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CSCE416
Lab Two
October 16, 2017

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? To answer this question, it's probably easiest to select an HTTP message and explore the details of the TCP packet used to carry this HTTP message, using the "details of the selected packet header window" (refer to Figure 2 in the "Getting Started with Wireshark" Lab if you're uncertain about the Wireshark windows.**

The IP Address is : 192.168.1.102, and the port is 1161

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?**

The IP Address for gaia.cs.umass.edu is: 128.119.245.12, and the 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?**

No.	Time	Source	Destination	Protocol	Length	Info
169	1.311084	72.21.206.53	192.168.0.3	TLSv1.2	445	Application Data
172	1.312182	192.168.0.3	72.21.206.53	TLSv1.2	1012	Application Data
176	1.317377	72.21.206.53	192.168.0.3	TLSv1.2	445	Application Data
181	1.343818	72.21.206.53	192.168.0.3	TLSv1.2	445	Application Data
182	1.347358	72.21.206.53	192.168.0.3	TLSv1.2	445	Application Data
190	2.154107	104.16.60.57	192.168.0.3	TLSv1.2	361	Application Data
180	1.341954	192.168.0.3	72.21.206.53	TLSv1.2	105	Change Cipher Spec, Encrypted Handshake Message
175	1.315270	192.168.0.3	72.21.206.53	TLSv1.2	287	Client Hello
154	1.243710	128.119.245.12	192.168.0.3	HTTP	831	HTTP/1.1 200 OK (text/html)
106	1.171487	192.168.0.3	128.119.245.12	HTTP	3455	POST /wireshark-labs/lab3-1-reply.htm HTTP/1.1 (text/plain)
179	1.341785	72.21.206.53	192.168.0.3	TLSv1.2	210	Server Hello, Change Cipher Spec, Encrypted Handshake Message
178	1.341254	72.21.206.53	192.168.0.3	TCP	60	[TCP Dup ACK 177#1] 443 → 64477 [ACK] Seq=1 Ack=234 Win=2096896 Len=0

> Frame 154: 831 bytes on wire (6648 bits), 831 bytes captured (6648 bits) on interface 0
> Ethernet II, Src: HonHaiPr_ef:6b:de (40:b8:9a:ef:6b:de), Dst: AsrockIn_ea:53:cb (bc:5f:f4:ea:53:cb)
> Internet Protocol Version 4, Src: 128.119.245.12, Dst: 192.168.0.3
∨ Transmission Control Protocol, Src Port: 80, Dst Port: 64476, Seq: 1, Ack: 152983, Len: 777
    Source Port: 80
    Destination Port: 64476
    [Stream index: 2]
    [TCP Segment Len: 777]
    Sequence number: 1   (relative sequence number)
    [Next sequence number: 778   (relative sequence number)]
    Acknowledgment number: 152983   (relative ack number)
    0101 .... = Header Length: 20 bytes (5)
> Flags: 0x018 (PSH, ACK)
    Window size value: 1801
    [Calculated window size: 230528]
    [Window size scaling factor: 128]

The IP address is 192.168.0.3 and the port is 64476

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?**

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

> Frame 1: 62 bytes on wire (496 bits), 62 bytes captured (496 bits)
> Ethernet II, Src: PremaxPe_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: 0, Len: 0
    Source Port: 1161
    Destination Port: 80
    [Stream index: 0]
    [TCP Segment Len: 0]
    Sequence number: 0   (relative sequence number)
    Acknowledgment number: 0
    0111 .... = Header Length: 28 bytes (7)
∨ 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: 16384

The sequence number is 0. The [SYN] flag in the information field identifies the segment as 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?**

The sequence number for the SYNACK segment is 0. The value for the Acknowledgement field is 1. The gaia.cs.umass.edu knew the acknowledgement would be 1 because it is a relative ack number. The [SYN,ACK] flag in the Info field identifies this segment as 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.**

The packet number 4 contains the HTTP POST command, and the sequence number of the HTTP POST command is 1.

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)?**

1, 566, 2026, 3486, 4946, 6406

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?

Segment 1: Sent time: 0.026477; Ack time: 0.053937; RTT: 0.053937-0.026477 = 0.02746
Segment 2: Sent time: 0.041737; Ack time: 0.077294; RTT: 0.077294-0.041737 = 0.035557
Segment3: Sent time: 0.054026; Ack time: 0.124085; RTT: : 0.124085-0.054026 = 0.070059
Segment4: Sent time: 0.054690; Ack time: 0.169118; RTT: 0.169118-0.054690 = 0.114428
Segment5: Sent time: 0.077405; Ack time: 0.217299: RTT: 0.217299-0.077405 = 0.139894
Segment6: Sent time: 0.078157; Ack time: 0.267802; RTT: 0.267802-0.078157 = 0.189645

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. Note: Wireshark has a nice feature that allows you to plot the RTT for each of the TCP segments sent. Select a TCP segment in the "listing of captured packets" window that is being sent from the client to the gaia.cs.umass.edu server. Then select: Statistics->TCP Stream Graph- >Round Trip Time Graph.

The estimated RTT is calculated by : 0.875 * Estimated RTT(previous) + 0.125 * SampleRTT

Segment1: 0.02746
Segment2: 0.875*0.02746 + 0.125*0.035557 = 0.02847
Segment3: 0.875*0.0285 + 0.125*0.070059 = 0.03369
Segment4: 0.875*0.0337 + 0.125*0.0114428 = 0.0438
Segment5: 0.875*0.0438 + 0.125*0.139894 = 0.0558
Segment6: 0.875*0.0558 + 0.125*0.189645 = 0.0725

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

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```
˅ Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 1, Ack: 1, Len: 565
      Source Port: 1161
      Destination Port: 80
      [Stream index: 0]
      [TCP Segment Len: 565]


´ Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 566, Ack: 1, Len: 1460
      Source Port: 1161
      Destination Port: 80
      [Stream index: 0]
      [TCP Segment Len: 1460]
      Coguenco numbon: E66    (nolative coguenco numbon)
```

Segment1: 565 bytes
Segment2: 1460
Segment3: 1460
Segment4: 1460
Segment5: 1460
Segment6: 1460

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?**

```
 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
 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
 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
 8 0.054690      192.168.1.102      128.119.245.12     TCP    1514 1161 → 80 [ACK] Seq=3486 Ack=1 Win=17520 Len=1460
 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
11 0.078157      192.168.1.102      128.119.245.12     TCP    1514 1161 → 80 [ACK] Seq=6406 Ack=1 Win=17520 Len=1460
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
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: PremaxPe_8a:70:1a (00:20:e0:8a:70:1a)
> Internet Protocol Version 4, Src: 128.119.245.12, Dst: 192.168.1.102
v Transmission Control Protocol, Src Port: 80, Dst Port: 1161, Seq: 0, Ack: 1, Len: 0
    Source Port: 80
    Destination Port: 1161
    [Stream index: 0]
    [TCP Segment Len: 0]
    Sequence number: 0    (relative sequence number)
    Acknowledgment number: 1    (relative ack number)
    0111 .... = Header Length: 28 bytes (7)
  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: 5840
    [Calculated window size: 5840]
```

The minimum amount of available buffer space is 5640 bytes. The sender is never throttled.

10) **Are there any retransmitted segments in the trace file? What did you check for (in the trace) in order to answer this question?**
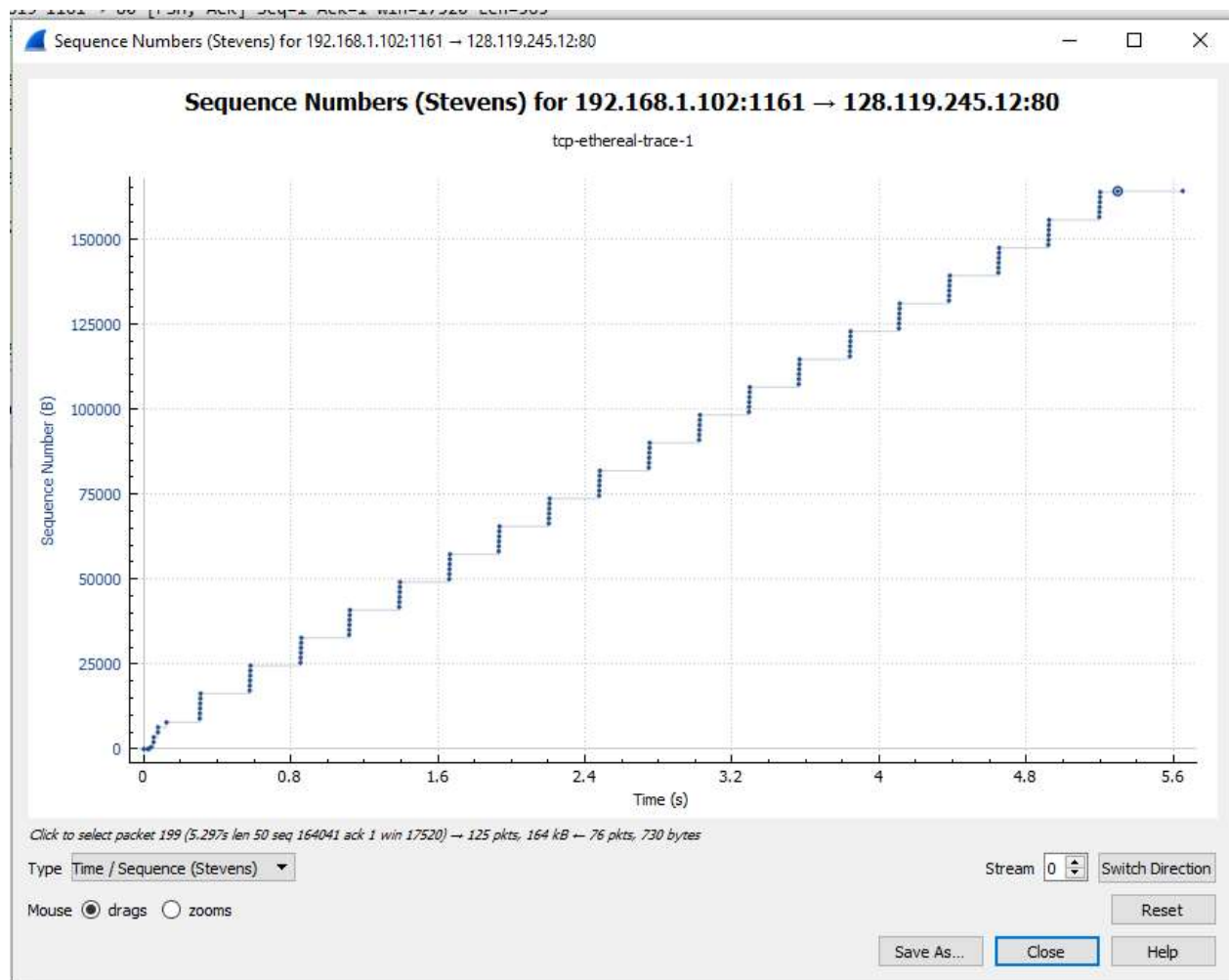
There are no retransmitted segments. Analyzing the Time-Sequence-Graph(Stevens), we can determine that no sequence is out of place, everything is increased in both the x and y direction with no backtracking, thus there were no retransmitted segments.

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).**

In Package 6, the acknowledge sequence number is 566.
In Package 9, the acknowledge sequence number is 2026.
In Package 12, acknowledge sequence number is 3486.
In Package 14, acknowledge sequence number is 4946.

The receiver typically acknowledges 1460 bytes of data.

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

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
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
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
8 0.054690	192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=3486 Ack=1 Win=17520 Len=1460
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
11 0.078157	192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=6406 Ack=1 Win=17520 Len=1460
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
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

```
> Frame 4: 619 bytes on wire (4952 bits), 619 bytes captured (4952 bits)
> Ethernet II, Src: PremaxPe_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
v Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 1, Ack: 1, Len: 565
     Source Port: 1161
     Destination Port: 80
     [Stream index: 0]
     [TCP Segment Len: 565]
     Sequence number: 1    (relative sequence number)
     [Next sequence number: 566    (relative sequence number)]
     Acknowledgment number: 1    (relative ack number)
     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 used)]
     Checksum: 0x1fbd [unverified]
     [Checksum Status: Unverified]
     Urgent pointer: 0
  v [SEQ/ACK analysis]
        [iRTT: 0.023265000 seconds]
        [Bytes in flight: 565]
        [Bytes sent since last PSH flag: 565]
     TCP payload (565 bytes)
v Data (565 bytes)
     Data: 504f5354202f657468657265616c2d6c6162732f616233...
     [Length: 565]
```

```
    203 5.461175     128.119.245.12    192.168.1.102    TCP     784 80 → 1161 [PSH, ACK] Seq=1 Ack=164091 Win=62780 Len=730
    204 5.598090     192.168.1.100     192.168.1.1      SSDP    174 M-SEARCH * HTTP/1.1
    205 5.599082     192.168.1.100     192.168.1.1      SSDP    175 M-SEARCH * HTTP/1.1
    206 5.651141     192.168.1.102     128.119.245.12   TCP     54 1161 → 80 [ACK] Seq=164091 Ack=731 Win=16790 Len=0
    207 6.101044     192.168.1.100     192.168.1.1      SSDP    174 M-SEARCH * HTTP/1.1
    208 6.102069     192.168.1.100     192.168.1.1      SSDP    175 M-SEARCH * HTTP/1.1
    209 6.600152     192.168.1.100     192.168.1.1      SSDP    174 M-SEARCH * HTTP/1.1
    210 6.601063     192.168.1.100     192.168.1.1      SSDP    175 M-SEARCH * HTTP/1.1
    211 7.102852     192.168.1.100     192.168.1.1      SSDP    174 M-SEARCH * HTTP/1.1
    212 7.103780     192.168.1.100     192.168.1.1      SSDP    175 M-SEARCH * HTTP/1.1
    213 7.595557     192.168.1.102     199.2.53.206     TCP     62 1162 → 631 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1

> Frame 206: 54 bytes on wire (432 bits), 54 bytes captured (432 bits)
> Ethernet II, Src: PremaxPe_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
v Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 164091, Ack: 731, Len: 0
      Source Port: 1161
      Destination Port: 80
      [Stream index: 0]
      [TCP Segment Len: 0]
      Sequence number: 164091    (relative sequence number)
      Acknowledgment number: 731    (relative ack number)
      0101 .... = Header Length: 20 bytes (5)
   > Flags: 0x010 (ACK)
      Window size value: 16790
      [Calculated window size: 16790]
      [Window size scaling factor: -2 (no window scaling used)]
      Checksum: 0xf574 [unverified]
      [Checksum Status: Unverified]
      Urgent pointer: 0
   v [SEQ/ACK analysis]
         [This is an ACK to the segment in frame: 203]
         [The RTT to ACK the segment was: 0.189966000 seconds]
         [iRTT: 0.023265000 seconds]
```

164090 / (5.651141 – 0.026477) = 29173.298 bytes per second

The final packet acknowledgement is packet 206, which occurred at time 5.651141. The final sequence number is 164091. The first packet occurred at time 0.026477. I used the calculation above to determine the throughput.

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 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.**

Sequence Numbers (Stevens) for 192.168.1.102:1161 → 128.119.245.12:80
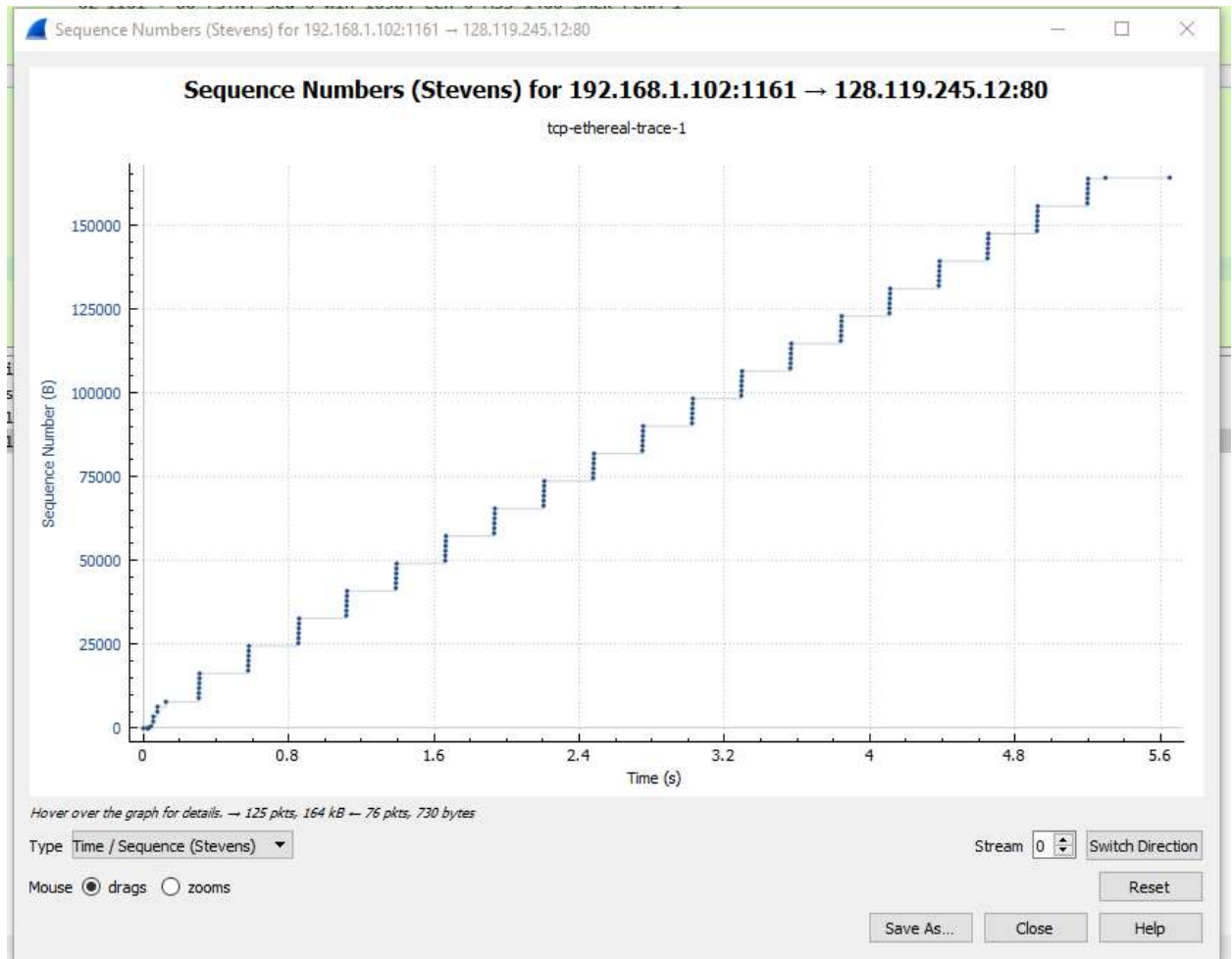
The slow start phase begins at time 0, and lasts until rough time 0.2. The congestion avoidance starts around 0.3, and lasts until the end of the packets.

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**

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

```
  22 1.540380    192.168.0.3    128.119.245.12    TCP    715 64847 → 80 [PSH, ACK] Seq=1 Ack=1 Win=65536 Len=661
  21 1.540020    192.168.0.3    128.119.245.12    TCP     54 64847 → 80 [ACK] Seq=1 Ack=1 Win=65536 Len=0
  16 1.496596    192.168.0.3    128.119.245.12    TCP     66 64847 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 S
 317 2.158260    192.168.0.3    104.16.60.37      TCP     54 49922 → 443 [ACK] Seq=1 Ack=1113 Win=256 Len=0
 264 1.959758    192.168.0.3    104.16.60.37      TCP     54 49922 → 443 [ACK] Seq=1 Ack=554 Win=252 Len=0
```

```
> Frame 22: 715 bytes on wire (5720 bits), 715 bytes captured (5720 bits) on interface 0
> Ethernet II, Src: AsrockIn_ea:53:cb (bc:5f:f4:ea:53:cb), Dst: HonHaiPr_ef:6b:de (40:b8:9a:ef:6b:de)
> Internet Protocol Version 4, Src: 192.168.0.3, Dst: 128.119.245.12
v Transmission Control Protocol, Src Port: 64847, Dst Port: 80, Seq: 1, Ack: 1, Len: 661
     Source Port: 64847
     Destination Port: 80
     [Stream index: 1]
     [TCP Segment Len: 661]
     Sequence number: 1     (relative sequence number)
     [Next sequence number: 662     (relative sequence number)]
     Acknowledgment number: 1     (relative ack number)
     0101 .... = Header Length: 20 bytes (5)
   > Flags: 0x018 (PSH, ACK)
     Window size value: 256
     [Calculated window size: 65536]
     [Window size scaling factor: 256]
     Checksum: 0x38df [unverified]
     [Checksum Status: Unverified]
     Urgent pointer: 0
```

```
 182 1.774176    192.168.0.3    128.119.245.12    TCP       54 64847 → 80 [ACK] Seq=152983 Ack=778 Win=64768 Len=0
 108 1.672193    192.168.0.3    128.119.245.12    TCP     2794 64847 → 80 [PSH, ACK] Seq=150243 Ack=1 Win=65536 Len=2740
 106 1.672052    192.168.0.3    128.119.245.12    TCP     5894 64847 → 80 [PSH, ACK] Seq=144403 Ack=1 Win=65536 Len=5840
 104 1.671016    192.168.0.3    128.119.245.12    TCP     2974 64847 → 80 [ACK] Seq=141483 Ack=1 Win=65536 Len=2920
 102 1.670271    192.168.0.3    128.119.245.12    TCP     2974 64847 → 80 [ACK] Seq=138563 Ack=1 Win=65536 Len=2920
 100 1.670202    192.168.0.3    128.119.245.12    TCP     5894 64847 → 80 [ACK] Seq=132723 Ack=1 Win=65536 Len=5840
```

```
> Frame 22: 715 bytes on wire (5720 bits), 715 bytes captured (5720 bits) on interface 0
> Ethernet II, Src: AsrockIn_ea:53:cb (bc:5f:f4:ea:53:cb), Dst: HonHaiPr_ef:6b:de (40:b8:9a:ef:6b:de)
> Internet Protocol Version 4, Src: 192.168.0.3, Dst: 128.119.245.12
v Transmission Control Protocol, Src Port: 64847, Dst Port: 80, Seq: 1, Ack: 1, Len: 661
     Source Port: 64847
     Destination Port: 80
     [Stream index: 1]
     [TCP Segment Len: 661]
     Sequence number: 1     (relative sequence number)
     [Next sequence number: 662     (relative sequence number)]
     Acknowledgment number: 1     (relative ack number)
     0101 .... = Header Length: 20 bytes (5)
   > Flags: 0x018 (PSH, ACK)
     Window size value: 256
     [Calculated window size: 65536]
     [Window size scaling factor: 256]
     Checksum: 0x38df [unverified]
     [Checksum Status: Unverified]
     Urgent pointer: 0
   > [SEQ/ACK analysis]
     TCP payload (661 bytes)
```

152983 / (1.774176 – 1.540380) = 654343.95798 bytes per second
The first packet #22 occurred at time 1.540380. The final packet #182 occurred at 1.774176, and the final sequence number was 152983.

b) **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.

Sequence Numbers (Stevens) for 192.168.0.3:64847 → 128.119.245.12:80
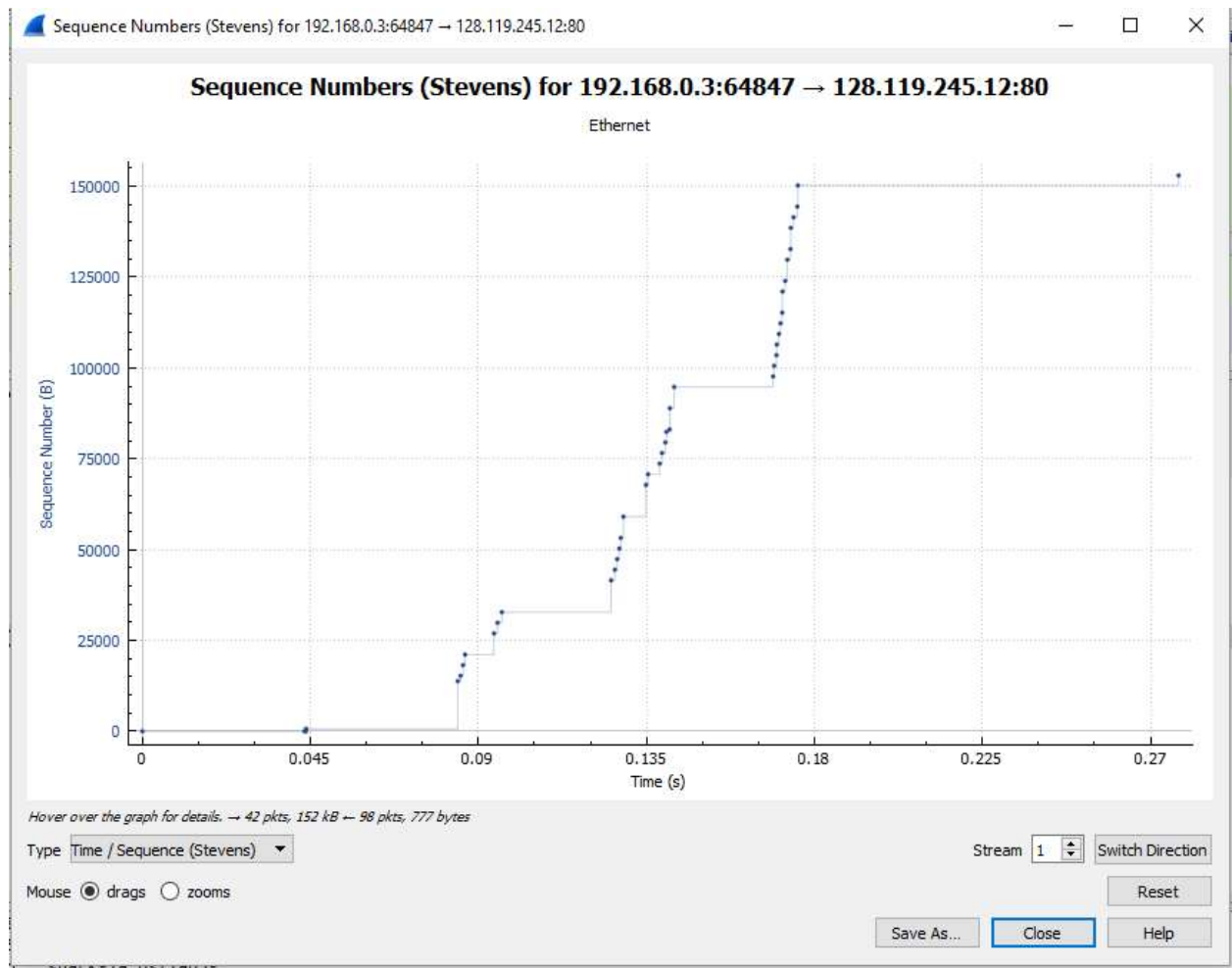
The slow start segment occurs around the 0.045 time, ending around the 0.05 time.The congestion avoidance takes over around the 0.08 time.