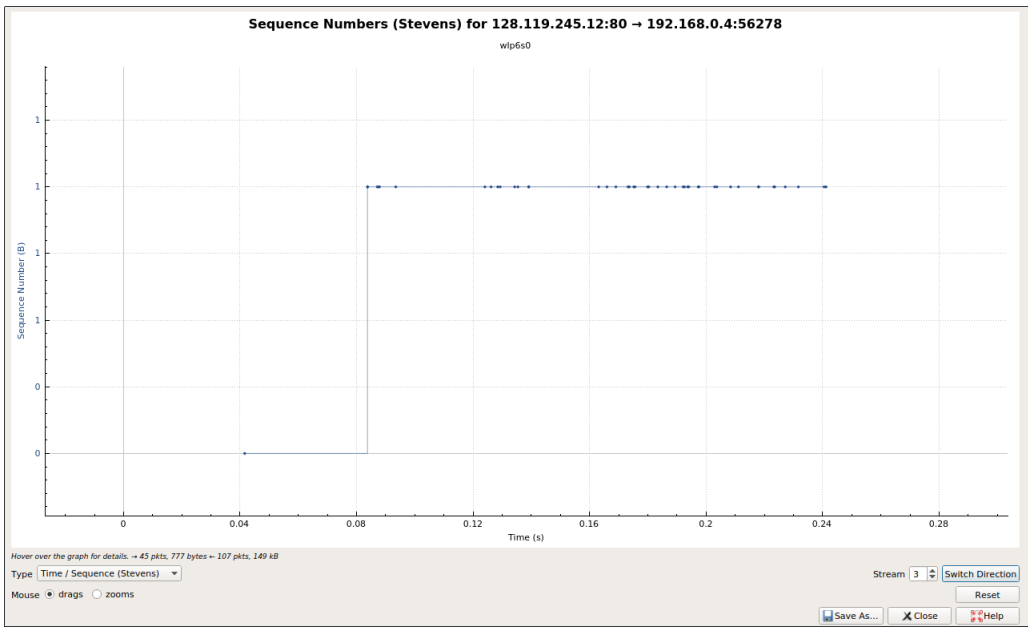


Figure 15: Time sequence graph