

## Third Lab

## 2. A first look at the captured trace

1. What is the IP address and TCP port number used by the client computer (source) that is transferring the alice.txt file to gaia.cs.umass.edu?

```
> Frame 154: 210 bytes on wire (1680 bits), 210 bytes captured (1680 bits) on interface en0, id 0
> Ethernet II, Src: Apple_48:f6:10:88:66:5a, Dst: Arcadyan_3b:55:89 (3c:bd:c5:3b:55:89)
> Internet Protocol Version 4, Src: 192.168.1.155, Dst: 128.119.245.12
> Transmission Control Protocol, Src Port: 61853, Dst Port: 80, Seq: 152786, Ack: 1, Len: 144
  Source Port: 61853
  Destination Port: 80
  [Stream index: 4]
  [TCP Segment Len: 144]
  Sequence Number: 152786 (relative sequence number)
  Sequence Number (raw): 583158443
  [Next Sequence Number: 152930 (relative sequence number)]
  Acknowledgment Number: 1 (relative ack number)
  Acknowledgment number (raw): 1808046805
  1808 .... = Header Length: 32 bytes (8)
  > Flags: 0x018 (PSH, ACK)
  Window: 2058
  [Calculated window size: 131712]
  [Window size scaling factor: 64]
  Checksum: 0xb0d1 (unverified)
0000 3c bd c5 3b 55 89 88 66 5a 48 f6 10 88 00 45 00 <...U...f ZH...E-
0010 00 c4 00 00 40 00 40 06 02 6d c0 a8 01 9b 00 77 ...@ @-m...w
0020 f5 0c ee 78 00 58 22 c2 4a ab 6b c4 97 b5 00 18 ...P- J k...
0030 00 0a ee 61 00 00 01 01 08 0a 49 68 9a a4 fd 31 ...a...-Ih...1
0040 56 3b 6d 65 6d 62 65 72 69 6e 67 20 68 65 72 20 V;member ing her
0050 6f 77 6e 20 63 68 69 6c 64 2d 6c 69 66 65 2c 20 own chil d-lfe,
0060 61 6e 64 20 74 68 65 20 68 61 70 79 20 73 75 and the happy su
0070 6d 6d 65 72 20 64 61 79 73 2e 0d 0a 0d 0a 20 20 mmer day s....
0080 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 THE E
0090 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 NO...-WebK
00a0 4e 44 0d 0a 0a 2d 2d 2d 2d 2d 2d 2d 2d 2d 2d 4b itForba undaryof
00b0 69 74 46 6f 72 6d 42 6f 75 6e 64 61 72 79 6f 59 MoY2IFQc GuoQBT-
00c0 4d 6f 59 5a 31 46 51 63 47 75 6f 51 42 66 2d 2d
00d0 0d 0a
```

**IP address used by the client's computer is : 192.168.242.1**

**TCP port number used by the client's computer is : 61853**

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?

```
> Frame 168: 843 bytes on wire (6744 bits), 843 bytes captured (6744 bits) on interface en0, id 0
> Ethernet II, Src: Arcadyan_3b:55:89 (3c:bd:c5:3b:55:89), Dst: Apple_48:f6:10:88:66:5a, Len: 144
> Internet Protocol Version 4, Src: 128.119.245.12, Dst: 192.168.1.155
> Transmission Control Protocol, Src Port: 80, Dst Port: 61853, Seq: 1, Ack: 152930, Len: 777
  Source Port: 80
  Destination Port: 61853
  [Stream index: 4]
  [TCP Segment Len: 777]
  Sequence Number: 1 (relative sequence number)
  Sequence Number (raw): 1808046805
  [Next Sequence Number: 778 (relative sequence number)]
  Acknowledgment Number: 152930 (relative ack number)
  Acknowledgment number (raw): 583158587
  1808 .... = Header Length: 32 bytes (8)
  > Flags: 0x018 (PSH, ACK)
  Window: 1479
  [Calculated window size: 189312]
  [Window size scaling factor: 128]
  Checksum: 0xf698 (unverified)
  [Checksum Status: Unverified]
  Urgent Pointer: 0
  > Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
  > [SEQ/ACK analysis]
  > [Timestamps]
0020 01 9b 00 50 ee 7d 6b c4 97 b5 22 c2 4b 3b 80 18 ...P-)K...K;-
0030 05 c7 f6 98 00 00 01 01 08 0a fd 31 56 52 49 68 .....-1VRlh
0040 9a a4 48 54 54 50 2f 31 2e 31 20 32 30 20 4f HTTP/1.1 200 0
0050 4b 0d 0a 4d 61 74 65 3a 20 5f 65 64 2c 20 30 33 K-Date: Wed, 03
0060 20 4e 6f 76 20 32 30 32 31 20 31 38 3a 33 39 3a Nov 202 1:18:39:
0070 31 38 20 47 4d 54 0d 0a 53 65 72 76 65 72 3a 20 18 GMT - Server:
0080 41 70 61 6d 65 2f 32 2e 34 2e 36 20 20 43 65 Apache/2.4.6 (Ce
0090 6e 74 4f 53 29 20 4f 70 65 6e 53 53 4c 2f 31 2e ntOS) Op enSSL/1.
00a0 30 2e 32 6d 2d 66 69 70 73 20 50 48 50 2f 37 2e 0.2k-fip s PHP/7.
00b0 34 2e 32 35 20 6d 6f 64 5f 70 65 72 6c 2f 32 2e 4.25 mod_perl/2.
```

***IP address of gaia.cs.umass.edu is : 128.119.245.12***

***TCP port number : 80***

### 3. TCP Basics

***Answer the following questions for the TCP segments:***

3. 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 this TCP segment that identifies the segment as a SYN segment? Will the TCP receiver in this session be able to use Selective Acknowledgments (allowing TCP to function a bit more like a “selective repeat” receiver, see section 3.4.5 in the text)?

```
Sequence Number (raw): 583005657
[Next Sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 0
Acknowledgment number (raw): 0
1011 .... = Header Length: 44 bytes (11)
Flags: 0x002 (SYN)
0000 .... = Reserved: Not set
...0 .... = Nonce: Not set
....0... = Congestion Window Reduced (CWR): Not set
....0... = ECH-Echo: Not set
....0... = Urgent: Not set
....0... = Acknowledgment: Not set
....0... = Push: Not set
....0... = Reset: Not set
> 00000000 = Syn: set
....0... = Fin: Not set
[TCP Flags: .....S.]
Window: 65535
[Calculated window size: 65535]
Checksum: 0x140d [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0
> Options: (24 bytes), Maximum segment size, No-Operation (NOP), Window scale, No-Operation (NOP), No-Operation (NOP), Timestamps, SACK permitted, End of Option List (EOL)
> [Timestamps]
0000 3c bd c5 3b 55 89 88 66 5a 48 f6 10 00 00 45 00 <.:U..f ZH...E-
0010 00 40 00 00 40 00 40 06 02 f1 c0 a0 01 9b 00 77 -@..@.-.....w
0020 f5 0c ee 7d 00 50 22 bf f5 d9 00 00 00 b0 02 ...}.P.....
0030 ff ff 14 0d 00 00 02 04 05 04 01 03 03 06 01 01 .....S.....
0040 00 0a 49 68 9a 58 00 00 00 00 04 02 00 00 ..InX.....
```

***The sequence number of the TCP SYN segment used to establish a TCP connection between the client computer and gaia.cs.umass.edu is zero. The SYN flag is set to 1 in the Flags section, indicating that this is a SYN segment. Yes, the TCP receiver in this session will be able to use Selective Acknowledgments; we can see that SACK-permitted is present in the options section.***

4. 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 it in the segment that identifies the segment as a SYNACK segment? What is the value of the Acknowledgement field in the SYNACK segment? How did gaia.cs.umass.edu determine that value?

Destination Port: 61853	
[Stream index: 4]	
[TCP Segment Len: 0]	
Sequence Number: 0 (relative sequence number)	
Sequence Number (raw): 1808046004	
[Next Sequence Number: 1 (relative sequence number)]	
Acknowledgment Number: 1 (relative ack number)	
Acknowledgment number (raw): 583005658	
1018 .... = Header Length: 40 bytes (10)	
Flags: 0x012 (SYN, ACK)	
0000 .... = 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: Set	
.... 0... = Push: Not set	
.... 0... = Reset: Not set	
.... 0... = SYN: Set	
.... 0... = FIN: Not set	
[TCP Flags: .....A..S.]	
Window: 28968	
[Calculated window size: 28968]	
Checksum: 0x5d2f [unverified]	
0000 88 66 5a 48 f6 10 3c bd c5 35 55 09 00 00 45 00 --f2H<-<-;U...E-	
0010 00 3c 00 00 00 00 33 06 0f f5 80 77 f5 0c c0 a8 --<-@.3-...u...-	
0020 01 9b 00 50 ee 7d 6b c4 97 04 22 bf f5 da a0 12 --P.jk-...-...1	
0030 71 20 5d 2f 00 00 02 04 05 04 04 02 00 8a fd 31 q./...-...1	
0040 56 05 49 68 9a 58 01 03 03 07 V In X-...	

**The sequence number of the SYNACK segment sent by gaia.cs.umass.edu in response to the SYN is 0. The SYN and Acknowledgement flags in the Flags section are both set to 1, indicating that this is a SYNACK segment. The Acknowledgement field in the SYNACK segment has a value of 1. The gaia.cs.umass.edu server adds 1 to the initial sequence number of the client computer's SYN segment. Because the client computer's initial sequence number for the SYN segment is 0, the value of the Acknowledgement field in the SYNACK segment is 1.**

5. What is the sequence number of the TCP segment containing the header of the HTTP POST command? Note that in order to find the POST message header, you'll need to dig into the packet content field at the bottom of the Wireshark window, looking for a segment with the ASCII text "POST" within its DATA Field4,5 . How many bytes of data are contained in the payload (data) field of this TCP segment? Did all of the data in the transferred file alice.txt fit into this single Segment?

> Frame 37: 674 bytes on wire (5392 bits), 674 bytes captured (5392 bits) on interface en0, id 0	
> Ethernet II, Src: Apple_88:f6:18 (88:66:5a:48:f6:18), Dst: Arcadyan_3b:55:09 (3c:bd:c3:3b:55:09)	
> Internet Protocol Version 4, Src: 192.168.1.155, Dst: 128.119.245.12	
▼ Transmission Control Protocol, Src Port: 61853, Dst Port: 80, Seq: 1, Ack: 1, Len: 688	
Source Port: 61853	
Destination Port: 80	
[Stream index: 4]	
[TCP Segment Len: 688]	
Sequence Number: 1 (relative sequence number)	
Sequence Number (raw): 583005658	
[Next Sequence Number: 609 (relative sequence number)]	
Acknowledgment Number: 1 (relative ack number)	
Acknowledgment number (raw): 1808046005	
1808 .... = Header Length: 32 bytes (8)	
Flags: 0x018 (PSH, ACK)	
Window: 2058	
[Calculated window size: 131712]	
[Window size scaling factor: 64]	
Checksum: 8bd75a [unverified]	
[Checksum Status: Unverified]	
Urgent Pointer: 0	
Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps	
> [SEQ/ACK analysis]	
> [Timestamps]	
TCP payload (688 bytes)	
[Reassembled PDU in frame: 154]	
TCP segment data (688 bytes)	
0040 56 05 50 4f 53 54 20 2f 77 69 72 65 73 68 61 72 V-POST // wireshar	
0050 60 2d 6c 61 62 73 2f 6c 63 62 33 24 31 26 72 65 k-labs/ a03-i-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 28 67 61 69 61 2e 63 73 2e -Host: gaia.cs.	
0080 75 6d 61 73 73 2e 65 64 75 8d 0a 4f 72 69 67 69 mass-ed u-origi	
0090 6e 3a 20 68 74 74 70 3a 2f 2f 67 61 69 61 2e 63 n: http: //gaia.c	
00a0 73 2e 75 6d 61 73 73 2e 65 64 75 8d 0a 43 6f 6e s.umass. edu-Con	
00b0 74 65 6e 74 2d 54 79 70 65 3a 20 6d 75 6c 74 69 tent-type: multi	
00c0 70 61 72 74 2f 66 6f 72 6d 2d 64 61 74 61 3b 20 part/for m-data;	
00d0 62 6f 75 6e 64 61 72 79 3d 2d 2d 2d 57 65 62 boundary =Web	
00e0 4b 69 74 4d 6f 73 6d 42 6f 75 6e 64 61 72 70 6f Kliformb oundaryo	
00f0 59 4d 6f 59 5a 31 46 51 63 47 75 6f 51 42 66 8d WovZ1fQ cGu08f-	
0100 0a 41 63 63 65 70 74 2d 45 6e 63 6f 64 69 6e 67 -Accept- Encoding	
0110 3a 20 6f 7a 69 70 2c 20 64 65 66 6c 61 74 65 8d ; gzip, deflate;	
0120 0a 43 6f 6e 6e 65 63 74 69 6f 6e 3a 20 6b 65 85 -Connect ion: kee	

```

> Frame 154: 210 bytes on wire (1680 bits), 210 bytes captured (1680 bits) on interface en0, id 0
> Ethernet II, Src: Apple b8:14:f6:16:10 (88:146:3a:48:16:10), Dst: Arcadyan 3b:55:89 (3c:bd:c5:3b:55:89)
> Internet Protocol Version 4, Src: 192.168.1.155, Dst: 128.119.245.12
> Transmission Control Protocol, Src Port: 61053, Dst Port: 80, Seq: 152786, Ack: 1, Len: 144
> [154] Reassembly TCP Segment (152929 bytes): #37(608), #38(1137), #39(1440), #40(1440), #41(1440), #42(1440), #43(1440), #44(1440), #45(1440), #46(1440), #47(1440), #49(1440), #52(1440), #53(1440), #54(1440), #55(1440), #56(1440)
> Hypertext Transfer Protocol
> MIME multipart media encapsulation, Type: multipart/form-data, Boundary: "-----WebKitFormBoundaryMoyZ1FQcGuo0BF"

```

```

00000000 50 4f 53 54 20 2f 77 69 72 65 73 68 61 72 60 2d POST /wireshark-
00000010 6c 61 62 73 2f 6c 61 62 33 2d 31 2d 72 65 70 6c labs/lab-3-1-repl
00000020 79 2e 68 74 6d 20 48 54 54 50 2f 31 2e 31 0d 0a y.htm HTTP/1.1...
00000030 48 6f 73 74 3a 20 67 61 69 61 2e 63 73 2e 75 6d Host: gaia.cs.um
00000040 61 73 73 2e 65 64 75 0d 0a 4f 72 69 67 69 6e 3a ss.edu ->Origin:
00000050 20 68 74 74 70 3a 2f 2f 67 61 69 61 2e 63 73 2e http://gaia.cs.
00000060 75 6e 61 73 73 2e 65 64 75 0d 0a 43 6f 6e 74 65 umass.edu u-Conte
00000070 6e 14 2d 54 79 70 65 3a 20 6d 75 6c 74 69 70 61 nt-Type: multipa
00000080 72 74 2f 66 6f 72 6d 2d 64 61 74 61 3b 20 62 6f rt/form-data; bo
00000090 75 6e 64 61 72 79 3d 2d 2d 2d 2d 57 65 62 4b 69 undary=-----WebKi
000000a0 74 46 6f 72 6d 42 6f 75 6e 64 61 72 79 6f 59 4d fFormBoundaryM
000000b0 6f 59 5a 31 46 51 63 47 75 6f 51 42 66 0d 0a 41 oY21FQcGuo0BF--A
000000c0 63 65 70 74 2d 45 6e 63 6f 64 69 6e 67 3a 28 ccept-En coding:
000000d0 67 7a 69 70 2c 20 64 65 66 6c 61 74 65 0d 0a 43 grip, de flate-C
000000e0 6f 6e 6e 65 63 74 69 6f 6e 3a 20 6b 65 65 70 2d onnectio n: keep-
000000f0 61 6c 69 76 65 0d 0a 55 70 67 72 61 64 65 2d 49 alive-U pgrade-I
00000100 6e 73 65 63 75 72 65 2d 52 65 71 75 65 73 74 73 nsecure-Requests
00000110 3a 20 31 0d 0a 41 63 63 65 70 74 3a 20 74 65 70 i 1-Acc ept: tex
00000120 74 2f 68 74 6d 6c 2c 61 70 70 6c 69 63 61 74 69 t/html,a pplicati
00000130 6f 6e 2f 78 68 74 6d 6c 2b 70 6d 6c 2c 61 70 78 on/html+xml, app
00000140 6c 69 63 61 74 69 6f 6e 2f 78 6d 6c 3b 71 3d 30 lication /xml;q=0
00000150 2e 39 2c 2a 2f 2a 3b 71 3d 30 2e 38 0d 0a 55 73 ,9,*/*;q =0.8-US
00000160 65 72 2d 41 67 65 6e 74 3a 20 4d 6f 7a 69 6c 6c er-Agent : Mozilla
00000170 61 2f 35 2e 30 20 28 4d 61 63 69 6e 74 6f 73 68 a/5.0 (Macintosh
00000180 20 20 49 6e 74 65 6c 20 4d 61 63 20 4f 53 20 58 ; Intel Mac OS X
00000190 20 31 30 5f 31 35 5f 37 29 20 41 70 70 6c 65 57 10.15.7 ) AppleW
000001a0 65 62 4b 69 74 2f 36 30 35 2e 31 2e 31 35 20 28 ebKit/60.5.1.15 (
000001b0 4b 48 54 4d 4c 2c 20 6c 69 6b 65 20 47 65 63 6b iHTML, l ike Geck
000001c0 6f 29 20 56 65 72 73 69 6f 6e 2f 31 3a 2e 31 2e o) Version/34.1.

```

**The sequence number of the TCP segment containing the HTTP header is 1. This TCP segment contains 608 bytes of data. No, the data was divided into 108 segments.**

6. Consider the TCP segment containing the HTTP “POST” as the first segment in the data transfer part of the TCP connection.

- At what time was the first segment (the one containing the HTTP POST) in the data-transfer part of the TCP connection sent?

```

Sequence Number: 1 (relative sequence number)
Sequence Number (raw): 583805658
[Next Sequence Number: 609 (relative sequence number)]
Acknowledgment Number: 1 (relative ack number)
Acknowledgment number (raw): 1808046005
1800 .... = Header Length: 32 bytes (8)
> Flags: 0x018 (PSH, ACK)
Window: 2058
[Calculated window size: 131712]
[Window size scaling factor: 64]
Checksum: 8bd75e [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0
> Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
> [SEQ/ACK analysis]
> [Timestamps]
TCP payload (608 bytes)
[Reassembled PDU in frame: 154]
TCP segment data (608 bytes)
0000 3c bd c5 3b 55 89 88 66 5a 48 f6 10 08 00 45 00 <>U 5F ZH...E
0010 02 94 00 00 40 00 40 00 00 9d c0 a0 01 30 80 77 ...@ @.....w
0020 f5 0c ee 7d 00 50 22 bf f5 da 6b c4 97 b5 80 18 ...} P...k:...
0030 00 0a d7 5a 00 00 01 01 08 0a 49 68 9a 72 fd 31 ...Z...Th r.l
0040 56 05 50 4f 53 54 20 2f 77 69 72 65 73 68 61 72 V POST /wireshar
0050 6b 2d 6c 61 62 73 2f 6c 61 62 33 2d 31 2d 72 65 k-labs/l ab3-1-re
0060 70 6c 79 2e 68 74 74 6d 20 48 54 54 50 2f 31 2e 31 ply.htm HTTP/1.1
0070 0d 0a 48 6f 72 74 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 4f 72 69 67 69 6e umass.edu u-Origi
0090 6e 3a 20 68 74 74 70 3a 2f 2f 67 61 69 61 2e 63 n: http://gaia.c
00a0 72 2e 75 6d 61 73 73 2e 65 64 75 0d 0a 43 6f 6e s.umass.edu Con
00b0 74 65 6e 74 2d 54 79 70 65 3a 20 6d 75 6c 74 69 tent-ty e: multi
00c0 70 61 72 74 2f 66 6f 72 6d 2d 64 61 74 61 3b 20 part/for m-data;
00d0 6f 6e 2f 78 68 74 6d 6c 2b 70 6d 6c 2c 61 70 78

```

**Answer: The first segment in the data-transfer part of the TCP connection was sent at 0.837022.**

- At what time was the ACK for this first data-containing segment received?

**Answer: The ACK for the first data-containing segment was received at 0.853552.**

- What is the RTT for this first data-containing segment?

**Answer:  $RTT = 0.853552 - 0.832022 = 0.02153$  EstimatedRTT for first data-containing segment is: 0.02153 s**

- What is the RTT value the second data-carrying TCP segment and its ACK?
- What is the EstimatedRTT value (see Section 3.5.3, in the text) after the ACK for the second data-carrying segment is received?

```
Destination Port: 61053
[Stream index: 4]
[TCP Segment Len: 0]
Sequence Number: 1 (relative sequence number)
Sequence Number (raw): 1808046005
[Next Sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 745 (relative ack number)
Acknowledgment number (raw): 583006403
1000 .... = Header Length: 32 bytes (8)
> Flags: 0x010 (ACK)
Window: 246
[Calculated window size: 31488]
[Window size scaling factor: 128]
Checksum: 0xf918 [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0
> Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
> [SEQ/ACK analysis]
> [Timestamps]
0000 00 66 5a 48 16 10 3c bd c5 3b 55 89 00 00 45 00  -ZH<-<-U...E-
0010 00 34 c1 a4 40 00 33 06 4e 58 80 77 f5 0c c0 a8  -4@3: NXw....
0020 01 90 00 50 ee 7d 6b c4 97 b5 22 bf f8 c3 80 10  -Pjk.....
0030 00 16 19 10 00 00 01 01 08 0a fd 31 56 16 49 68  -.....IV-In
0040 9a 73  -s
[Checksum Status: Unverified]
Urgent Pointer: 0
> Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
0000 3c bd c5 3b 55 89 88 66 5a 48 16 10 00 00 45 00  <-;U-f ZH...E-
0010 00 bd 00 00 48 06 92 74 c0 a8 01 9b 80 77  -@ t...w
0020 15 8c ee 7d 00 58 22 bf f8 3a 0b c4 97 b5 05 80 18  -3p- -jk....
0030 00 0a 26 51 00 00 01 01 08 0a 49 68 9a 73 fd 31  -6Q....-Ih-s-1
0040 56 85 2d 2f 20 2d 2d 20 57 65 02 4b 69 74 46 6f  -V-----WebKlfo
0050 72 6d 42 6f 75 6e 64 61 72 79 6f 59 4d 6f 59 5a  -rmBounda ryoMoyZ
0060 31 46 51 63 47 75 6f 51 42 66 0d 0a 43 6f 6e 74  -lFQcGuoQ BF-Cont
0070 65 6e 74 2d 44 69 73 70 6f 73 69 74 69 6f 6e 3a  -ent-Disp osition:
0080 20 66 6f 72 6d 2d 64 61 74 61 31 3b 20 6e 01 6d 65  -form-da ts; name
0090 3d 22 66 69 6c 65 22 3b 20 66 69 6c 65 6e 61 6d  -"file"; filenan
00a0 65 3d 22 61 78 74 22 6d 0a 43  -er"alice .txt"-C
00b0 6f 6e 74 65 6e 74 2d 54 79 70 65 3a 20 74 65 78  -otent-T ype: tex
00c0 74 2f 70 6c 61 69 6e 8d 0a 0d 0a  -t/plain ...
```

**The first TCP segment is 608 bytes long, and the second TCP segment is 137 bytes long. Each of the following five TCP segments is 1448 bytes long.**

8. What is the minimum amount of available buffer space advertised to the client by gaia.cs.umass.edu among these first four data-carrying TCP segments?

Does the lack of receiver buffer space ever throttle the sender for these first four data-carrying segments?

```
Transmission Control Protocol, Src Port: 61053, Dst Port: 80, Seq: 1, Ack: 1, Len: 608
Source Port: 61053
Destination Port: 80
[Stream index: 4]
[TCP Segment Len: 608]
Sequence Number: 1 (relative sequence number)
Sequence Number (raw): 583005658
[Next Sequence Number: 609 (relative sequence number)]
Acknowledgment Number: 1 (relative ack number)
Acknowledgment number (raw): 1808046005
1000 .... = Header Length: 32 bytes (8)
> Flags: 0x010 (PSH, ACK)
Window: 2050
[Calculated window size: 131712]
[Window size scaling factor: 64]
Checksum: 0xd75a [unverified]
[Checksum Status: Unverified]
Urgent Pointer: 0
> Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
0030 00 0a d7 5a 00 00 01 01 08 0a 49 68 9a 72 fd 31  -...Z....-Ih-r-1
0040 56 05 50 4f 53 54 20 2f 77 69 72 65 73 68 61 72  -V POST / wireshar
0050 60 38 6c 61 62 73 2f 6c 61 62 33 2d 31 2d 72 65  -k-labs/l 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 15 6d 61 73 73 2e 65 64 75 0d 0a 4f 72 69 67 69  -umass.ed u-Origi
0090 6e 3a 20 68 74 74 70 3a 2f 2f 67 61 69 61 2e 63  -n: http: //gaia.C
00a0 73 2e 75 6d 61 73 73 2e 65 64 75 0d 0a 43 6f 6e  -s.umass. edu-Con
00b0 74 65 6e 74 2d 54 79 70 65 3a 20 6d 75 6c 74 69  -ent-Type e: null
00c0 70 61 72 74 2f 66 6f 72 6d 2d 64 61 74 61 3b 20  -part/for m-data;
00d0 62 6f 75 6e 64 61 72 79 3d 2d 2d 2d 2d 57 65 62  -boundary -----Web
00e0 4b 69 74 46 6f 72 6d 42 6f 75 6e 64 61 72 79 6f  -kitform boundaryo
00f0 59 4d 6f 59 3a 31 46 51 63 47 75 6f 51 42 66 8d  -YMoY2lFQ cGuoQBF-
0100 0a 41 63 63 65 70 74 2d 45 6e 63 6f 64 69 6e 67  -Accept- Encoding
```

**Gaia.cs.umass.edu advertises 131712 Bytes of available buffer space among the first four data-carrying TCP segments to the client. For these first four data-carrying segments, the sender is never throttled due to a lack of receiver buffer space.**

9. 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 the trace file. We can verify this by checking the sequence numbers of the TCP segments in the trace file. In the trace, all sequence numbers are increasing monotonically with respect to time. If there is a retransmitted segment, the sequence number of this retransmitted segment should be smaller than those of its neighboring segments and these retransmitted segments would be highlighted in black.***

10. How much data does the receiver typically acknowledge in an ACK among the first ten data-carrying segments sent from the client to gaia.cs.umass.edu? Can you identify cases where the receiver is ACKing every other received segment (see Table 3.2 in the text) among these first ten data-carrying segments?

Acknowledgement	Acknowledged Sequence Number	Acknowledged Data
ACK 1	609	608
ACK 2	746	137
ACK 3	2194	1448
ACK 4	3642	1448
ACK 5	5090	1448
ACK 6	6538	1448
ACK 7	7986	1448
ACK 8	9434	1448
ACK 9	10882	1448
ACK 10	12330	1448

***Among the first ten data-carrying segments sent from the client to gaia.cs.umass.edu, the receiver typically acknowledges 1448 bytes in an ACK. There are cases where the receiver is ACKing every other segment based on the amount of acknowledged data by each ACK. A segment of No. 80, for example, acknowledged data with 2920 bytes = 1460\*2 bytes.***

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



Length	Info
60	01052 → 443 [ACK] Seq=1423 Ack=1203 Win=130490 Len=0 TSval=1231592050 TSecr=3463011010
78	61053 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 WS=64 TSval=1231592024 TSecr=0 SACK_PERM=1
66	61053 → 80 [ACK] Seq=1 Ack=1 Win=131712 Len=0 TSval=1231592050 TSecr=4247868933
674	61053 → 80 [PSH, ACK] Seq=1 Ack=1 Win=131712 Len=608 TSval=1231592050 TSecr=4247868933 [TCP segment of a reassembled PDU]
203	61053 → 80 [PSH, ACK] Seq=609 Ack=1 Win=131712 Len=137 TSval=1231592051 TSecr=4247868933 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=746 Ack=1 Win=131712 Len=1448 TSval=1231592052 TSecr=4247868933 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=2194 Ack=1 Win=131712 Len=1448 TSval=1231592052 TSecr=4247868933 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=3642 Ack=1 Win=131712 Len=1448 TSval=1231592052 TSecr=4247868933 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=5090 Ack=1 Win=131712 Len=1448 TSval=1231592052 TSecr=4247868933 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=6538 Ack=1 Win=131712 Len=1448 TSval=1231592052 TSecr=4247868933 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=7986 Ack=1 Win=131712 Len=1448 TSval=1231592052 TSecr=4247868933 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=9434 Ack=1 Win=131712 Len=1448 TSval=1231592052 TSecr=4247868933 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=10882 Ack=1 Win=131712 Len=1448 TSval=1231592052 TSecr=4247868933 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=12330 Ack=1 Win=131712 Len=1448 TSval=1231592052 TSecr=4247868933 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=13778 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=15226 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=16674 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=18122 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=19570 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=21018 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=22466 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=23914 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=25362 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=26810 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=28258 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=29706 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=31154 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=32602 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=34050 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=35498 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=36946 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=38394 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=39842 Ack=1 Win=131712 Len=1448 TSval=1231592067 TSecr=4247868950 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=41290 Ack=1 Win=131712 Len=1448 TSval=1231592083 TSecr=4247868967 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=42738 Ack=1 Win=131712 Len=1448 TSval=1231592083 TSecr=4247868967 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=44186 Ack=1 Win=131712 Len=1448 TSval=1231592083 TSecr=4247868967 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=45634 Ack=1 Win=131712 Len=1448 TSval=1231592083 TSecr=4247868967 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=47082 Ack=1 Win=131712 Len=1448 TSval=1231592083 TSecr=4247868967 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=48530 Ack=1 Win=131712 Len=1448 TSval=1231592083 TSecr=4247868967 [TCP segment of a reassembled PDU]
1514	61053 → 80 [ACK] Seq=49978 Ack=1 Win=131712 Len=1448 TSval=1231592083 TSecr=4247868967 [TCP segment of a reassembled PDU]

#### 4. TCP congestion control in action

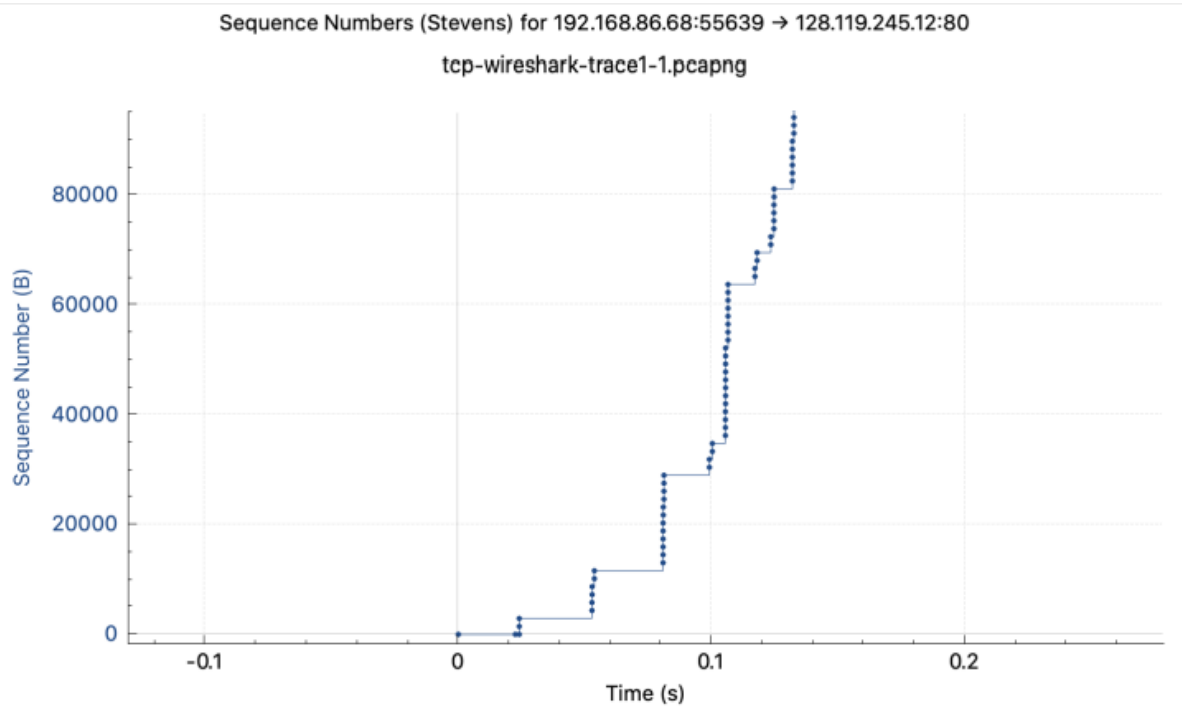


Figure 5: A sequence-number-versus-time plot (Stevens format) of TCP segments.

**The *alice.txt* on the hard drive is 152,138 bytes, and the download time is 5.981633 (last ACK) - 0.837022. (first TCP segment) = 5.144611 seconds. Therefore, the throughput for the TCP connection is computed as  $152,138/5.144611 = 29572.3039$  bytes/second.**

198	11.084593	17.248.175.178	192.168.1.155	TCP	74 443 → 61854 [SYN, ACK] Seq=0 Ack=518 Len=0 MSS=1460 SACK_PERM=1 TSval=2979118827 TSecr=1754624390 WS=128
201	11.095325	17.248.175.178	192.168.1.155	TCP	86 443 → 61854 [ACK] Seq=1 Ack=518 Win=64768 Len=0 TSval=2979118838 TSecr=1754624390
202	11.097826	17.248.175.178	192.168.1.155	TLSv1.3	3514 Server Hello, Change Cipher Spec, Application Data
203	11.097829	17.248.175.178	192.168.1.155	TCP	1514 443 → 61854 [ACK] Seq=1449 Ack=518 Win=64768 Len=3448 TSval=2979118839 TSecr=1754624390 [TCP segment of a reassembled PDU]
204	11.097830	17.248.175.178	192.168.1.155	TCP	1266 443 → 61854 [PSH, ACK] Seq=2897 Ack=518 Win=64768 Len=1280 TSval=2979118839 TSecr=1754624390 [TCP segment of a reassembled PDU]
205	11.097831	17.248.175.178	192.168.1.155	TCP	1514 443 → 61854 [ACK] Seq=4897 Ack=518 Win=64768 Len=3448 TSval=2979118839 TSecr=1754624390 [TCP segment of a reassembled PDU]
206	11.097832	17.248.175.178	192.168.1.155	TLSv1.3	617 Application Data, Application Data, Application Data
216	11.112287	17.248.175.178	192.168.1.155	TCP	92 443 → 61854 [ACK] Seq=6896 Ack=582 Win=64768 Len=0 TSval=2979118856 TSecr=1754624487
217	11.115227	17.248.175.178	192.168.1.155	TLSv1.3	337 Application Data
218	11.115229	17.248.175.178	192.168.1.155	TLSv1.3	337 Application Data
219	11.115238	17.248.175.178	192.168.1.155	TLSv1.3	128 Application Data
220	11.115238	17.248.175.178	192.168.1.155	TCP	85 443 → 61854 [ACK] Seq=6896 Ack=582 Win=64768 Len=0 TSval=2979118856 TSecr=1754624487

13. These “fleets” of segments appear to have some periodicity. What can you say about the period?

**The slow begin of the TCP appears to begin at approximately 0.27 seconds and then ends at approximately zero.35 seconds. Congestion avoidance takes over at about 0.7 seconds because it reduce down the quantity being despatched Via staring at the plot, we will see that the gradual -begin segment handiest lasts for first 1-1.5 2d. Afterwards, it appears that evidently the TCP consultation is usually in congestion avoidance kingdom. In this situation, we do no longer examine the anticipated linear increase behaviour, i.e. the TCP transmit window does no longer grow linearly at some stage in this segment. In truth, it appears that the sender transmits packets in batches of 6. this does not seem to be caused by drift control for the reason that receiver marketed window is substantially large than five packets. The reason for this behaviour might be due to the truth that the HTTP server has enforced a fee-restrict of some kind.**

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](http://gaia.cs.umass.edu)

