CSE – 5344 Lab 2

Submitted by:
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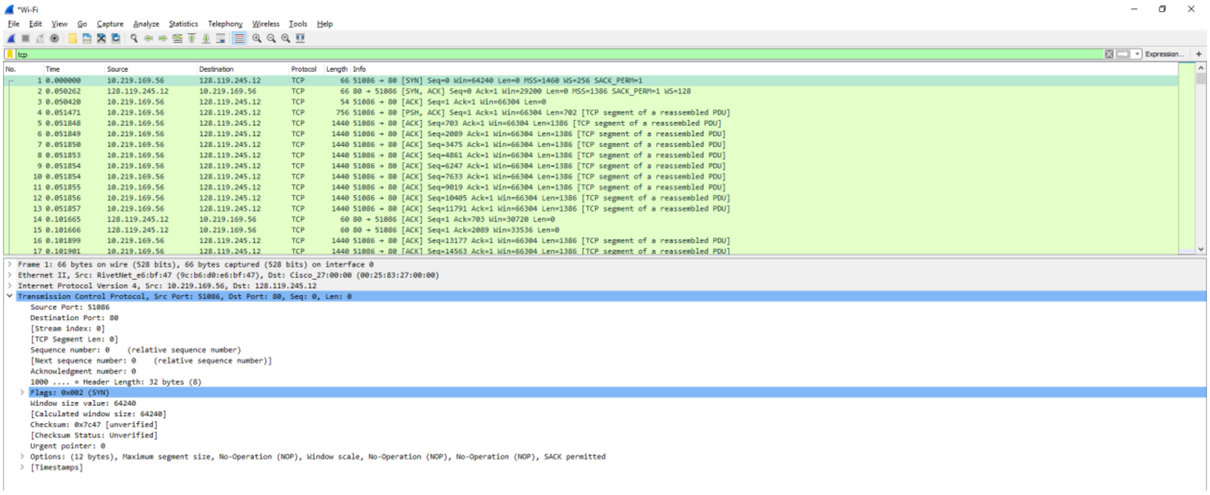
UTA ID – 1001505046

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?
   IP Address – 10.219.169.56
   TCP Port - 51086


*Wi-Fi
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
tcp
Expression…

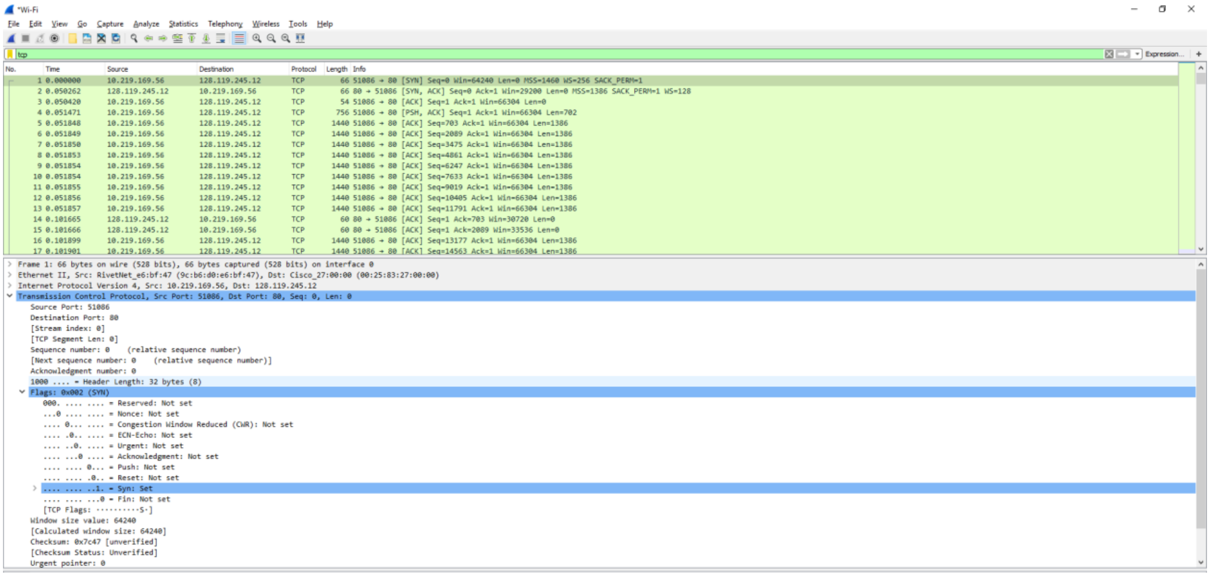
```
No.  Time      Source          Destination     Protocol Length Info
   1 0.000000  10.219.169.56   128.119.245.12  TCP        66 51086 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
   2 0.050262  128.119.245.12  10.219.169.56   TCP        66 80 → 51086 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1386 SACK_PERM=1 WS=128
   3 0.050420  10.219.169.56   128.119.245.12  TCP        54 51086 → 80 [ACK] Seq=1 Ack=1 Win=66304 Len=0
   4 0.051471  10.219.169.56   128.119.245.12  TCP       756 51086 → 80 [PSH, ACK] Seq=1 Ack=1 Win=66304 Len=702 [TCP segment of a reassembled PDU]
   5 0.051848  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=703 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
   6 0.051849  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=2089 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
   7 0.051850  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=3475 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
   8 0.051853  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=4861 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
   9 0.051854  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=6247 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
  10 0.051854  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=7633 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
  11 0.051855  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=9019 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
  12 0.051856  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=10405 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
  13 0.051857  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=11791 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
  14 0.101665  128.119.245.12  10.219.169.56   TCP        60 80 → 51086 [ACK] Seq=1 Ack=703 Win=30720 Len=0
  15 0.101666  128.119.245.12  10.219.169.56   TCP        60 80 → 51086 [ACK] Seq=1 Ack=2089 Win=33536 Len=0
  16 0.101899  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=13177 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
  17 0.101901  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=14563 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
```

```
> Frame 1: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
> Ethernet II, Src: RivetNet_e6:bf:47 (9c:b6:d0:e6:bf:47), Dst: Cisco_27:00:00 (00:25:83:27:00:00)
> Internet Protocol Version 4, Src: 10.219.169.56, Dst: 128.119.245.12
v Transmission Control Protocol, Src Port: 51086, Dst Port: 80, Seq: 0, Len: 0
    Source Port: 51086
    Destination Port: 80
    [Stream index: 0]
    [TCP Segment Len: 0]
    Sequence number: 0    (relative sequence number)
    [Next sequence number: 0    (relative sequence number)]
    Acknowledgment number: 0
    1000 .... = Header Length: 32 bytes (8)
  > Flags: 0x002 (SYN)
    Window size value: 64240
    [Calculated window size: 64240]
    Checksum: 0x7c47 [unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
  > Options: (12 bytes), Maximum segment size, No-Operation (NOP), Window scale, No-Operation (NOP), No-Operation (NOP), SACK permitted
  > [Timestamps]
```

2. What is the IP address of gaia.cs.umass.edu? On what port number is it sending and receiving TCP segments for this connection?
   IP Address – 128.119.245.12
   TCP Port - 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?
   IP Address – 10.219.169.56
   TCP Port - 51086

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?

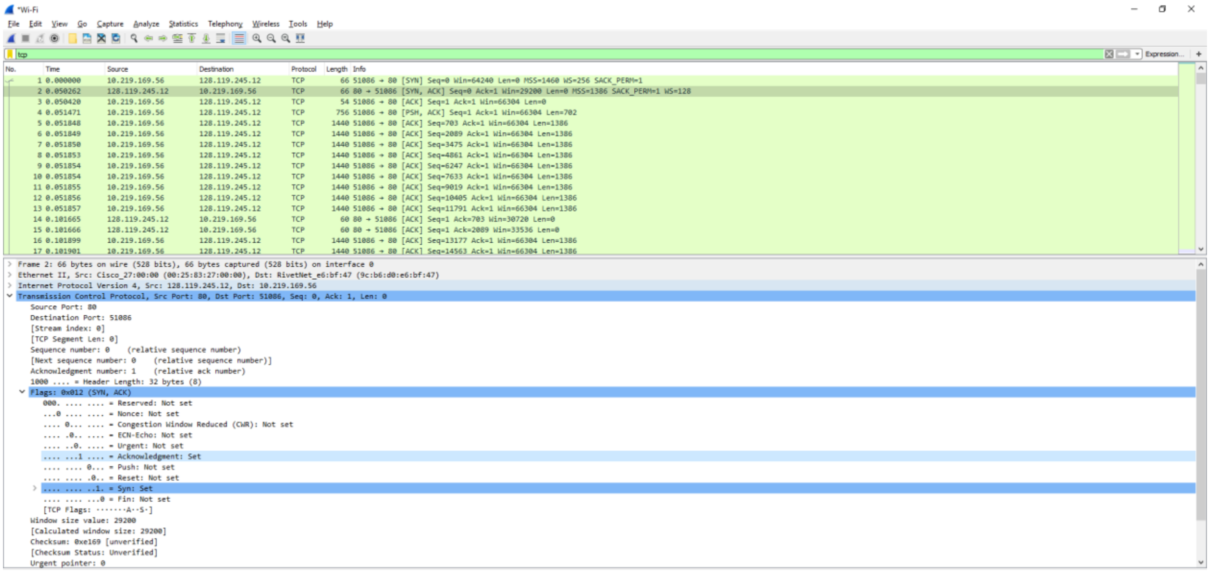

*Wi-Fi
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
tcp
Expression…

```
No.  Time      Source          Destination     Protocol Length Info
   1 0.000000  10.219.169.56   128.119.245.12  TCP        66 51086 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
   2 0.050262  128.119.245.12  10.219.169.56   TCP        66 80 → 51086 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1386 SACK_PERM=1 WS=128
   3 0.050420  10.219.169.56   128.119.245.12  TCP        54 51086 → 80 [ACK] Seq=1 Ack=1 Win=66304 Len=0
   4 0.051471  10.219.169.56   128.119.245.12  TCP       756 51086 → 80 [PSH, ACK] Seq=1 Ack=1 Win=66304 Len=702
   5 0.051848  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=703 Ack=1 Win=66304 Len=1386
   6 0.051849  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=2089 Ack=1 Win=66304 Len=1386
   7 0.051850  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=3475 Ack=1 Win=66304 Len=1386
   8 0.051853  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=4861 Ack=1 Win=66304 Len=1386
   9 0.051854  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=6247 Ack=1 Win=66304 Len=1386
  10 0.051854  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=7633 Ack=1 Win=66304 Len=1386
  11 0.051855  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=9019 Ack=1 Win=66304 Len=1386
  12 0.051856  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=10405 Ack=1 Win=66304 Len=1386
  13 0.051857  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=11791 Ack=1 Win=66304 Len=1386
  14 0.101665  128.119.245.12  10.219.169.56   TCP        60 80 → 51086 [ACK] Seq=1 Ack=703 Win=30720 Len=0
  15 0.101666  128.119.245.12  10.219.169.56   TCP        60 80 → 51086 [ACK] Seq=1 Ack=2089 Win=33536 Len=0
  16 0.101899  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=13177 Ack=1 Win=66304 Len=1386
  17 0.101901  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=14563 Ack=1 Win=66304 Len=1386
```

```
> Frame 1: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
> Ethernet II, Src: RivetNet_e6:bf:47 (9c:b6:d0:e6:bf:47), Dst: Cisco_27:00:00 (00:25:83:27:00:00)
> Internet Protocol Version 4, Src: 10.219.169.56, Dst: 128.119.245.12
v Transmission Control Protocol, Src Port: 51086, Dst Port: 80, Seq: 0, Len: 0
    Source Port: 51086
    Destination Port: 80
    [Stream index: 0]
    [TCP Segment Len: 0]
    Sequence number: 0    (relative sequence number)
    [Next sequence number: 0    (relative sequence number)]
    Acknowledgment number: 0
    1000 .... = Header Length: 32 bytes (8)
  v Flags: 0x002 (SYN)
      000. .... .... = Reserved: Not set
      ...0 .... .... = Nonce: Not set
      .... 0... .... = Congestion Window Reduced (CWR): Not set
      .... .0.. .... = ECN-Echo: Not set
      .... ..0. .... = Urgent: Not set
      .... ...0 .... = Acknowledgment: Not set
      .... .... 0... = Push: Not set
      .... .... .0.. = Reset: Not set
    > .... .... ..1. = Syn: Set
      .... .... ...0 = Fin: Not set
      [TCP Flags: ··········S·]
    Window size value: 64240
    [Calculated window size: 64240]
    Checksum: 0x7c47 [unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
```

Sequence Number – 0. The SYN flag is set to 1 which indicates that this segment is a SYN segment.

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?


*Wi-Fi
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
tcp
Expression...

```
No.   Time       Source            Destination       Protocol  Length Info
  1 0.000000   10.219.169.56     128.119.245.12    TCP         66 51086 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
  2 0.050262   128.119.245.12    10.219.169.56     TCP         66 80 → 51086 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1386 SACK_PERM=1 WS=128
  3 0.050420   10.219.169.56     128.119.245.12    TCP         54 51086 → 80 [ACK] Seq=1 Ack=1 Win=66304 Len=0
  4 0.051471   10.219.169.56     128.119.245.12    TCP        756 51086 → 80 [PSH, ACK] Seq=1 Ack=1 Win=66304 Len=702
  5 0.051848   10.219.169.56     128.119.245.12    TCP       1440 51086 → 80 [ACK] Seq=703 Ack=1 Win=66304 Len=1386
  6 0.051849   10.219.169.56     128.119.245.12    TCP       1440 51086 → 80 [ACK] Seq=2089 Ack=1 Win=66304 Len=1386
  7 0.051850   10.219.169.56     128.119.245.12    TCP       1440 51086 → 80 [ACK] Seq=3475 Ack=1 Win=66304 Len=1386
  8 0.051853   10.219.169.56     128.119.245.12    TCP       1440 51086 → 80 [ACK] Seq=4861 Ack=1 Win=66304 Len=1386
  9 0.051854   10.219.169.56     128.119.245.12    TCP       1440 51086 → 80 [ACK] Seq=6247 Ack=1 Win=66304 Len=1386
 10 0.051854   10.219.169.56     128.119.245.12    TCP       1440 51086 → 80 [ACK] Seq=7633 Ack=1 Win=66304 Len=1386
 11 0.051855   10.219.169.56     128.119.245.12    TCP       1440 51086 → 80 [ACK] Seq=9019 Ack=1 Win=66304 Len=1386
 12 0.051856   10.219.169.56     128.119.245.12    TCP       1440 51086 → 80 [ACK] Seq=10405 Ack=1 Win=66304 Len=1386
 13 0.051857   10.219.169.56     128.119.245.12    TCP       1440 51086 → 80 [ACK] Seq=11791 Ack=1 Win=66304 Len=1386
 14 0.101665   128.119.245.12    10.219.169.56     TCP         60 80 → 51086 [ACK] Seq=1 Ack=703 Win=30720 Len=0
 15 0.101666   128.119.245.12    10.219.169.56     TCP         60 80 → 51086 [ACK] Seq=1 Ack=2089 Win=33536 Len=0
 16 0.101899   10.219.169.56     128.119.245.12    TCP       1440 51086 → 80 [ACK] Seq=13177 Ack=1 Win=66304 Len=1386
 17 0.101901   10.219.169.56     128.119.245.12    TCP       1440 51086 → 80 [ACK] Seq=14563 Ack=1 Win=66304 Len=1386
```

```
> Frame 2: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
> Ethernet II, Src: Cisco_27:00:00 (00:25:83:27:00:00), Dst: RivetNet_e6:bf:47 (9c:b6:d0:e6:bf:47)
> Internet Protocol Version 4, Src: 128.119.245.12, Dst: 10.219.169.56
v Transmission Control Protocol, Src Port: 80, Dst Port: 51086, Seq: 0, Ack: 1, Len: 0
    Source Port: 80
    Destination Port: 51086
    [Stream index: 0]
    [TCP Segment Len: 0]
    Sequence number: 0    (relative sequence number)
    [Next sequence number: 0    (relative sequence number)]
    Acknowledgment number: 1    (relative ack number)
    1000 .... = Header Length: 32 bytes (8)
  v Flags: 0x012 (SYN, ACK)
      000. .... .... = Reserved: Not set
      ...0 .... .... = Nonce: Not set
      .... 0... .... = Congestion Window Reduced (CWR): Not set
      .... .0.. .... = ECN-Echo: Not set
      .... ..0. .... = Urgent: Not set
      .... ...1 .... = Acknowledgment: Set
      .... .... 0... = Push: Not set
      .... .... .0.. = Reset: Not set
    > .... .... ..1. = Syn: Set
      .... .... ...0 = Fin: Not set
      [TCP Flags: ·······A··S·]
    Window size value: 29200
    [Calculated window size: 29200]
    Checksum: 0xe169 [unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
```

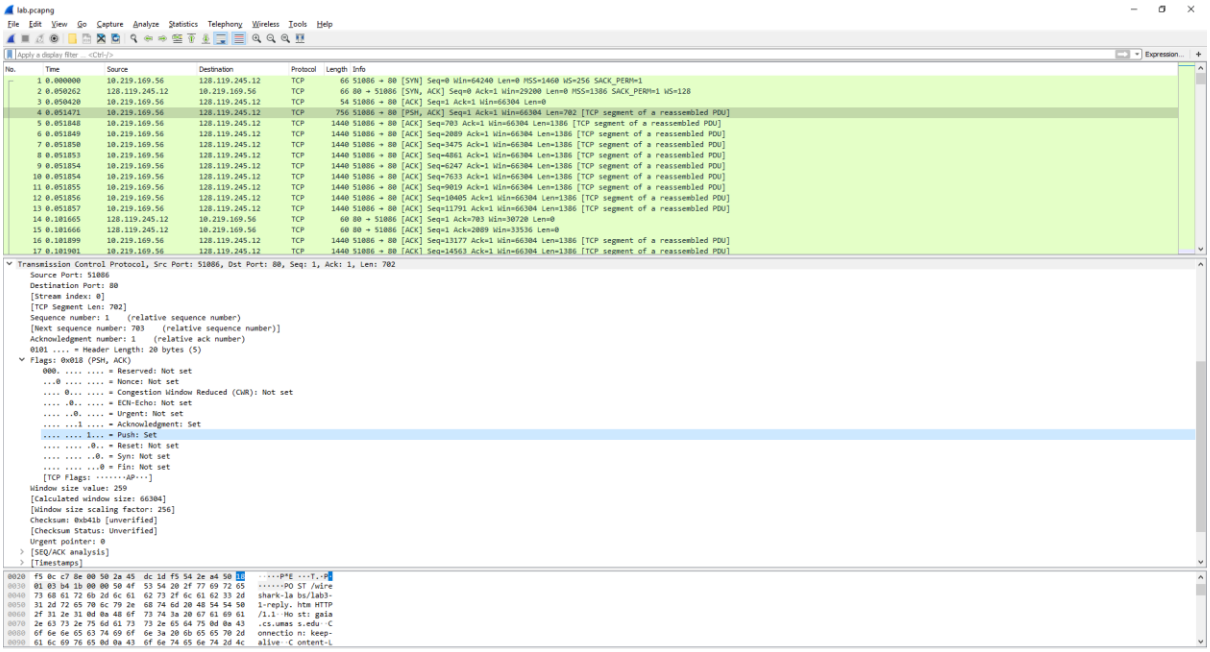
Sequence Number – 0

Acknowledgement field – 1

The value was determined by adding 1 to the initial sequence number of SYN segment (0) from the client computer.

The SYN flag and Acknowledgement flag in the segment are set to 1 which indicate that this segment is a SYNACK segment.

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.


lab.pcapng
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>
Expression...

```
No.  Time      Source          Destination     Protocol Length Info
   1 0.000000  10.219.169.56   128.119.245.12  TCP        66 51086 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
   2 0.050262  128.119.245.12  10.219.169.56   TCP        66 80 → 51086 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1386 SACK_PERM=1 WS=128
   3 0.050420  10.219.169.56   128.119.245.12  TCP        54 51086 → 80 [ACK] Seq=1 Ack=1 Win=66304 Len=0
   4 0.051471  10.219.169.56   128.119.245.12  TCP       756 51086 → 80 [PSH, ACK] Seq=1 Ack=1 Win=66304 Len=702 [TCP segment of a reassembled PDU]
   5 0.051848  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=703 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
   6 0.051849  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=2089 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
   7 0.051850  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=3475 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
   8 0.051853  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=4861 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
   9 0.051854  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=6247 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
  10 0.051854  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=7633 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
  11 0.051855  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=9019 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
  12 0.051856  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=10405 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
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  14 0.101665  128.119.245.12  10.219.169.56   TCP        60 80 → 51086 [ACK] Seq=1 Ack=703 Win=30720 Len=0
  15 0.101666  128.119.245.12  10.219.169.56   TCP        60 80 → 51086 [ACK] Seq=1 Ack=2089 Win=33536 Len=0
  16 0.101899  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=13177 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
  17 0.101901  10.219.169.56   128.119.245.12  TCP      1440 51086 → 80 [ACK] Seq=14563 Ack=1 Win=66304 Len=1386 [TCP segment of a reassembled PDU]
```

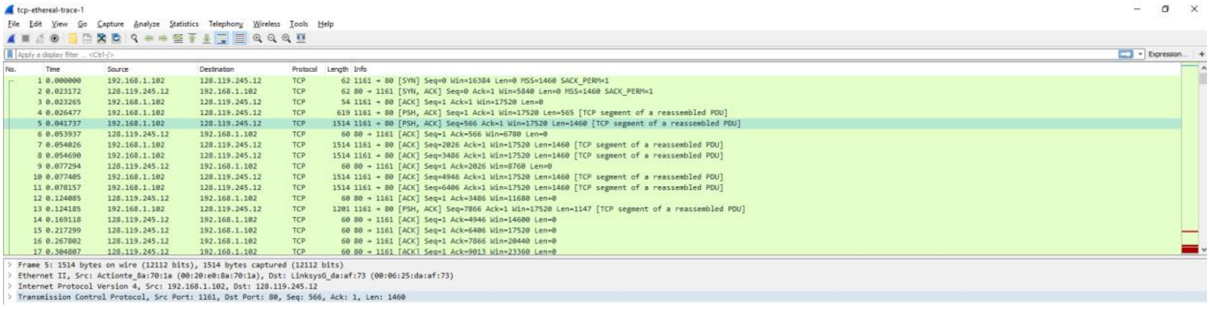
```
Transmission Control Protocol, Src Port: 51086, Dst Port: 80, Seq: 1, Ack: 1, Len: 702
    Source Port: 51086
    Destination Port: 80
    [Stream index: 0]
    [TCP Segment Len: 702]
    Sequence number: 1    (relative sequence number)
    [Next sequence number: 703    (relative sequence number)]
    Acknowledgment number: 1    (relative ack number)
    0101 .... = Header Length: 20 bytes (5)
    Flags: 0x018 (PSH, ACK)
        000. .... .... = Reserved: Not set
        ...0 .... .... = Nonce: Not set
        .... 0... .... = Congestion Window Reduced (CWR): Not set
        .... .0.. .... = ECN-Echo: Not set
        .... ..0. .... = Urgent: Not set
        .... ...1 .... = Acknowledgment: Set
        .... .... 1... = Push: Set
        .... .... .0.. = Reset: Not set
        .... .... ..0. = Syn: Not set
        .... .... ...0 = Fin: Not set
        [TCP Flags: ·······AP···]
    Window size value: 259
    [Calculated window size: 66304]
    [Window size scaling factor: 256]
    Checksum: 0xb41b [unverified]
    [Checksum Status: Unverified]
    Urgent pointer: 0
  > [SEQ/ACK analysis]
  > [Timestamps]
```

```
0020  f5 0c c7 8e 00 50 2a 45  dc 1d f5 54 2e a4 50 18   ·····P*E ···T.·P·
0030  01 03 b4 1b 00 00 50 4f  53 54 20 2f 77 69 72 65   ······PO ST /wire
0040  73 68 61 72 6b 2d 6c 61  62 73 2f 6c 61 62 33 2d   shark-la bs/lab3-
0050  31 2d 72 65 70 6c 79 2e  68 74 6d 20 48 54 54 50   1-reply. htm HTTP
0060  2f 31 2e 31 0d 0a 48 6f  73 74 3a 20 67 61 69 61   /1.1··Ho st: gaia
0070  2e 63 73 2e 75 6d 61 73  73 2e 65 64 75 0d 0a 43   .cs.umas s.edu··C
0080  6f 6e 6e 65 63 74 69 6f  6e 3a 20 6b 65 65 70 2d   onnectio n: keep-
0090  61 6c 69 76 65 0d 0a 43  6f 6e 74 65 6e 74 2d 4c   alive··C ontent-L
```

Sequence Number – 1

NOTE: From 7 to 12 I have used the trace from http://gaia.cs.umass.edu/wireshark-labs/wireshark-traces.zip as I found a lot of inconsistencies in the trace that I pulled from my computer.

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.


tcp-ethereal-trace-1
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>
Expression...

```
No.  Time      Source          Destination     Protocol Length Info
   1 0.000000  192.168.1.102   128.119.245.12  TCP        62 1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1
   2 0.023172  128.119.245.12  192.168.1.102   TCP        62 80 → 1161 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 SACK_PERM=1
   3 0.023265  192.168.1.102   128.119.245.12  TCP        54 1161 → 80 [ACK] Seq=1 Ack=1 Win=17520 Len=0
   4 0.026477  192.168.1.102   128.119.245.12  TCP       619 1161 → 80 [PSH, ACK] Seq=1 Ack=1 Win=17520 Len=565 [TCP segment of a reassembled PDU]
   5 0.041737  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [PSH, ACK] Seq=566 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   6 0.053937  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
   7 0.054026  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=2026 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   8 0.054690  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=3486 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   9 0.077294  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=2026 Win=8760 Len=0
  10 0.077405  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=4946 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
  11 0.078157  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=6406 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
  12 0.124085  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=3486 Win=11680 Len=0
  13 0.124185  192.168.1.102   128.119.245.12  TCP      1201 1161 → 80 [PSH, ACK] Seq=7866 Ack=1 Win=17520 Len=1147 [TCP segment of a reassembled PDU]
  14 0.169118  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=4946 Win=14600 Len=0
  15 0.217299  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=6406 Win=17520 Len=0
  16 0.267802  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=7866 Win=20440 Len=0
  17 0.304807  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=9013 Win=23360 Len=0
```

```
> Frame 5: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits)
> Ethernet II, Src: Actionte_8a:70:1a (00:20:e0:8a:70:1a), Dst: LinksysG_da:af:73 (00:06:25:da:af: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: 566, Ack: 1, Len: 1460
```

Segment 1 – Number 4 - sequence number: 1
Segment 2 – Number 5 - sequence number: 566
Segment 3 – Number 7 - sequence number: 2026
Segment 4 – Number 8 - sequence number: 3486
Segment 5 – Number 10 - sequence number: 4946

Segment 6 – Number 11 - sequence number: 6406

	Sent time	ACK Time	RTT
Segment 1	0.026477	0.053937	0.02746
Segment 2	0.041737	077294	0.035557
Segment 3	0.054026	0.124085	0.070059
Segment 4	0.054690	0.169118	0.11443
Segment 5	0.077405	0.217299	0.13989
Segment 6	0.078157	0.267802	0.18964

EstimatedRTT after the receipt of the ACK of segment 1:
EstimatedRTT = RTT for Segment 1 = **0.02746**

EstimatedRTT after the receipt of the ACK of segment 2:
EstimatedRTT = 0.875 * 0.02746 + 0.125 * 0.035557 = **0.0285**

EstimatedRTT after the receipt of the ACK of segment 3:
EstimatedRTT = 0.875 * 0.0285 + 0.125 * 0.070059 = **0.0337**

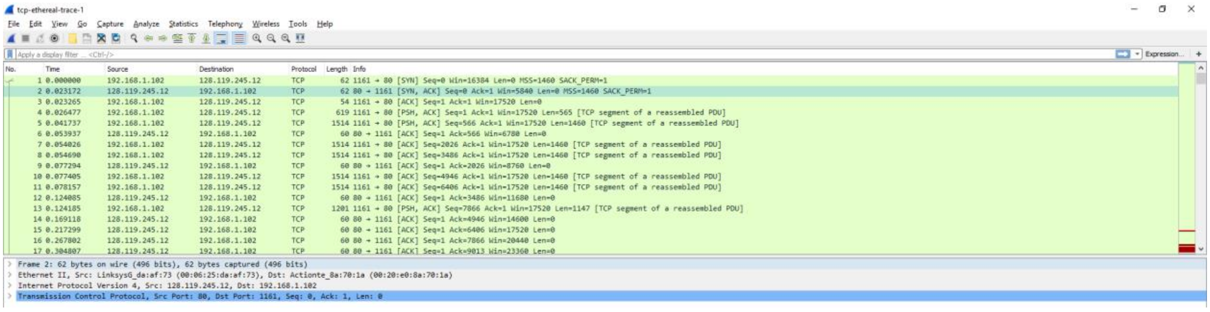
EstimatedRTT after the receipt of the ACK of segment 4:
EstimatedRTT = 0.875 * 0.0337+ 0.125 * 0.11443 = **0.0438**

EstimatedRTT after the receipt of the ACK of segment 5:
EstimatedRTT = 0.875 * 0.0438 + 0.125 * 0.13989 = **0.0558**

EstimatedRTT after the receipt of the ACK of segment 6:
EstimatedRTT = 0.875 * 0.0558 + 0.125 * 0.18964 = **0.0725**

8. What is the length of each of the first six TCP segments?
   Length of the first TCP segment (containing the HTTP POST): **565 bytes**
   Length of each of the other five TCP segments: **1460 bytes**

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?


tcp-ethereal-trace-1
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>
Expression...

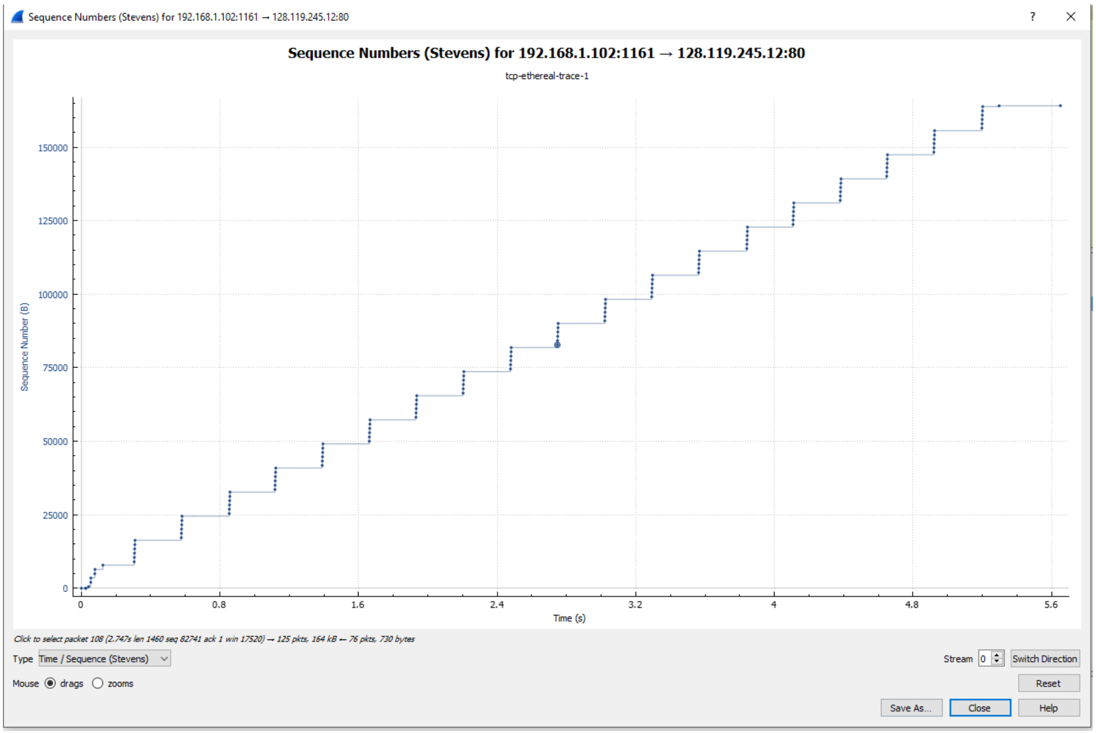
```
No.  Time      Source          Destination     Protocol Length Info
  1 0.000000  192.168.1.102   128.119.245.12  TCP        62 1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1
  2 0.023172  128.119.245.12  192.168.1.102   TCP        62 80 → 1161 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 SACK_PERM=1
  3 0.023265  192.168.1.102   128.119.245.12  TCP        54 1161 → 80 [ACK] Seq=1 Ack=1 Win=17520 Len=0
  4 0.026477  192.168.1.102   128.119.245.12  TCP       619 1161 → 80 [PSH, ACK] Seq=1 Ack=1 Win=17520 Len=565 [TCP segment of a reassembled PDU]
  5 0.041737  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [PSH, ACK] Seq=566 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
  6 0.053937  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
  7 0.054026  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=2026 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
  8 0.054690  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=3486 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
  9 0.077294  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=2026 Win=8760 Len=0
 10 0.077405  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=4946 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
 11 0.078157  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=6406 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
 12 0.124085  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=3486 Win=11680 Len=0
 13 0.124185  192.168.1.102   128.119.245.12  TCP      1201 1161 → 80 [PSH, ACK] Seq=7866 Ack=1 Win=17520 Len=1147 [TCP segment of a reassembled PDU]
 14 0.169118  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=4946 Win=14600 Len=0
 15 0.217299  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=6406 Win=17520 Len=0
 16 0.267802  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=7866 Win=20440 Len=0
 17 0.304807  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=9013 Win=23360 Len=0

> Frame 2: 62 bytes on wire (496 bits), 62 bytes captured (496 bits)
> Ethernet II, Src: LinksysG_da:af:73 (00:06:25:da:af:73), Dst: Actionte_8a:70:1a (00:20:e0:8a:70:1a)
> Internet Protocol Version 4, Src: 128.119.245.12, Dst: 192.168.1.102
> Transmission Control Protocol, Src Port: 80, Dst Port: 1161, Seq: 0, Ack: 1, Len: 0
```

Minimum amount of buffer space - **5840 bytes** (which is receiver window size as shown in the first acknowledgement from the server). The sender is **NOT** throttled, the buffer size steadily increased.

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

There are no retransmitted segments in this trace file. The TimeSequence-Graph (Stevens) of this trace reveals the sequence numbers w.r.t time. As seen in the figure below, the sequence numbers are increasing with respect to time and no dips can be seen which means there are no retransmissions


Sequence Numbers (Stevens) for 192.168.1.102:1161 → 128.119.245.12:80
?
×
Sequence Numbers (Stevens) for 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
0.8
1.6
2.4
3.2
4
4.8
5.6
Time (s)

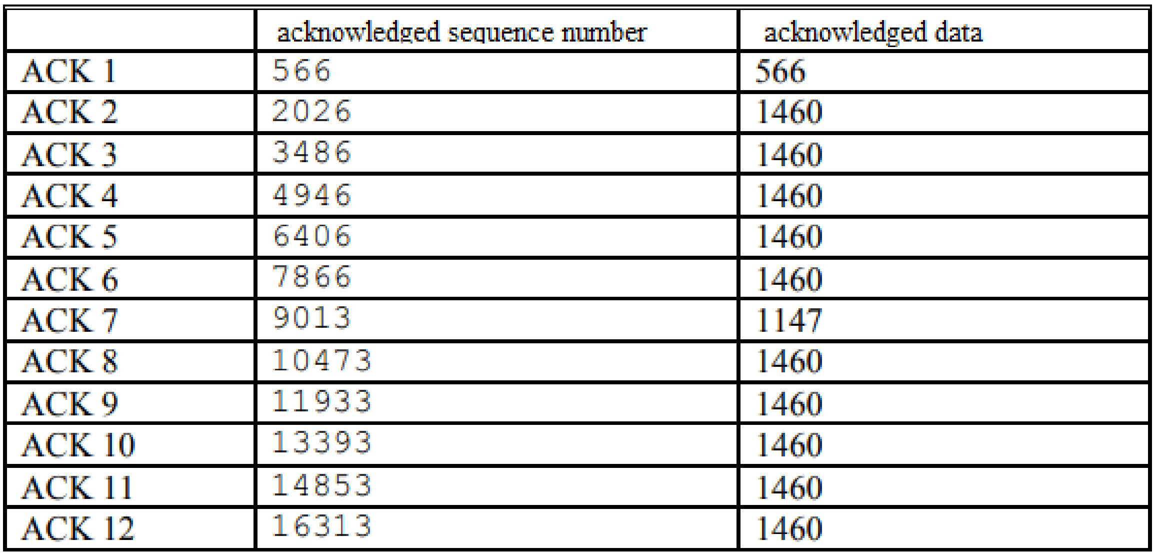
Click to select packet 108 (2.747s len 1460 seq 82741 ack 1 win 17520) → 125 pkts, 164 kB ← 76 pkts, 730 bytes

Type Time / Sequence (Stevens)

Mouse ● drags ○ zooms

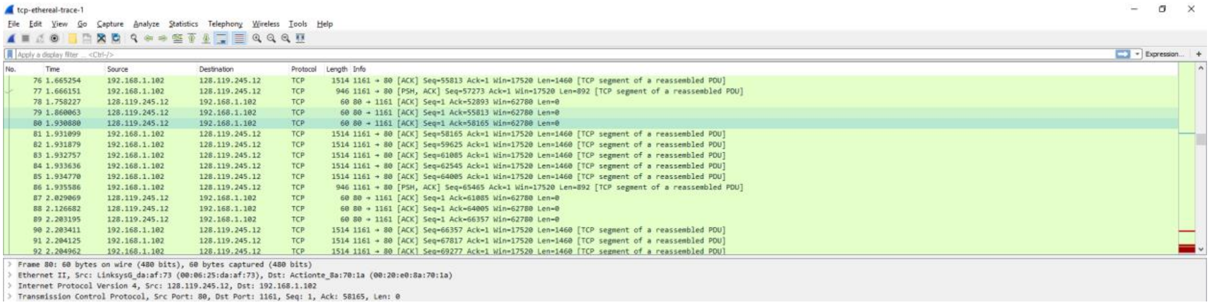
Stream 0

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).



	acknowledged sequence 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

The difference between the acknowledged sequence numbers of two consecutive ACKs indicates the data received by the server between these two ACKs. By inspecting this, we can find a few cases where the receiver is ACKing every other received segment. For eg. segment of No. 80 acknowledged data with 2920 bytes = 1460*2 bytes.


tcp-ethereal-trace-1
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter … <Ctrl-/>
Expression…
+

```
No.   Time      Source          Destination     Protocol Length Info
   76 1.665254  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=55813 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   77 1.666151  192.168.1.102   128.119.245.12  TCP       946 1161 → 80 [PSH, ACK] Seq=57273 Ack=1 Win=17520 Len=892 [TCP segment of a reassembled PDU]
   78 1.758227  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=52893 Win=62780 Len=0
   79 1.860063  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=55813 Win=62780 Len=0
   80 1.930880  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=58165 Win=62780 Len=0
   81 1.931099  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=58165 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   82 1.931879  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=59625 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   83 1.932757  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=61085 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   84 1.933636  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=62545 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   85 1.934770  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=64005 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   86 1.935586  192.168.1.102   128.119.245.12  TCP       946 1161 → 80 [PSH, ACK] Seq=65465 Ack=1 Win=17520 Len=892 [TCP segment of a reassembled PDU]
   87 2.029069  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=61085 Win=62780 Len=0
   88 2.126682  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=64005 Win=62780 Len=0
   89 2.203195  128.119.245.12  192.168.1.102   TCP        60 80 → 1161 [ACK] Seq=1 Ack=66357 Win=62780 Len=0
   90 2.203411  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=66357 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   91 2.204125  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=67817 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
   92 2.204962  192.168.1.102   128.119.245.12  TCP      1514 1161 → 80 [ACK] Seq=69277 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]

> Frame 80: 60 bytes on wire (480 bits), 60 bytes captured (480 bits)
> Ethernet II, Src: LinksysG_da:af:73 (00:06:25:da:af:73), Dst: Actionte_8a:70:1a (00:20:e0:8a:70:1a)
> Internet Protocol Version 4, Src: 128.119.245.12, Dst: 192.168.1.102
> Transmission Control Protocol, Src Port: 80, Dst Port: 1161, Seq: 1, Ack: 58165, Len: 0
```

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

    Total amount data transmitted = acknowledged sequence number of the last ACK - sequence number of the first TCP segment

    = 164091 - 1 = 164090 bytes.

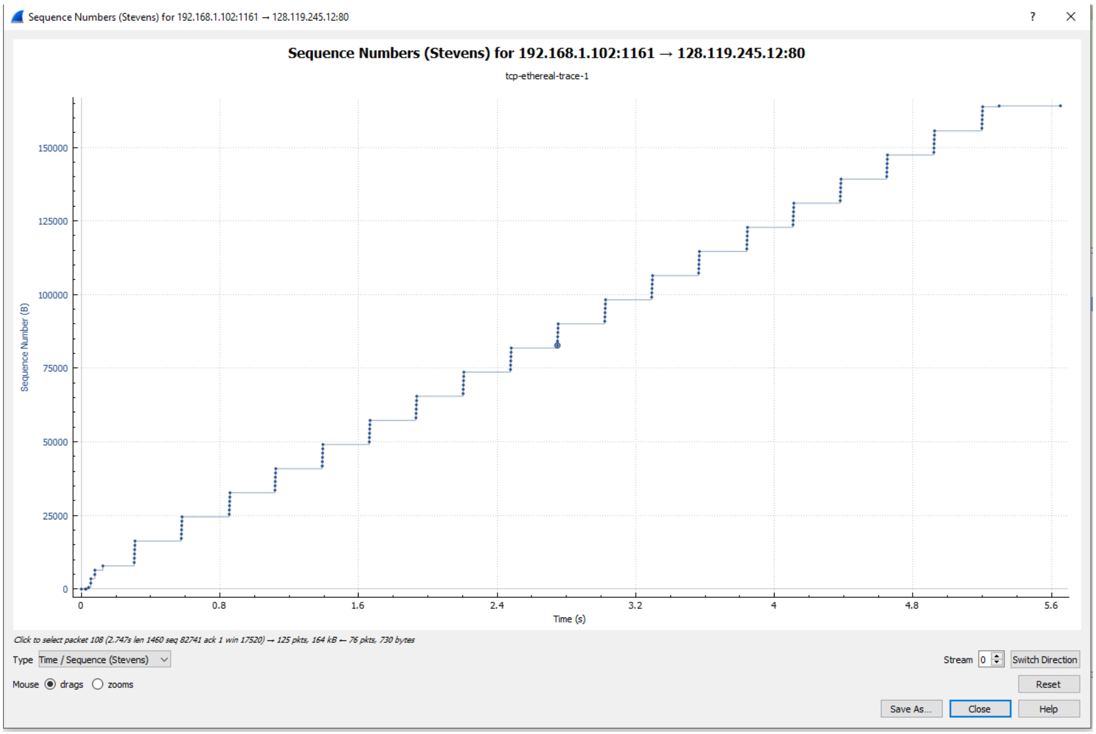
    Transmission time = time instance of the last ACK - time instance of the first TCP segment

    = 5.455830 - 0.026477 = 5.4294 seconds

    Throughput = Total amount data transmitted/ Transmission time

    Therefore, throughput = 164090/5.4294 = **30.222 KByte/sec.**

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.



Click to select packet 108 (2.747s len 1460 seq 82741 ack 1 win 17520) → 125 pkts, 164 kB ← 76 pkts, 730 bytes

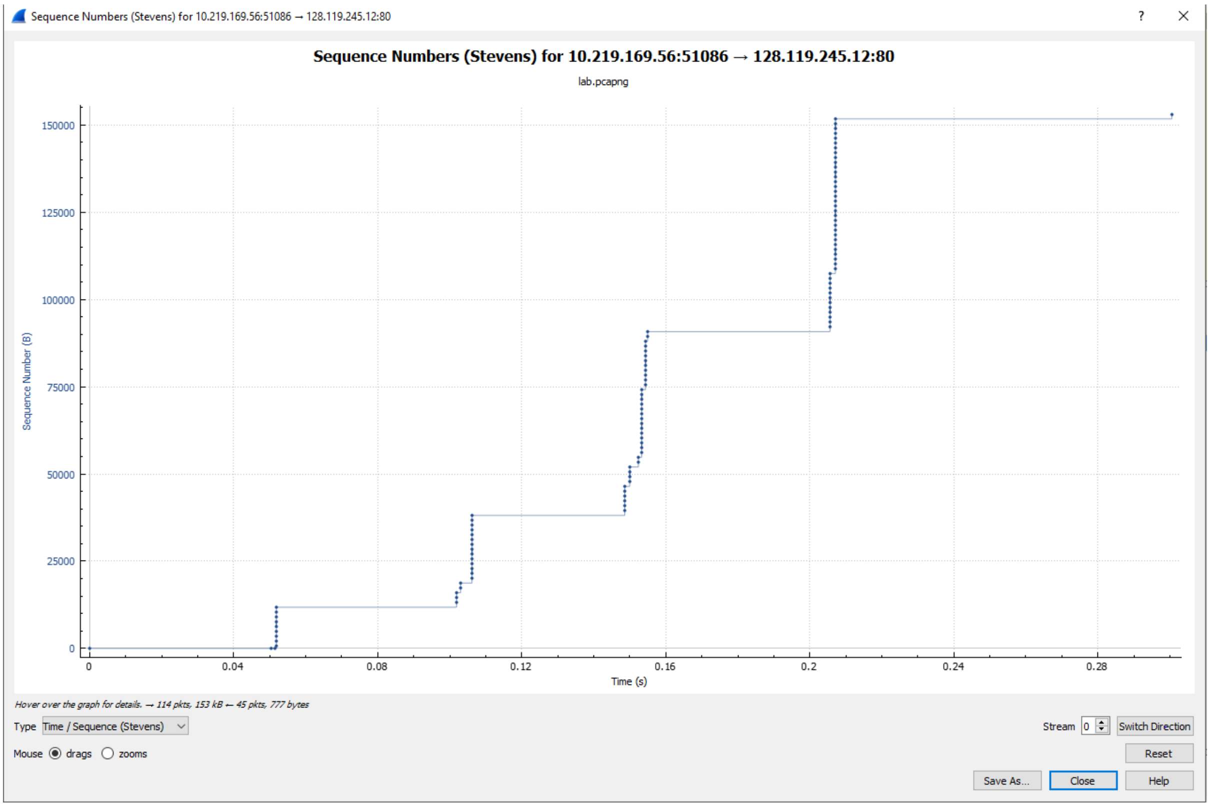
Type: Time / Sequence (Stevens)

Stream: 0

Mouse: ● drags ○ zooms

The slow-start phase only lasts for first 0.1-0.15 second. Afterwards, it seems that the TCP session is always in congestion avoidance state. In this case, we do not observe the expected linear increase behaviour, i.e. the TCP transmit window does not grow linearly during this phase. In fact, it appears that the sender transmits packets in batches of 6. This does not seem to be caused by flow control since the receiver advertised window is significantly larger than 5 packets.

14. Answer each of two questions above for the trace that you have gathered when you transferred a file from your computer to gaia.cs.umass.edu



Hover over the graph for details. → 114 pkts, 153 kB ← 45 pkts, 777 bytes

Type Time / Sequence (Stevens)

Stream 0

Mouse ● drags ○ zooms

The slow start phase begins around 0 and ends around 0.05 seconds in according to the graph; after that congestion takes over. The measured data uses only a fraction of the window size instead of the 1/3 to a half.