

CENG 435 - Data Communications and Networking

2023-1

Wireshark Assignment 3

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1. IP address of my (the client) computer: 144.122.97.2

202	2.489025	144.122.97.2	128.119.245.12	HTTP	3197	POST /wireshark-labs/lab3-1-reply.htm HTTP/1.1 (text/plain)
235	2.655356	128.119.245.12	144.122.97.2	HTTP	831	HTTP/1.1 200 OK (text/html)

Figure 1: IP address of the client computer

2. The client-side port number of the client computer (source): 64535

No.	Time	Source	Destination	Protocol	Length	Info
202	2.489025	144.122.97.2	128.119.245.12	HTTP	3197	POST /wireshark-labs/lab3-1-reply.htm HTTP/1.1 (text/plain)
235	2.655356	128.119.245.12	144.122.97.2	HTTP	831	HTTP/1.1 200 OK (text/html)

Frame 202: 3197 bytes on wire (25576 bits), 3197 bytes captured (25576 bits) on interface \Device\NPF_{C8CA7682-5C7F-429D-9DE7-0BB02CB24562}, id 0	
Ethernet II, Src: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4), Dst: IntelCor_d2:46:ed (00:1b:21:d2:46:ed)	
Internet Protocol Version 4, Src: 144.122.97.2, Dst: 128.119.245.12	
Transmission Control Protocol, Src Port: 64535, Dst Port: 80, Seq: 149872, Ack: 1, Len: 3143	
Source Port: 64535	
Destination Port: 80	
[Stream index: 3]	
[Conversation completeness: Incomplete, DATA (15)]	
[TCP Segment Len: 3143]	
Sequence Number: 149872 (relative sequence number)	
Sequence Number (raw): 1217246652	
[Next Sequence Number: 153015 (relative sequence number)]	
Acknowledgment Number: 1 (relative ack number)	
Acknowledgment number (raw): 905837222	
0101 = Header Length: 20 bytes (5)	
Flags: 0x018 (ACK)	

Figure 2: Port number of the client computer

3. IP address of gaia.cs.umass.edu: 128.119.245.12

202	2.489025	144.122.97.2	128.119.245.12	HTTP	3197	POST /wireshark-labs/lab3-1-reply.htm HTTP/1.1 (text/plain)
235	2.655356	128.119.245.12	144.122.97.2	HTTP	831	HTTP/1.1 200 OK (text/html)

Figure 3: IP address of gaia.cs.umass.edu

4. Port number in which gaia.cs.umass.edu sending and receiving TCP segments for this TCP connection: 80

No.	Time	Source	Destination	Protocol	Length	Info
->	202.2.489025	144.122.97.2	128.119.245.12	HTTP	3197	POST /wireshark-labs/lab3-1-reply.htm HTTP/1.1 (text/plain)
->	235.2.655356	128.119.245.12	144.122.97.2	HTTP	831	HTTP/1.1 200 OK (text/html)


```

> Frame 202: 3197 bytes on wire (25576 bits), 3197 bytes captured (25576 bits) on interface \Device\NPF_{C8CA7682-5C7F-429D-90E7-08B02CB24562}, id 0
> Ethernet II, Src: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4), Dst: IntelCor_d2:46:ed (00:1b:21:d2:46:ed)
> Internet Protocol Version 4, Src: 144.122.97.2, Dst: 128.119.245.12
> Transmission Control Protocol, Src Port: 64535, Dst Port: 80, Seq: 149872, Ack: 1, Len: 3143
  Source Port: 64535
  Destination Port: 80
  [Stream index: 3]
  [Conversation completeness: Incomplete, DATA (15)]
  [TCP Segment Len: 3143]
  Sequence Number: 149872 (relative sequence number)
  Sequence Number (raw): 1217246652
  [Next Sequence Number: 153015 (relative sequence number)]
  Acknowledgment Number: 1 (relative ack number)
  Acknowledgment number (raw): 905837222
  0101 .... = Header Length: 20 bytes (5)

```

Figure 4: Port number of gaia.cs.umass.edu

5. Sequence number of the TCP SYN segment: 1217096780

```

> Frame 122: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface \Device\NPF_{C8CA7682-5C7F-429D-90E7-08B02CB24562}, id 0
> Ethernet II, Src: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4), Dst: IntelCor_d2:46:ed (00:1b:21:d2:46:ed)
> Internet Protocol Version 4, Src: 144.122.97.2, Dst: 128.119.245.12
> Transmission Control Protocol, Src Port: 64535, Dst Port: 80, Seq: 0, Len: 0
  Source Port: 64535
  Destination Port: 80
  [Stream index: 3]
  [Conversation completeness: Incomplete, DATA (15)]
  [TCP Segment Len: 0]
  Sequence Number: 0 (relative sequence number)
  Sequence Number (raw): 1217096780
  [Next Sequence Number: 1 (relative sequence number)]
  Acknowledgment Number: 0
  Acknowledgment number (raw): 0
  1000 .... = Header Length: 32 bytes (8)
  Flags: 0x002 (SYN)
    000. .... = Reserved: Not set
    ...0 .... = Accurate ECN: Not set
    ....0... = Congestion Window Reduced: 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.]

```

Figure 5: Sequence number of the TCP SYN segment

- 6.

```

> Frame 122: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface \Device\NPF_{C8CA7682-5C7F-429D-90E7-08B02CB24562}, id 0
> Ethernet II, Src: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4), Dst: IntelCor_d2:46:ed (00:1b:21:d2:46:ed)
> Internet Protocol Version 4, Src: 144.122.97.2, Dst: 128.119.245.12
> Transmission Control Protocol, Src Port: 64535, Dst Port: 80, Seq: 0, Len: 0
  Source Port: 64535
  Destination Port: 80
  [Stream index: 3]
  [Conversation completeness: Incomplete, DATA (15)]
  [TCP Segment Len: 0]
  Sequence Number: 0 (relative sequence number)
  Sequence Number (raw): 1217096780
  [Next Sequence Number: 1 (relative sequence number)]
  Acknowledgment Number: 0
  Acknowledgment number (raw): 0
  1000 .... = Header Length: 32 bytes (8)
  Flags: 0x002 (SYN)
    000. .... = Reserved: Not set
    ...0 .... = Accurate ECN: Not set
    ....0... = Congestion Window Reduced: 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.]

```

Figure 6: Identification of SYN segment

7.

```
> Frame 122: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface \Device\NPF_{C8CA7682-5C7F-429D-9DE7-0B802CB24562}, id 0
> Ethernet II, Src: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4), Dst: IntelCor_d2:46:ed (00:1b:21:d2:46:ed)
> Internet Protocol Version 4, Src: 144.122.97.2, Dst: 128.119.245.12
▼ Transmission Control Protocol, Src Port: 64535, Dst Port: 80, Seq: 0, Len: 0
  Source Port: 64535
  Destination Port: 80
  [Stream index: 3]
  [Conversation completeness: Incomplete, DATA (15)]
  [TCP Segment Len: 0]
  Sequence Number: 0 (relative sequence number)
  Sequence Number (raw): 1217096780
  [Next Sequence Number: 1 (relative sequence number)]
  Acknowledgment Number: 0
  Acknowledgment number (raw): 0
  1000 .... = Header Length: 32 bytes (8)
  ▼ Flags: 0x002 (SYN)
    Window: 64240
    [Calculated window size: 64240]
    [Checksum: 0x6727 [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
    > TCP Option - Maximum segment size: 1460 bytes
    > TCP Option - No-Operation (NOP)
    > TCP Option - Window scale: 8 (multiply by 256)
    > TCP Option - No-Operation (NOP)
    > TCP Option - No-Operation (NOP)
    > TCP Option - SACK permitted
```

Figure 7: Selective Acknowledgment is permitted

8. Sequence number of the TCP SYNACK segment: 905837221

```
> Frame 137: 66 bytes on wire (528 bits), 66 bytes captured (528 bits)
> Ethernet II, Src: IntelCor_d2:46:ed (00:1b:21:d2:46:ed), Dst: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4)
> Internet Protocol Version 4, Src: 128.119.245.12, Dst: 144.122.97.2
▼ Transmission Control Protocol, Src Port: 80, Dst Port: 64535, Seq: 0, Ack: 1, Len: 0
  Source Port: 80
  Destination Port: 64535
  [Stream index: 3]
  [Conversation completeness: Incomplete, DATA (15)]
  [TCP Segment Len: 0]
  Sequence Number: 0 (relative sequence number)
  Sequence Number (raw): 905837221
  [Next Sequence Number: 1 (relative sequence number)]
  Acknowledgment Number: 1 (relative ack number)
  Acknowledgment number (raw): 1217096781
  1000 .... = Header Length: 32 bytes (8)
  ▼ Flags: 0x012 (SYN, ACK)
    000. .... = Reserved: Not set
    ...0 .... = Accurate ECN: Not set
    .... 0... = Congestion Window Reduced: 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: 29200
  [Calculated window size: 29200]
```

Figure 8: Sequence number of the TCP SYNACK segment

9.

```
[Stream index: 3]
[Conversation completeness: Incomplete, DATA (15)]
[TCP Segment Len: 0]
Sequence Number: 0 (relative sequence number)
Sequence Number (raw): 905837221
[Next Sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 1 (relative ack number)
Acknowledgment number (raw): 1217096781
1000 .... = Header Length: 32 bytes (8)
▼ Flags: 0x012 (SYN, ACK)
  000. .... = Reserved: Not set
  ...0 .... = Accurate ECN: Not set
  .... 0... = Congestion Window Reduced: 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: 29200
```

Figure 9: Identification of SYNACK segment

10. Value in the Acknowledgment field of the TCP SYNACK segment: 1217096781

```
> Frame 137: 66 bytes on wire (528 bits), 66 bytes captured (528 bits)
> Ethernet II, Src: IntelCor_d2:46:ed (00:1b:21:d2:46:ed), Dst: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4)
> Internet Protocol Version 4, Src: 128.119.245.12, Dst: 144.122.97.2
▼ Transmission Control Protocol, Src Port: 80, Dst Port: 64535, Seq: 0, Ack: 1, Len: 0
  Source Port: 80
  Destination Port: 64535
  [Stream index: 3]
  [Conversation completeness: Incomplete, DATA (15)]
  [TCP Segment Len: 0]
  Sequence Number: 0 (relative sequence number)
  Sequence Number (raw): 905837221
  [Next Sequence Number: 1 (relative sequence number)]
  Acknowledgment Number: 1 (relative ack number)
  Acknowledgment number (raw): 1217096781
  1000 .... = Header Length: 32 bytes (8)
  ▼ Flags: 0x012 (SYN, ACK)
    000. .... = Reserved: Not set
    ...0 .... = Accurate ECN: Not set
    .... 0... = Congestion Window Reduced: 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: 29200
    [Calculated window size: 29200]
```

Figure 10: Acknowledgment field of the TCP SYNACK segment

11. The value of the ACK number field is the sequence number of the next expected byte of data to be received at the server on the client-to-server direction of this connection – one higher than the sequence number used as the sequence number in the initial SYN segment sent from client to server.

12. Sequence number of the TCP segment containing the HTTP POST command: 1217096781

```
> Frame 139: 749 bytes on wire (5992 bits), 749 bytes captured (5992 bits)
> Ethernet II, Src: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4), Dst: IntelCor_d2:46:ed (00:1b:21:d2:46:ed)
> Internet Protocol Version 4, Src: 144.122.97.2, Dst: 128.119.245.12
▼ Transmission Control Protocol, Src Port: 64535, Dst Port: 80, Seq: 1, Ack: 1, Len: 695
    Source Port: 64535
    Destination Port: 80
    [Stream index: 3]
    [Conversation completeness: Incomplete, DATA (15)]
    [TCP Segment Len: 695]
    Sequence Number: 1 (relative sequence number)
    Sequence Number (raw): 1217096781
    [Next Sequence Number: 696 (relative sequence number)]
    Acknowledgment Number: 1 (relative ack number)
    Acknowledgment number (raw): 905837222
    0101 .... = Header Length: 20 bytes (5)
    ▼ Flags: 0x018 (PSH, ACK)
        000. .... = Reserved: Not set
        ...0 .... = Accurate ECN: Not set

0020 f5 0c fc 17 00 50 48 8b 6c 4d 35 fd fa a6 50 18 .....PH..MS...P.
0030 01 00 69 d2 00 00 50 4f 53 54 20 2f 77 69 72 65 ...i...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 l-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.umass.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
00a0 65 6e 67 74 68 3a 20 31 35 32 33 31 39 0d 0a 43 length: 1 52319..C
00b0 61 63 68 65 2d 43 6f 6e 74 72 6f 6c 3a 20 6d 61 ache-Con trol: ma
00c0 78 2d 61 67 65 3d 30 0d 0a 55 70 67 72 61 64 65 x-age=0. .Upgrade
00d0 2d 49 6e 73 65 63 75 72 65 2d 52 65 71 75 65 73 -Insecu re-Reques
00e0 74 73 3a 20 31 0d 0a 4f 72 69 67 69 6e 3a 20 68 ts: 1..O rigin: h
00f0 74 74 70 3a 2f 2f 67 61 69 61 2e 63 73 2e 75 6d ttp://ga ia.cs.um
0100 61 73 73 2e 65 64 75 0d 0a 43 6f 6e 74 65 6e 74 ass.edu.. .Content
0110 2d 54 79 70 65 3a 20 6d 75 6c 74 69 70 61 72 74 -Type: m ultipart
0120 2f 66 6f 72 6d 2d 64 61 74 61 3b 20 62 6f 75 6e /form-da ta; boun
0130 64 61 72 79 3d 2d 2d 2d 2d 5f 65 62 4b 69 74 46 dary=--- -WebKitF
0140 6f 72 6d 42 6f 75 6e 64 61 72 79 44 55 4a 6b 63 ormBound aryDUJkc
0150 78 73 52 31 73 54 4b 77 32 55 56 0d 0a 55 73 65 xsRlsTKw 2UV..Use
0160 72 2d 41 67 65 6e 74 3a 20 4d 6f 7a 69 6c 6c 61 n-Agent: Mozilla
0170 2f 35 2e 30 20 28 57 69 6e 64 6f 77 73 20 4e 54 /5.0 (Wi ndows NT
0180 20 31 30 2e 30 3b 20 57 69 6e 36 34 3b 20 78 36 10.0; W in64; x6
```

Figure 11: Sequence number of the TCP segment containing the HTTP POST command

13. Number of bytes of data are contained in the payload (data) field of this TCP segment: 695

```
> Frame 139: 749 bytes on wire (5992 bits), 749 bytes captured (5992 bits)
> Ethernet II, Src: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4), Dst: IntelCor_d2:46:ed (00:1b:21:d2:46:ed)
> Internet Protocol Version 4, Src: 144.122.97.2, Dst: 128.119.245.12
▼ Transmission Control Protocol, Src Port: 64535, Dst Port: 80, Seq: 1, Ack: 1, Len: 695
    Source Port: 64535
    Destination Port: 80
    [Stream index: 3]
    [Conversation completeness: Incomplete, DATA (15)]
    [TCP Segment Len: 695]
    Sequence Number: 1 (relative sequence number)
    Sequence Number (raw): 1217096781
    [Next Sequence Number: 696 (relative sequence number)]
    Acknowledgment Number: 1 (relative ack number)
    Acknowledgment number (raw): 905837222
    0101 .... = Header Length: 20 bytes (5)
    ▼ Flags: 0x018 (PSH, ACK)
        Window: 256
        [Calculated window size: 65536]
        [Window size scaling factor: 256]
        Checksum: 0x69d2 [unverified]
        [Checksum Status: Unverified]
        Urgent Pointer: 0
    > [Timestamps]
    > [SEQ/ACK analysis]
    TCP payload (695 bytes)
    Reassembled PDU in frame: 202
    TCP segment data (695 bytes)
```

Figure 12: Number of bytes of data are contained in the payload (data)

14. Nope. Not even close. The `alice.txt` file is much larger, and so multiple TCP segments will be needed to transfer the file as part of the single application-level HTTP POST message. **I understand this from the fact that content of the file is spread across multiple segment. Here is a part of the content in another (the second segment sent to server) segment.**

```
> Frame 140: 11628 bytes on wire (93024 bits), 11628 bytes captured (93024 bits)
> Ethernet II, Src: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4), Dst: IntelCor_d2:46:ed (00:1b:21:d2:46:ed)
> Internet Protocol Version 4, Src: 144.122.97.2, Dst: 128.119.245.12
✓ Transmission Control Protocol, Src Port: 64535, Dst Port: 80, Seq: 696, Ack: 1, Len: 11574
  Source Port: 64535
  Destination Port: 80
  [Stream index: 3]
  [Conversation completeness: Incomplete, DATA (15)]
  [TCP Segment Len: 11574]
  Sequence Number: 696      (relative sequence number)
  Sequence Number (raw): 1217097476
  [Next Sequence Number: 12270      (relative sequence number)]
  Acknowledgment Number: 1      (relative ack number)
  Acknowledgment number (raw): 905837222
  0101 .... = Header Length: 20 bytes (5)
  > Flags: 0x010 (ACK)
  Window: 256
  [Calculated window size: 65536]
```

0150	0a 0d 0a 0d 0a 0d 0a 0d	0a 20 20 20 20 20 20 20
0160	20 20 20 20 20 20 20 20	20 20 20 20 20 20 20 20	
0170	20 20 20 20 20 43 48 41	50 54 45 52 20 49 0d 0a	CHAPTER I...
0180	0d 0a 20 20 20 20 20 20	20 20 20 20 20 20 20 20	..
0190	20 20 20 20 20 20 20 20	44 6f 77 6e 20 74 68 65	Down the
01a0	20 52 61 62 62 69 74 2d	48 6f 6c 65 0d 0a 0d 0a	Rabbit-Hole....
01b0	0d 0a 20 20 41 6c 69 63	65 20 77 61 73 20 62 65	.. Alic e was be
01c0	67 69 6e 6e 69 6e 67 20	74 6f 20 67 65 74 20 76	ginning to get v
01d0	65 72 79 20 74 69 72 65	64 20 6f 66 20 73 69 74	ery tire d of sit
01e0	74 69 6e 67 20 62 79 20	68 65 72 20 73 69 73 74	ting by her sist
01f0	65 72 0d 0a 6f 6e 20 74	68 65 20 62 61 6e 6b 2c	er..on t he bank,
0200	20 61 6e 64 20 6f 66 20	68 61 76 69 6e 67 20 6e	and of having n
0210	6f 74 68 69 6e 67 20 74	6f 20 64 6f 3a 20 20 6f	othing t o do: o
0220	6e 63 65 20 6f 72 20 74	77 69 63 65 20 73 68 65	nce or t wice she
0230	20 68 61 64 0d 0a 70 65	65 70 65 64 20 69 6e 74	had..pe eped int
0240	6f 20 74 68 65 20 62 6f	6f 6b 20 68 65 72 20 73	o the bo ok her s
0250	69 73 74 65 72 20 77 61	73 20 72 65 61 64 69 6e	ister wa s readin
0260	67 2c 20 62 75 74 20 69	74 20 68 61 64 20 6e 6f	g, but i t had no
0270	0d 0a 70 69 63 74 75 72	65 73 20 6f 72 20 63 6f	..pictur es or co
0280	6e 76 65 72 73 61 74 69	6f 6e 73 20 69 6e 20 69	nversati ons in i
0290	74 2c 20 60 61 6e 64 20	77 68 61 74 20 69 73 20	t, `and what is
02a0	74 68 65 20 75 73 65 20	6f 66 20 61 20 62 6f 6f	the use of a boo
02b0	6b 2c 27 0d 0a 74 68 6f	75 67 68 74 20 41 6c 69	k,'..tho ught Ali

Figure 13: Part of the data in `alice.txt` in another segment

15. Time that the first segment (the one containing the HTTP POST) in the data-transfer part of the TCP connection sent: 2.021111

```
139 2.021111 144.122.97.2 128.119.245.12 TCP 749 64535 → 80 [PSH, ACK] Seq=1 Ack=1 Win=65536 Len=695 [TCP segment of a reassembled PDU]
```

Figure 14: t_{sent}

16. Time that the ACK for this first data-containing segment received: 2.174320

```
150 2.174320 128.119.245.12 144.122.97.2 TCP 56 80 → 64535 [ACK] Seq=1 Ack=696 Win=30592 Len=0
```

Figure 15: t_{ACK}

$$17. t_{ACK} - t_{sent} = 2.174320 - 2.021111 = 0.153209 \text{ s}$$

```

> Frame 150: 56 bytes on wire (448 bits), 56 bytes captured (448 bits)
> Ethernet II, Src: IntelCor_d2:46:ed (00:1b:21:d2:46:ed), Dst: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4)
> Internet Protocol Version 4, Src: 128.119.245.12, Dst: 144.122.97.2
v Transmission Control Protocol, Src Port: 80, Dst Port: 64535, Seq: 1, Ack: 696, Len: 0
    Source Port: 80
    Destination Port: 64535
    [Stream index: 3]
    [Conversation completeness: Incomplete, DATA (15)]
    [TCP Segment Len: 0]
    Sequence Number: 1 (relative sequence number)
    Sequence Number (raw): 905837222
    [Next Sequence Number: 1 (relative sequence number)]
    Acknowledgment Number: 696 (relative ack number)
    Acknowledgment number (raw): 1217097476
    0101 .... = Header Length: 20 bytes (5)
> Flags: 0x010 (ACK)
    Window: 239
    [Calculated window size: 30592]
    [Window size scaling factor: 128]
    Checksum: 0x6349 [unverified]
    [Checksum Status: Unverified]
    Urgent Pointer: 0
> [Timestamps]
v [SEQ/ACK analysis]
    [This is an ACK to the segment in frame: 139]
    [The RTT to ACK the segment was: 0.153209000 seconds]
    [iRTT: 0.146998000 seconds]

```

Figure 16: RTT for the first segment

$$18. t_{ACK2} - t_{sent2} = 2.174320 - 2.021336 = 0.152984 \text{ s}$$

140	2.021336	144.122.97.2	128.119.245.12	TCP	11628	64535 → 80	[ACK] Seq=696 Ack=1 Win=65536 Len=11574	[TCP segment of a reassembled PDU]
-----	----------	--------------	----------------	-----	-------	------------	---	------------------------------------

Figure 17: t_{sent2}

153	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535	[ACK] Seq=1 Ack=12270 Win=54144 Len=0
-----	----------	----------------	--------------	-----	----	------------	---------------------------------------

Figure 18: t_{ACK2}

```

> Frame 153: 56 bytes on wire (448 bits), 56 bytes captured (448 bits)
> Ethernet II, Src: IntelCor_d2:46:ed (00:1b:21:d2:46:ed), Dst: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4)
> Internet Protocol Version 4, Src: 128.119.245.12, Dst: 144.122.97.2
✓ Transmission Control Protocol, Src Port: 80, Dst Port: 64535, Seq: 1, Ack: 12270, Len: 0
    Source Port: 80
    Destination Port: 64535
    [Stream index: 3]
    [Conversation completeness: Incomplete, DATA (15)]
    [TCP Segment Len: 0]
    Sequence Number: 1 (relative sequence number)
    Sequence Number (raw): 905837222
    [Next Sequence Number: 1 (relative sequence number)]
    Acknowledgment Number: 12270 (relative ack number)
    Acknowledgment number (raw): 1217109050
    0101 .... = Header Length: 20 bytes (5)
  > Flags: 0x010 (ACK)
    Window: 423
    [Calculated window size: 54144]
    [Window size scaling factor: 128]
    Checksum: 0x355b [unverified]
    [Checksum Status: Unverified]
    Urgent Pointer: 0
  > [Timestamps]
  ✓ [SEQ/ACK analysis]
    [This is an ACK to the segment in frame: 140]
    [The RTT to ACK the segment was: 0.152984000 seconds]
    [iRTT: 0.146998000 seconds]

```

Figure 19: RTT for the second segment

$$19. \text{Estimated RTT} = (1 - 0.125) \times \text{Estimated RTT} + 0.125 \times \text{Sample RTT}$$

Estimated RTT after receiving ACK of the first segment

$$\text{Estimated RTT} = 0.153209$$

Estimated RTT after receiving ACK of the second segment

$$\text{Estimated RTT} = (1 - 0.125) \times 0.153209 + 0.125 \times 0.152984 = \mathbf{0.153181 \text{ s}}$$

No.	Time	Source	Destination	Protocol	Length	Info
102	1.649071	144.122.97.2	142.250.187.142	TCP	55	64490 → 443 [ACK] Seq=1 Ack=1 Win=251 Len=1 [TCP segment of a reassembled PDU]
104	1.666358	142.250.187.142	144.122.97.2	TCP	66	443 → 64490 [ACK] Seq=1 Ack=2 Win=288 Len=0 SLE=1 SRE=2
121	1.873287	144.122.97.2	128.119.245.12	TCP	54	64525 → 80 [FIN, ACK] Seq=1 Ack=1 Win=252 Len=0
122	1.873550	144.122.97.2	128.119.245.12	TCP	66	64535 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
136	2.020404	128.119.245.12	144.122.97.2	TCP	56	80 → 64525 [ACK] Seq=1 Ack=2 Win=237 Len=0
137	2.020404	128.119.245.12	144.122.97.2	TCP	66	80 → 64535 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1286 SACK_PERM WS=128
138	2.020548	144.122.97.2	128.119.245.12	TCP	54	64535 → 80 [ACK] Seq=1 Ack=1 Win=65536 Len=0
139	2.021111	144.122.97.2	128.119.245.12	TCP	749	64535 → 80 [PSH, ACK] Seq=1 Ack=1 Win=65536 Len=695 [TCP segment of a reassembled PDU]
140	2.021336	144.122.97.2	128.119.245.12	TCP	11628	64535 → 80 [ACK] Seq=696 Ack=1 Win=65536 Len=11574 [TCP segment of a reassembled PDU]
150	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=696 Win=30592 Len=0
151	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=1982 Win=33536 Len=0
152	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=7126 Win=43904 Len=0
153	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=12270 Win=54144 Len=0
154	2.174375	144.122.97.2	128.119.245.12	TCP	24488	64535 → 80 [PSH, ACK] Seq=12270 Ack=1 Win=65536 Len=24434 [TCP segment of a reassembled PDU]
171	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=13556 Win=57088 Len=0
172	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=18700 Win=67328 Len=0
173	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=25130 Win=80256 Len=0
174	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=31560 Win=93056 Len=0
175	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=36704 Win=103424 Len=0
176	2.329838	144.122.97.2	128.119.245.12	TCP	32204	64535 → 80 [PSH, ACK] Seq=36704 Ack=1 Win=65536 Len=32150 [TCP segment of a reassembled PDU]
177	2.329916	144.122.97.2	128.119.245.12	TCP	16772	64535 → 80 [PSH, ACK] Seq=68854 Ack=1 Win=65536 Len=16718 [TCP segment of a reassembled PDU]
190	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=37990 Win=106240 Len=0
191	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=43134 Win=116608 Len=0
192	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=49564 Win=129408 Len=0
193	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=55994 Win=142336 Len=0
194	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=62424 Win=155136 Len=0
195	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=68854 Win=168064 Len=0
196	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=70140 Win=170880 Len=0
197	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=75284 Win=179584 Len=0
198	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=81714 Win=179584 Len=0
199	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=85572 Win=181632 Len=0
200	2.488910	144.122.97.2	128.119.245.12	TCP	32204	64535 → 80 [PSH, ACK] Seq=85572 Ack=1 Win=65536 Len=32150 [TCP segment of a reassembled PDU]
201	2.488984	144.122.97.2	128.119.245.12	TCP	32204	64535 → 80 [PSH, ACK] Seq=117722 Ack=1 Win=65536 Len=32150 [TCP segment of a reassembled PDU]
202	2.489025	144.122.97.2	128.119.245.12	HTTP	3197	POST /wirespark-labs/lab3-1-reply.htm HTTP/1.1 (text/plain)
220	2.653676	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=86858 Win=183296 Len=0
221	2.653676	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=92002 Win=179584 Len=0
222	2.653676	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=98432 Win=174592 Len=0

Figure 20: Length (header plus payload) of each of the first four data-carrying TCP segments

139	2.021111	144.122.97.2	128.119.245.12	TCP	749	64535 → 80 [PSH, ACK] Seq=1 Ack=1 Win=65536 Len=695 [TCP segment of a reassembled PDU]
140	2.021336	144.122.97.2	128.119.245.12	TCP	11628	64535 → 80 [ACK] Seq=696 Ack=1 Win=65536 Len=11574 [TCP segment of a reassembled PDU]
150	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=696 Win=30592 Len=0
151	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=1982 Win=33536 Len=0
152	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=7126 Win=43904 Len=0
153	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=12270 Win=54144 Len=0
154	2.174375	144.122.97.2	128.119.245.12	TCP	24488	64535 → 80 [PSH, ACK] Seq=12270 Ack=1 Win=65536 Len=24434 [TCP segment of a reassembled PDU]
171	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=13556 Win=57088 Len=0
172	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=18700 Win=67328 Len=0
173	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=25130 Win=80256 Len=0
174	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=31560 Win=93056 Len=0
175	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=36704 Win=103424 Len=0
176	2.329838	144.122.97.2	128.119.245.12	TCP	32204	64535 → 80 [PSH, ACK] Seq=36704 Ack=1 Win=65536 Len=32150 [TCP segment of a reassembled PDU]
177	2.329916	144.122.97.2	128.119.245.12	TCP	16772	64535 → 80 [PSH, ACK] Seq=68854 Ack=1 Win=65536 Len=16718 [TCP segment of a reassembled PDU]
190	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=37990 Win=106240 Len=0
191	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=43134 Win=116608 Len=0
192	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=49564 Win=129408 Len=0
193	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=55994 Win=142336 Len=0
194	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=62424 Win=155136 Len=0
195	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=68854 Win=168064 Len=0
196	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=70140 Win=170880 Len=0
197	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=75284 Win=179584 Len=0
198	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=81714 Win=179584 Len=0
199	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=85572 Win=181632 Len=0

Figure 21: Minimum amount of available buffer space advertised to the client

22.

No.	Time	Source	Destination	Protocol	Length	Info
121	1.873287	144.122.97.2	128.119.245.12	TCP	54	64525 → 80 [FIN, ACK] Seq=1 Ack=1 Win=252 Len=0
122	1.873550	144.122.97.2	128.119.245.12	TCP	66	64535 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
136	2.020404	128.119.245.12	144.122.97.2	TCP	56	80 → 64525 [ACK] Seq=1 Ack=2 Win=237 Len=0
137	2.020404	128.119.245.12	144.122.97.2	TCP	66	80 → 64535 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1286 SACK_PERM WS=128
138	2.020548	144.122.97.2	128.119.245.12	TCP	54	64535 → 80 [ACK] Seq=1 Ack=1 Win=65536 Len=0
139	2.021111	144.122.97.2	128.119.245.12	TCP	749	64535 → 80 [PSH, ACK] Seq=1 Ack=1 Win=65536 Len=695 [TCP segment of a reassembled PDU]
140	2.021336	144.122.97.2	128.119.245.12	TCP	11628	64535 → 80 [ACK] Seq=696 Ack=1 Win=65536 Len=11574 [TCP segment of a reassembled PDU]
150	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=696 Win=30592 Len=0
151	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=1982 Win=33536 Len=0
152	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=7126 Win=43904 Len=0
153	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=12270 Win=54144 Len=0
154	2.174375	144.122.97.2	128.119.245.12	TCP	24488	64535 → 80 [PSH, ACK] Seq=12270 Ack=1 Win=65536 Len=24434 [TCP segment of a reassembled PDU]
171	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=13556 Win=57088 Len=0
172	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=18700 Win=67328 Len=0
173	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=25130 Win=80256 Len=0
174	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=31560 Win=93056 Len=0
175	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=36704 Win=103424 Len=0
176	2.329838	144.122.97.2	128.119.245.12	TCP	32204	64535 → 80 [PSH, ACK] Seq=36704 Ack=1 Win=65536 Len=32150 [TCP segment of a reassembled PDU]
177	2.329916	144.122.97.2	128.119.245.12	TCP	16772	64535 → 80 [PSH, ACK] Seq=68854 Ack=1 Win=65536 Len=16718 [TCP segment of a reassembled PDU]
190	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=37990 Win=106240 Len=0
191	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=43134 Win=116608 Len=0
192	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=49564 Win=129408 Len=0
193	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=55994 Win=142336 Len=0
194	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=62424 Win=155136 Len=0
195	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=68854 Win=168064 Len=0
196	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=70140 Win=170880 Len=0
197	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=75284 Win=179584 Len=0
198	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=81714 Win=179584 Len=0
199	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=85572 Win=181632 Len=0
200	2.488910	144.122.97.2	128.119.245.12	TCP	32204	64535 → 80 [PSH, ACK] Seq=85572 Ack=1 Win=65536 Len=32150 [TCP segment of a reassembled PDU]
201	2.488984	144.122.97.2	128.119.245.12	TCP	32204	64535 → 80 [PSH, ACK] Seq=117722 Ack=1 Win=65536 Len=32150 [TCP segment of a reassembled PDU]
202	2.489025	144.122.97.2	128.119.245.12	HTTP	3197	POST /wireshark-labs/lab3-1-reply.htm HTTP/1.1 (text/plain)
220	2.653676	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=86858 Win=183296 Len=0
221	2.653676	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=92002 Win=179584 Len=0
222	2.653676	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=98432 Win=174592 Len=0
223	2.653676	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=104862 Win=196096 Len=0
224	2.653676	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=111292 Win=209024 Len=0
225	2.653676	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=117722 Win=221824 Len=0

Figure 22: Throttle check

23. (together with 24)

24.

No.	Time	Source	Destination	Protocol	Length	Info
139	2.021111	144.122.97.2	128.119.245.12	TCP	749	64535 → 80 [PSH, ACK] Seq=1 Ack=1 Win=65536 Len=695 [TCP segment of a reassembled PDU]
140	2.021336	144.122.97.2	128.119.245.12	TCP	11628	64535 → 80 [ACK] Seq=696 Ack=1 Win=65536 Len=11574 [TCP segment of a reassembled PDU]
150	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=696 Win=30592 Len=0
151	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=1982 Win=33536 Len=0
152	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=7126 Win=43904 Len=0
153	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=12270 Win=54144 Len=0
154	2.174375	144.122.97.2	128.119.245.12	TCP	24488	64535 → 80 [PSH, ACK] Seq=12270 Ack=1 Win=65536 Len=24434 [TCP segment of a reassembled PDU]
171	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=13556 Win=57088 Len=0
172	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=18700 Win=67328 Len=0
173	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=25130 Win=80256 Len=0
174	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=31560 Win=93056 Len=0
175	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=36704 Win=103424 Len=0
176	2.329838	144.122.97.2	128.119.245.12	TCP	32204	64535 → 80 [PSH, ACK] Seq=36704 Ack=1 Win=65536 Len=32150 [TCP segment of a reassembled PDU]
177	2.329916	144.122.97.2	128.119.245.12	TCP	16772	64535 → 80 [PSH, ACK] Seq=68854 Ack=1 Win=65536 Len=16718 [TCP segment of a reassembled PDU]
190	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=37990 Win=106240 Len=0
191	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=43134 Win=116608 Len=0
192	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=49564 Win=129408 Len=0
193	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=55994 Win=142336 Len=0
194	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=62424 Win=155136 Len=0
195	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=68854 Win=168064 Len=0
196	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=70140 Win=170880 Len=0
197	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=75284 Win=179584 Len=0
198	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=81714 Win=179584 Len=0
199	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=85572 Win=181632 Len=0
200	2.488910	144.122.97.2	128.119.245.12	TCP	32204	64535 → 80 [PSH, ACK] Seq=85572 Ack=1 Win=65536 Len=32150 [TCP segment of a reassembled PDU]
201	2.488984	144.122.97.2	128.119.245.12	TCP	32204	64535 → 80 [PSH, ACK] Seq=117722 Ack=1 Win=65536 Len=32150 [TCP segment of a reassembled PDU]
202	2.489025	144.122.97.2	128.119.245.12	HTTP	3197	POST /wireshark-labs/lab3-1-reply.htm HTTP/1.1 (text/plain)
220	2.653676	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=86858 Win=183296 Len=0

Figure 23: Retransmission check

25. $1982 - 696 = 1286$
 $7126 - 1982 = 5144$
 $12270 - 7126 = 5144$
 $18700 - 13556 = 5144$
 $25130 - 18700 = 6430$

.
.
.

As you can see they are different. But they are multiple of 1286.

No.	Time	Source	Destination	Protocol	Length	Info
78	1.269786	195.175.180.171	144.122.97.2	TCP	56	443 → 64461 [ACK] Seq=1 Ack=9572 Win=4306 Len=0
84	1.356000	195.175.180.171	144.122.97.2	TLSv1.2	400	Application Data
85	1.356000	195.175.180.171	144.122.97.2	TLSv1.2	92	Application Data
86	1.356118	144.122.97.2	195.175.180.171	TCP	54	64461 → 443 [ACK] Seq=9572 Ack=385 Win=1020 Len=0
102	1.649071	144.122.97.2	142.250.187.142	TCP	55	64490 → 443 [ACK] Seq=1 Ack=1 Win=251 Len=1 [TCP segment of a reassembled PDU]
104	1.666358	142.250.187.142	144.122.97.2	TCP	66	443 → 64490 [ACK] Seq=1 Ack=2 Win=288 Len=0 SLE=1 SRE=2
121	1.873287	144.122.97.2	128.119.245.12	TCP	54	64525 → 80 [FIN, ACK] Seq=1 Ack=1 Win=252 Len=0
122	1.873550	144.122.97.2	128.119.245.12	TCP	66	64535 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM
136	2.020404	128.119.245.12	144.122.97.2	TCP	56	80 → 64525 [ACK] Seq=1 Ack=2 Win=237 Len=0
137	2.020404	128.119.245.12	144.122.97.2	TCP	66	80 → 64535 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1286 SACK_PERM WS=128
138	2.020548	144.122.97.2	128.119.245.12	TCP	54	64535 → 80 [ACK] Seq=1 Ack=1 Win=65536 Len=0
139	2.021111	144.122.97.2	128.119.245.12	TCP	749	64535 → 80 [PSH, ACK] Seq=1 Ack=1 Win=65536 Len=695 [TCP segment of a reassembled PDU]
140	2.021336	144.122.97.2	128.119.245.12	TCP	11628	64535 → 80 [ACK] Seq=696 Ack=1 Win=65536 Len=11574 [TCP segment of a reassembled PDU]
150	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=696 Win=30592 Len=0
151	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=1092 Win=33536 Len=0
152	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=7126 Win=43904 Len=0
153	2.174320	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=12270 Win=54144 Len=0
154	2.174375	144.122.97.2	128.119.245.12	TCP	24488	64535 → 80 [PSH, ACK] Seq=12270 Ack=1 Win=65536 Len=24434 [TCP segment of a reassembled PDU]
171	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=13556 Win=57088 Len=0
172	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=18700 Win=67328 Len=0
173	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=25130 Win=80256 Len=0
174	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=31560 Win=93056 Len=0
175	2.329789	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=36704 Win=103424 Len=0
176	2.329838	144.122.97.2	128.119.245.12	TCP	32204	64535 → 80 [PSH, ACK] Seq=36704 Ack=1 Win=65536 Len=32150 [TCP segment of a reassembled PDU]
177	2.329916	144.122.97.2	128.119.245.12	TCP	16772	64535 → 80 [PSH, ACK] Seq=68854 Ack=1 Win=65536 Len=16718 [TCP segment of a reassembled PDU]
190	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=37990 Win=106240 Len=0
191	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=43134 Win=116608 Len=0
192	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=49564 Win=129408 Len=0
193	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=55994 Win=142336 Len=0
194	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=62424 Win=155136 Len=0
195	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=68854 Win=168064 Len=0
196	2.488846	128.119.245.12	144.122.97.2	TCP	56	80 → 64535 [ACK] Seq=1 Ack=70140 Win=170880 Len=0

26. (together with 25)

27. (together with 28)

28.

I calculated throughput (bytes transferred per unit time) for the TCP connection as follows:

Total number of bytes transferred = 152319 bytes

Elapsed time = 2.701119 - 1.873287 = 0.827832 s

Throughput \approx 184000 bit per second = 0.184 Mbps

So, I said Around 1.2 Mbps.

```
> Frame 202: 3197 bytes on wire (25576 bits), 3197 bytes captured (25576 bits)
> Ethernet II, Src: IntelCor_e1:a6:f4 (3c:f0:11:e1:a6:f4), Dst: IntelCor_d2:46:ed (00:1b:21:d2:46:ed)
> Internet Protocol Version 4, Src: 144.122.97.2, Dst: 128.119.245.12
> Transmission Control Protocol, Src Port: 64535, Dst Port: 80, Seq: 149872, Ack: 1, Len: 3143
> [8 Reassembled TCP Segments (153014 bytes): #139(695), #140(11574), #154(24434), #176(32150), #177(16718), #200(32150), #201(32150), #202(3143)]
v Hypertext Transfer Protocol
  > POST /wireshark-labs/lab3-1-reply.htm HTTP/1.1\r\n
    Host: gaia.cs.umass.edu\r\n
    Connection: keep-alive\r\n
    Content-Length: 152319\r\n
    Cache-Control: max-age=0\r\n
    Upgrade-Insecure-Requests: 1\r\n
    Origin: http://gaia.cs.umass.edu\r\n
    Content-Type: multipart/form-data; boundary=---WebKitFormBoundaryDUJkcxSR1sTKw2UV\r\n
    User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/119.0.0.0 Safari/537.36\r\n
    Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,image/apng,*/*;q=0.8,application/signed-exchange;v=b3;q=0.7\r\n
    Referer: http://gaia.cs.umass.edu/wireshark-labs/TCP-wireshark-file1.html\r\n
    Accept-Encoding: gzip, deflate\r\n
    Accept-Language: tr\r\n
    \r\n
    [Full request URI: http://gaia.cs.umass.edu/wireshark-labs/lab3-1-reply.htm]
    [HTTP request 1/1]
    [Response in frame: 235]
    File Data: 152319 bytes
```

Figure 24: Total number of bytes transferred

```
121 1.873287 144.122.97.2 128.119.245.12 TCP 54 64525 → 80 [FIN, ACK] Seq=1 Ack=1 Win=252 Len=0
```

Figure 25: t_{start}

```
235 2.701119 144.122.97.2 128.119.245.12 TCP 54 64535 → 80 [ACK] Seq=153015 Ack=778 Win=64768 Len=0
```

Figure 26: t_{last}

29. (merged with 30)

30.

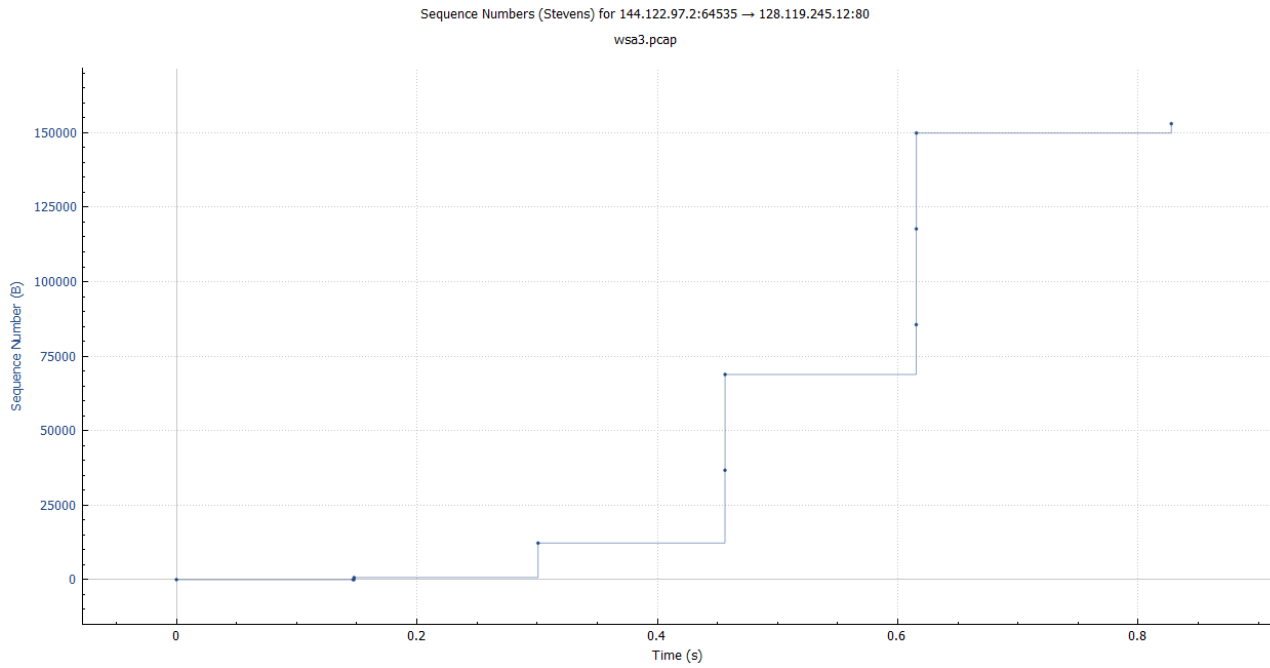


Figure 27: Time-Sequence-Graph (Stevens)

TCP is in its slow start phase as shown in the graph. Observe that each step takes approximately 0.15 seconds in the graph. Therefore, the period is nearly equal to the Round Trip Time which I calculated in the previous questions. So it is approximately equal to 0.153 seconds.