

Data Communication and Computer Network Laboratory

ASSIGNMENT - II

MCA 1st year 2nd Sem

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Assignment - II

Problem statement

The objective of this laboratory exercise is to look at the details of the Transmission Control Protocol (TCP).

TCP is a transport layer protocol. It is used by many application protocols like HTTP, FTP, SSH etc., where guaranteed and reliable delivery of messages is required.

To do this exercise you need to install the Wireshark tool. This tool would be used to capture and examine a packet trace. Wireshark can be downloaded from www.wireshark.org.

Step 1: Capture a Trace

- (i) Launch Wireshark
- (ii) From Capture → Options select Loopback interface
- (iii) Start a capture with a filter of “ip.addr==127.0.0.1 and tcp.port==xxxx”, where xxxx is the port number used by the TCP server.
- (iv) Run the TCP server program on a terminal.
- (v) Run two instances of the TCP client program on two separate terminals and send some dummy data to the server.
- (vi) Stop Wireshark capture

Step 2: TCP Connection Establishment

To observe the three-way handshake in action, look for a TCP segment with SYN flag set. A "SYN" segment is the start of the three-way handshake and is sent by the TCP client to the TCP server. The server then replies with a TCP segment with SYN and ACK flag set. And finally the client sends an "ACK" to the server. For all the above three segments record the values of the sequence number and acknowledgment fields.

Draw a time sequence diagram of the three-way handshake for TCP connection establishment in your trace. Do it for all the client connections.

Step 3: TCP Data Transfer

For all data segments sent by the client, record the value of the sequence number and acknowledgement number fields. Also, record the same for the corresponding acknowledgements sent by the server. Draw a time sequence diagram of the data transfer in your trace. Do it for all the client connections.

Step 4: TCP Connection Termination

Once the data transfer is over, the client initiates the connection termination by sending a TCP segment with FIN flag set, to the server. Server acknowledges it and sends its own intention to terminate the connection by sending a TCP segment with FIN and ACK flags set. The client finally sends an ACK segment to the server. For all the above three segments record the values of the sequence number and acknowledgment fields. Draw a time sequence diagram of the three-way handshake for TCP connection termination in your trace. Do it for all the client connections.

1. Capturing a Trace using Wireshark →

For this task, the client/server program of question 1 from assignment-1 is used, in which the TCP client program sends requests to the server to get the current time and date. The server returns the date and time along with status code (200 for success, 500 for error). Using wireshark the packets sent/received by the client/server will be observed.

Note: there will be two instances of clients, both will request the server for current date, one will send the appropriate command (for which the server will respond with appropriate date), the other will send an arbitrary command to server (for which the server will respond with an error msg).

- Wireshark capture with Loopback interface as input and with filter of “ip.addr==127.0.0.1 and tcp.port==7000” (Port 7000 is used by the TCP server)
- Two instances of the client connect to the server.

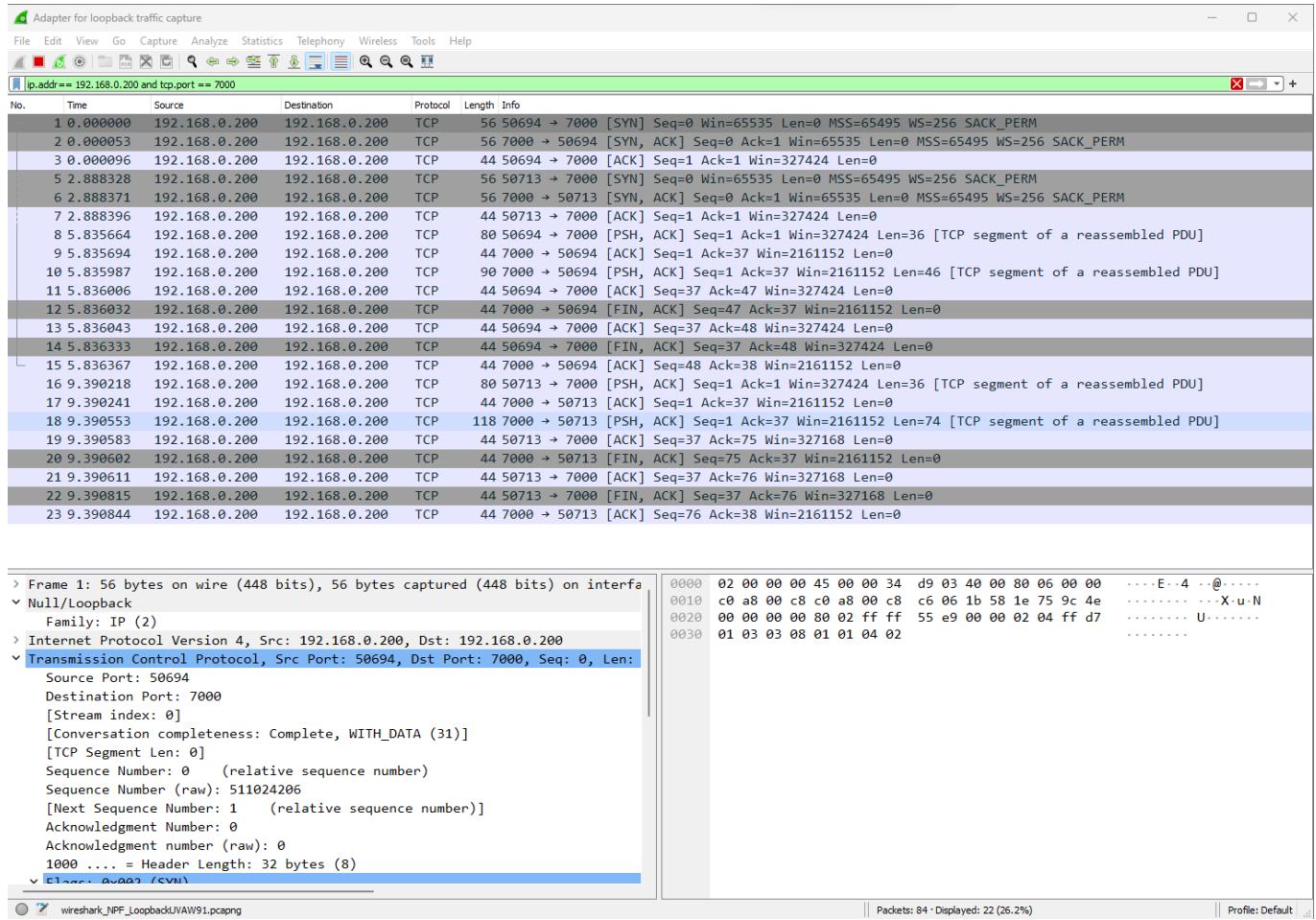


Figure 1: Capture of the packets from the client/server (TCP)

Time	Source	Destination	Protocol	Length	Info
1 0.000000	192.168.0.200	192.168.0.200	TCP	56	50694 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
2 0.000053	192.168.0.200	192.168.0.200	TCP	56	7000 → 50694 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
3 0.000096	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
5 2.888328	192.168.0.200	192.168.0.200	TCP	56	50713 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
6 2.888371	192.168.0.200	192.168.0.200	TCP	56	7000 → 50713 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
7 2.888396	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
8 5.835664	192.168.0.200	192.168.0.200	TCP	80	50694 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment of a reassembled PDU]
9 5.835694	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
10 5.835987	192.168.0.200	192.168.0.200	TCP	90	7000 → 50694 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=46 [TCP segment of a reassembled PDU]
11 5.836006	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=47 Win=327424 Len=0
12 5.836032	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [FIN, ACK] Seq=47 Ack=37 Win=2161152 Len=0
13 5.836043	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=48 Win=327424 Len=0
14 5.836333	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [FIN, ACK] Seq=37 Ack=48 Win=327424 Len=0
15 5.836367	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=48 Ack=38 Win=2161152 Len=0
16 9.390218	192.168.0.200	192.168.0.200	TCP	80	50713 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment of a reassembled PDU]
17 9.390241	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
18 9.390553	192.168.0.200	192.168.0.200	TCP	118	7000 → 50713 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=74 [TCP segment of a reassembled PDU]
19 9.390583	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=75 Win=327168 Len=0
20 9.390602	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [FIN, ACK] Seq=75 Ack=37 Win=2161152 Len=0
21 9.390611	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=76 Win=327168 Len=0
22 9.390815	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [FIN, ACK] Seq=37 Ack=76 Win=327168 Len=0
23 9.390844	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=76 Ack=38 Win=2161152 Len=0

Figure 2: TCP handshakes

From the above capture it is evident that →

- Two clients connect to the server at port 7000.
- Client 1 connects from 50694 → 7000 (3 way hand-shake with server)
- Client 2 connects from 50713 → 7000 (3 way hand-shake with server)
- Client 1 sends the message to server: {'method': 'GET', 'msg': 'Get time'}
 - ◆ Gets response from server: {'status': 200, 'data': '2023-08-14 13:27:46'}
 - ◆ After that client 1 terminates.
 - ◆ 4 way hand-shake with server to close connection.
- Client 2 sends the message to server: {'method': 'GET', 'msg': 'Get food'}
 - ◆ Gets response from server: {'status': 500, 'data': 'Unknown request command or commad not supported'}
 - ◆ After that client 2 terminates.
 - ◆ 4 way hand-shake with server to close connection.

The screenshot shows two separate Windows PowerShell windows side-by-side, illustrating the interaction between a client and a server.

Left Window (Server Side):

```
PS C:\Users\monda\OneDrive\Desktop\net_lab_updated\set_1_sockets\q1>
python sok_server.py
host: Deep post: 7000
setting up server at Deep:7000
server started at port: 7000
Received connection from address: ('192.168.0.200', 50694)
Received connection from address: ('192.168.0.200', 50713)
received data: {'method': 'GET', 'msg': 'Get time'}
received data: {'method': 'GET', 'msg': 'Get food'}
Unknown request command or commad not supported
```

Right Window (Client Side):

```
PS C:\Users\monda\OneDrive\Desktop\net_lab_updated\set_1_sockets\q1>
python sok_client.py
Client connected on Deep:7000
Enter command: Get time
Client request: {'method': 'GET', 'msg': 'Get time'}
response from server: {'status': 200, 'data': '2023-08-14 13:27:46'}
Server --> status: 200, data: 2023-08-14 13:27:46
PS C:\Users\monda\OneDrive\Desktop\net_lab_updated\set_1_sockets\q1>
```



```
PS C:\Users\monda\OneDrive\Desktop\net_lab_updated\set_1_sockets\q1>
python sok_client.py
Client connected on Deep:7000
Enter command: Get food
Client request: {'method': 'GET', 'msg': 'Get food'}
response from server: {'status': 500, 'data': 'Unknown request command or commad not s
upported'}
Server --> status: 500, data: Unknown request command or commad not s
upported
PS C:\Users\monda\OneDrive\Desktop\net_lab_updated\set_1_sockets\q1>
```

Figure 3: Requests and responses in the client/server console

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.0.200	192.168.0.200	TCP	56	50694 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
2	0.000053	192.168.0.200	192.168.0.200	TCP	56	7000 → 50694 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
3	0.000096	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
5	2.888328	192.168.0.200	192.168.0.200	TCP	56	50713 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
6	2.888371	192.168.0.200	192.168.0.200	TCP	56	7000 → 50713 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
7	2.888396	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
8	5.835664	192.168.0.200	192.168.0.200	TCP	80	50694 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment of a reassembled PDU]
9	5.835694	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
10	5.835987	192.168.0.200	192.168.0.200	TCP	90	7000 → 50694 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=46 [TCP segment of a reassembled PDU]
11	5.836006	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=47 Win=327424 Len=0
12	5.836032	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [FIN, ACK] Seq=47 Ack=37 Win=2161152 Len=0
13	5.836043	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=48 Win=327424 Len=0
14	5.836333	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [FIN, ACK] Seq=37 Ack=48 Win=327424 Len=0
15	5.836367	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=48 Ack=38 Win=2161152 Len=0
16	9.390218	192.168.0.200	192.168.0.200	TCP	80	50713 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment of a reassembled PDU]
17	9.390241	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
18	9.390553	192.168.0.200	192.168.0.200	TCP	118	7000 → 50713 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=74 [TCP segment of a reassembled PDU]
19	9.390583	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=75 Win=327168 Len=0
20	9.390602	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [FIN, ACK] Seq=75 Ack=37 Win=2161152 Len=0
21	9.390611	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=76 Win=327168 Len=0
22	9.390815	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [FIN, ACK] Seq=37 Ack=76 Win=327168 Len=0
23	9.390844	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=76 Ack=38 Win=2161152 Len=0

Response data

Request data

0000	02 00 00 00 45 00 00 56 d9 0b 40 00 80 06 00 00E..V ..@....	0000	02 00 00 00 45 00 00 4c d9 09 40 00 80 06 00 00E..L ..@....
0010	c0 a8 00 c8 c0 a8 00 c8 1b 58 c6 06 70 11 f7 0fX..P...	0010	c0 a8 00 c8 c0 a8 00 c8 c6 06 1b 58 1e 75 9c 4fX..u..O
0020	1e 75 9c 73 50 18 20 fa 74 96 00 00 7b 22 73 74	.u.SP. - t..{"st	0020	70 11 f7 0f 50 18 04 ff b6 48 00 00 7b 22 6d 65	p...P... .H-{"me
0030	61 74 75 73 22 3a 20 32 30 30 2c 20 22 64 61 74	atus": 2 00, "dat	0030	74 68 6f 64 22 3a 20 22 47 45 54 22 2c 20 22 6d	thod": " GET", "m
0040	61 22 3a 20 22 32 30 32 33 2d 30 38 2d 31 34 20	a": "202 3-08-14	0040	73 67 22 3a 20 22 47 65 74 20 69 6d 65 22 7d	sg": "Ge t time"}
0050	31 33 3a 32 37 3a 34 36 22 7d	13:27:46 "}			

Figure 4: Request and response from Client 1 to server

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.0.200	192.168.0.200	TCP	56	50694 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
2	0.000053	192.168.0.200	192.168.0.200	TCP	56	7000 → 50694 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
3	0.000096	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
5	2.888328	192.168.0.200	192.168.0.200	TCP	56	50713 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
6	2.888371	192.168.0.200	192.168.0.200	TCP	56	7000 → 50713 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
7	2.888396	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
8	5.835664	192.168.0.200	192.168.0.200	TCP	80	50694 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment of a reassembled PDU]
9	5.835694	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
10	5.835987	192.168.0.200	192.168.0.200	TCP	90	7000 → 50694 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=46 [TCP segment of a reassembled PDU]
11	5.836006	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=47 Win=327424 Len=0
12	5.836032	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [FIN, ACK] Seq=47 Ack=37 Win=2161152 Len=0
13	5.836043	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=48 Win=327424 Len=0
14	5.836333	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [FIN, ACK] Seq=37 Ack=48 Win=327424 Len=0
15	5.836367	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=48 Ack=38 Win=2161152 Len=0
16	9.390218	192.168.0.200	192.168.0.200	TCP	80	50713 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment of a reassembled PDU]
17	9.390241	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
18	9.390553	192.168.0.200	192.168.0.200	TCP	118	7000 → 50713 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=74 [TCP segment of a reassembled PDU]
19	9.390583	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=75 Win=327168 Len=0
20	9.390602	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [FIN, ACK] Seq=75 Ack=37 Win=2161152 Len=0
21	9.390611	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=76 Win=327168 Len=0
22	9.390815	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [FIN, ACK] Seq=37 Ack=76 Win=327168 Len=0
23	9.390844	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=76 Ack=38 Win=2161152 Len=0

Response data

Request data

0000	02 00 00 00 45 00 00 72 d9 13 40 00 80 06 00 00E..r ..@....	0000	02 00 00 00 45 00 00 4c d9 11 40 00 80 06 00 00E..L ..@....
0010	c0 a8 00 c8 c0 a8 00 c8 1b 58 c6 19 ee 56 a1 b1X..V...	0010	c0 a8 00 c8 c0 a8 00 c8 c6 19 1b 58 8d 98 a2 acX..v...
0020	8d 98 a2 d0 50 18 20 fa 40 1c 00 00 7b 22 73 74	.P. - @..{"st	0020	ee 56 a1 b1 50 18 04 ff 23 c9 00 00 7b 22 6d 65	V..P... #..{"me
0030	61 74 75 73 22 3a 20 35 30 30 2c 20 22 64 61 74	atus": 5 00, "dat	0030	74 68 6f 64 22 3a 20 22 47 45 54 22 2c 20 22 6d	thod": " GET", "m
0040	61 22 3a 20 22 55 66 6b 6e 6f 77 6e 20 72 65 71	a": "Unkown req	0040	73 67 22 3a 20 22 47 65 74 20 66 6f 64 22 7d	sg": "Ge t food")
0050	75 65 73 74 20 63 6f 6d 6d 61 6e 20 6f 72 20	uest com mand or			
0060	63 6f 6d 6d 61 64 20 6e 6f 74 20 73 75 70 76 6f	commad n ot supp			
0070	72 74 65 64 22 7d	orted"}			

Figure 5: Request and response from Client 2 to server

2. TCP Connection Establishment →

2.1 Client 1 to server →

- The following are records of 3 way handshake of the connection establishment of client 1 to server.
- Client 1 connects from 50694 → 7000
- Client 1 sends a SYN packet (50694 → 7000) with sequence no: 511024206 and acknowledge no: 0
- Server sends a SYN, ACK packet (7000 → 50694) with sequence no: 188022550 and acknowledge no: 511024207 (511024206 + 1)
- Client 1 sends a ACK packet (50694 → 7000) with sequence no: 511024207 and acknowledge no: 188022551 (188022550 + 1)
- Hence the 3-way hand-shake is completed

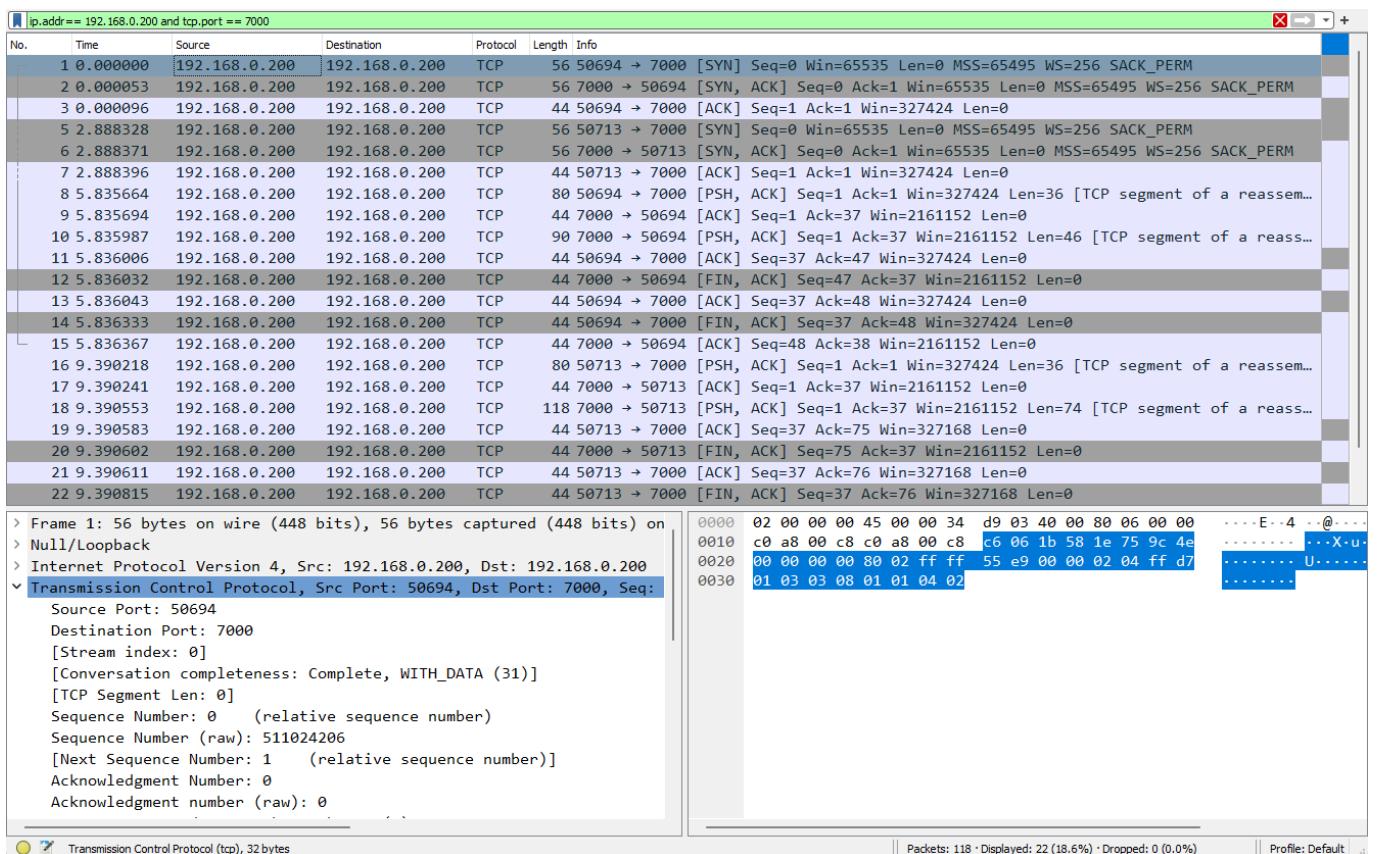


Figure 6.1: 3-way handshake step 1 (client 1/server)

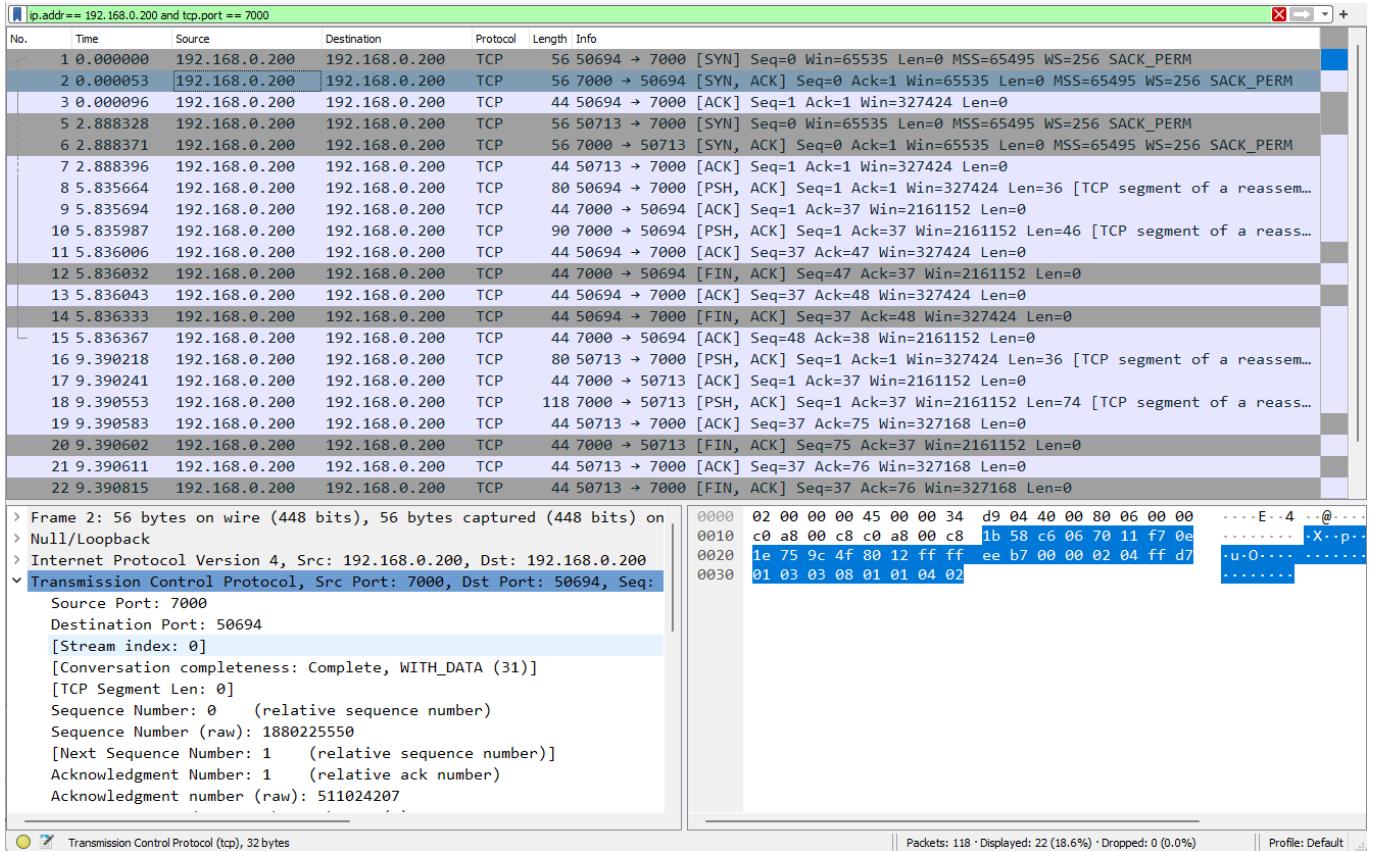


Figure 6.2: 3-way handshake step 2 (client 1/server)

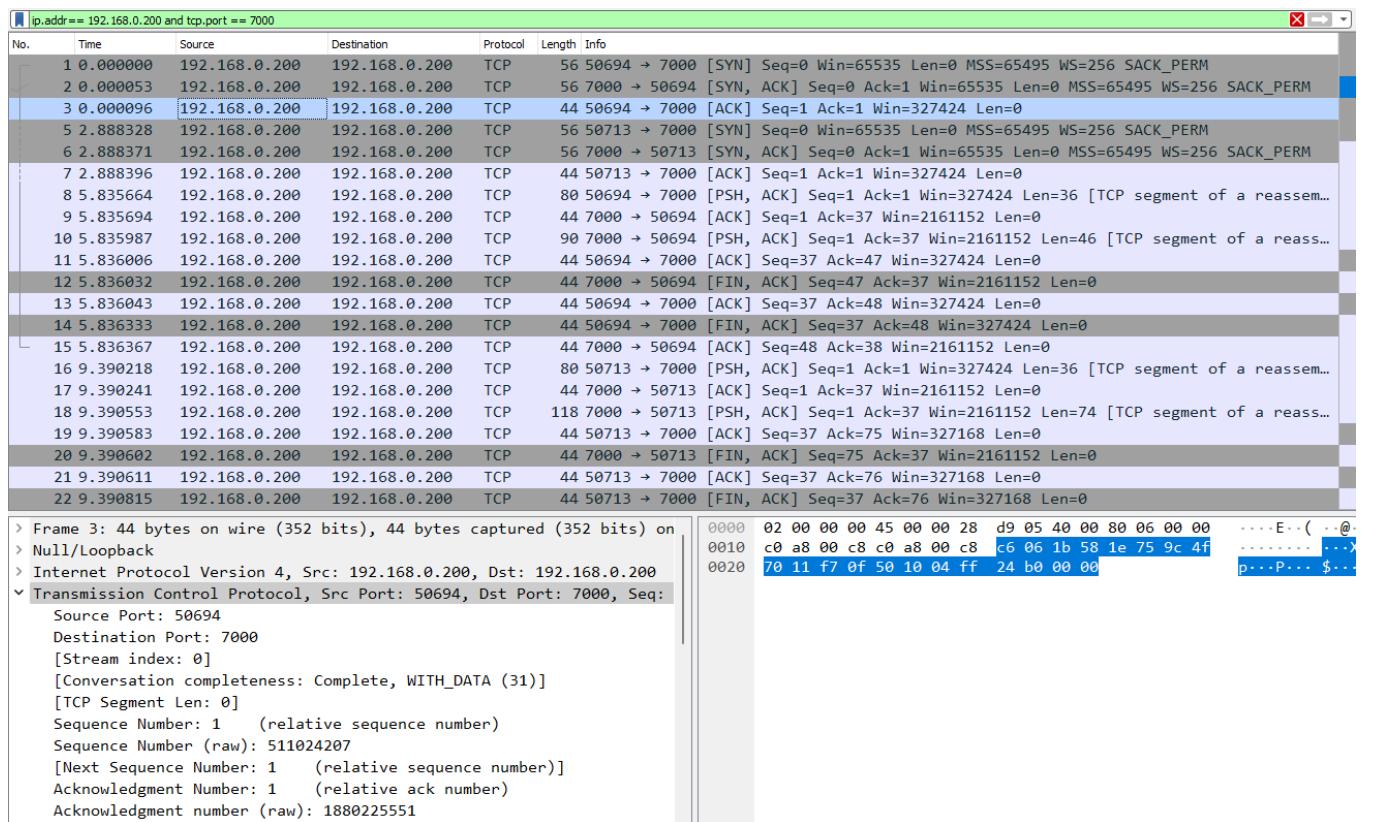


Figure 6.3: 3-way handshake step 3 (client 1/server)

2.2 Client 2 to server →

- The following are records of 3 way handshake of the connection establishment of client 2 to server.
- Client 2 connects from 50713 → 7000
- Client 1 sends a SYN packet (50713 → 7000) with sequence no: 2375590571 and acknowledge no: 0
- Server sends a SYN, ACK packet (7000 → 50713) with sequence no: 3998654896 and acknowledge no: 2375590572 (2375590571 + 1)
- Client 1 sends a ACK packet (50713 → 7000) with sequence no: 2375590572 and acknowledge no: 3998654897 (3998654896 + 1)
- Hence the 3-way hand-shake is completed

ip.addr == 192.168.0.200 and tcp.port == 7000						
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.0.200	192.168.0.200	TCP	56	50694 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
2	0.000053	192.168.0.200	192.168.0.200	TCP	56	7000 → 50694 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
3	0.000096	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
5	2.888328	192.168.0.200	192.168.0.200	TCP	56	50713 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
6	2.888371	192.168.0.200	192.168.0.200	TCP	56	7000 → 50713 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
7	2.888396	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
8	5.835664	192.168.0.200	192.168.0.200	TCP	80	50694 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment of a reassembled PD...]
9	5.835694	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
10	5.835987	192.168.0.200	192.168.0.200	TCP	90	7000 → 50694 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=46 [TCP segment of a reassembled ...]
11	5.836006	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=47 Win=327424 Len=0
12	5.836032	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [FIN, ACK] Seq=47 Ack=37 Win=2161152 Len=0
13	5.836043	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=48 Win=327424 Len=0
14	5.836333	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [FIN, ACK] Seq=37 Ack=48 Win=327424 Len=0
15	5.836367	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=48 Ack=38 Win=2161152 Len=0
16	9.390218	192.168.0.200	192.168.0.200	TCP	80	50713 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment of a reassembled PD...]
17	9.390241	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
18	9.390553	192.168.0.200	192.168.0.200	TCP	118	7000 → 50713 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=74 [TCP segment of a reassembled ...]
19	9.390583	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=75 Win=327168 Len=0
20	9.390602	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [FIN, ACK] Seq=75 Ack=37 Win=2161152 Len=0
21	9.390611	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=76 Win=327168 Len=0
22	9.390815	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [FIN, ACK] Seq=37 Ack=76 Win=327168 Len=0
23	9.390844	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=76 Ack=38 Win=2161152 Len=0

<pre>▼ Transmission Control Protocol, Src Port: 50713, Dst Port: 7000, Seq: 65535, Ack: 0, Len: 32 Source Port: 50713 Destination Port: 7000 [Stream index: 1] [Conversation completeness: Complete, WITH_DATA (31)] [TCP Segment Len: 0] Sequence Number: 0 (relative sequence number) Sequence Number (raw): 2375590571 [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</pre>		<pre>0000 02 00 00 00 45 00 00 34 d9 06 40 00 80 06 00 00 0010 c0 a8 00 c8 c0 a8 00 c8 c6 19 1b 58 8d 98 a2 ab 0020 00 00 00 00 80 02 ff ff e0 55 00 00 02 04 ff d7 0030 01 03 03 08 01 01 04 02</pre>	<pre>....E..4 ..@...X...U....</pre>
--	--	--	--

Figure 7.1: 3-way handshake step 1 (client 2/server)

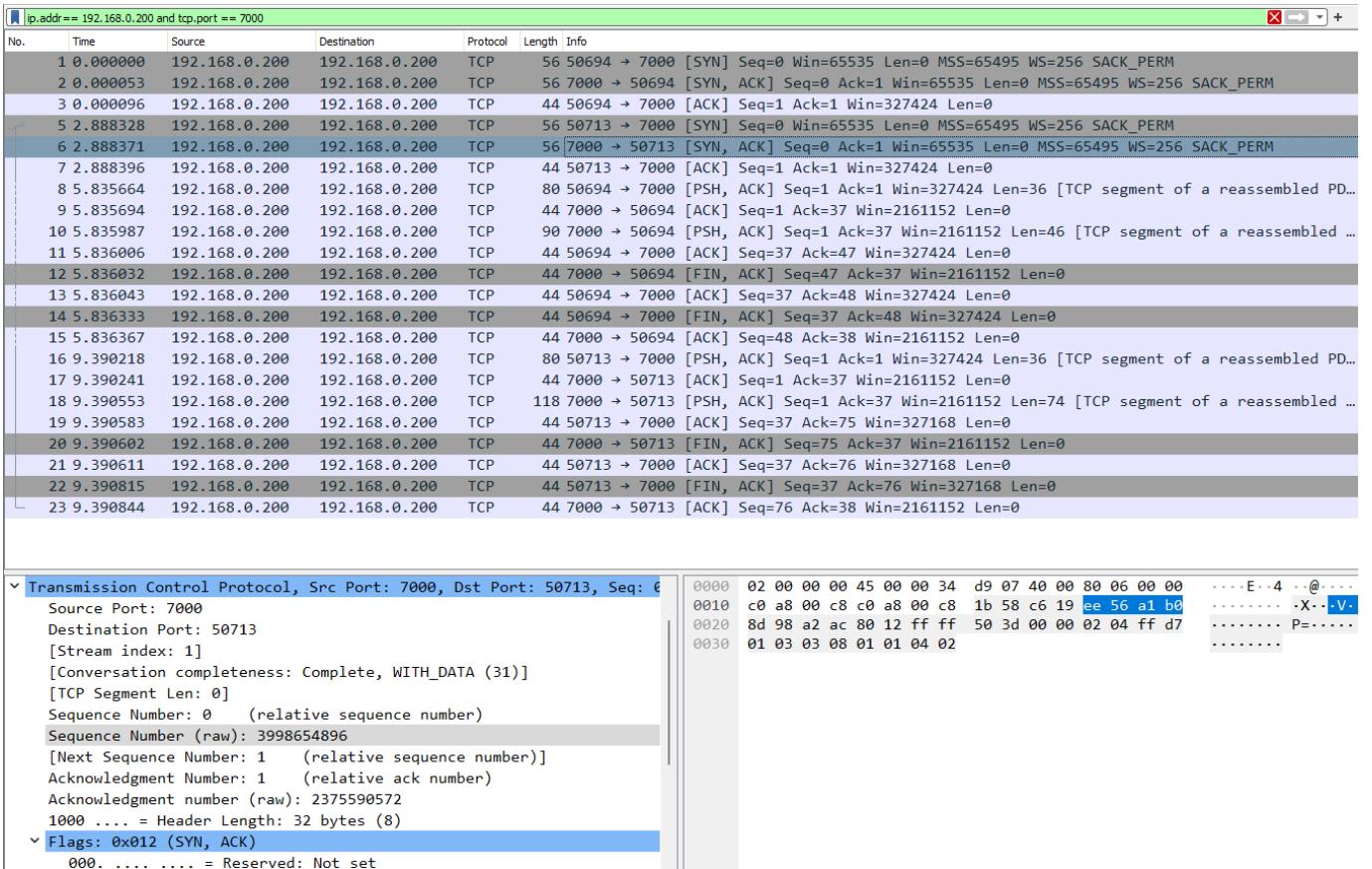


Figure 7.2: 3-way handshake step 2 (client 2/server)

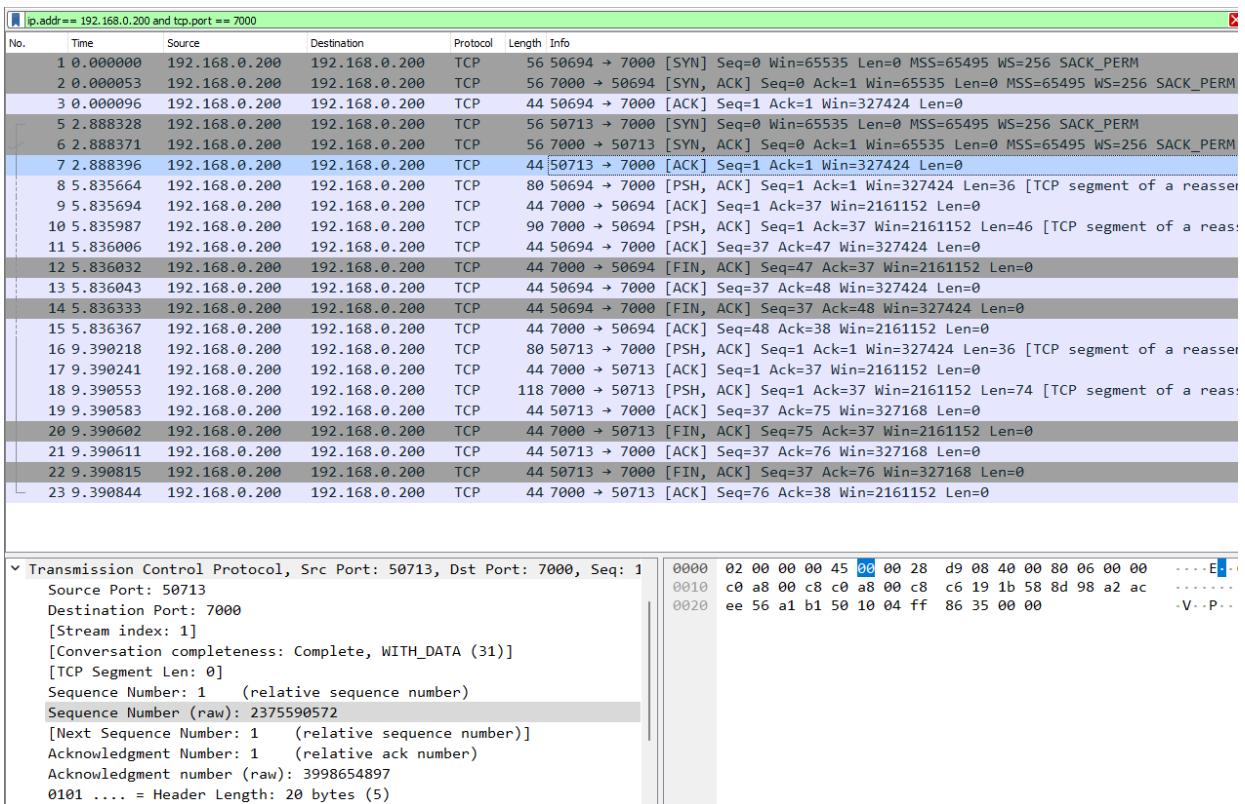


Figure 7.3: 3-way handshake step 3 (client 2/server)

Timing Sequence diagram for Connection establishment from client 1 to server →

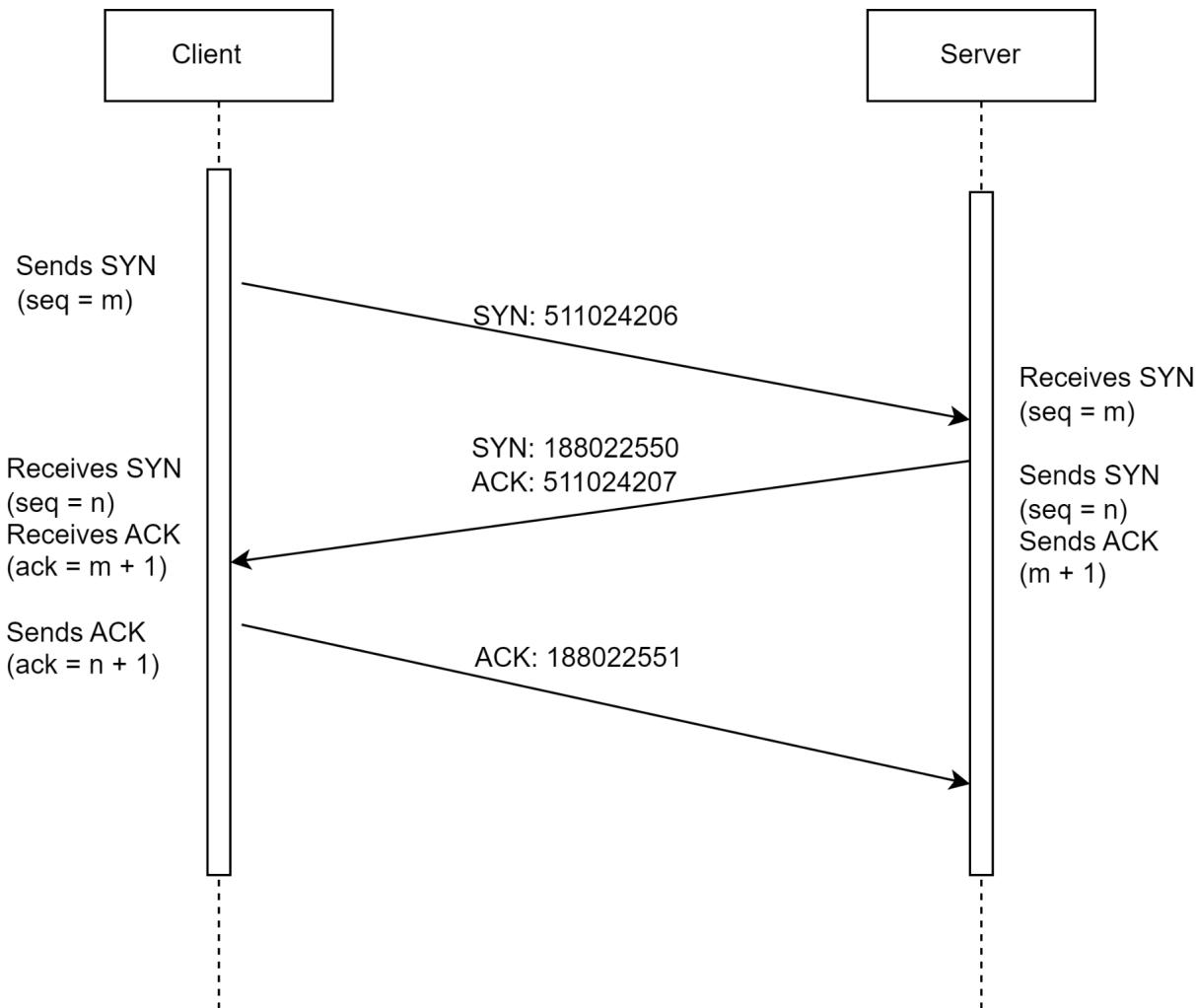


Figure 8: 3-way handshake connection establishment phase (client 1/server)

Timing Sequence diagram for Connection establishment from client 2 to server →

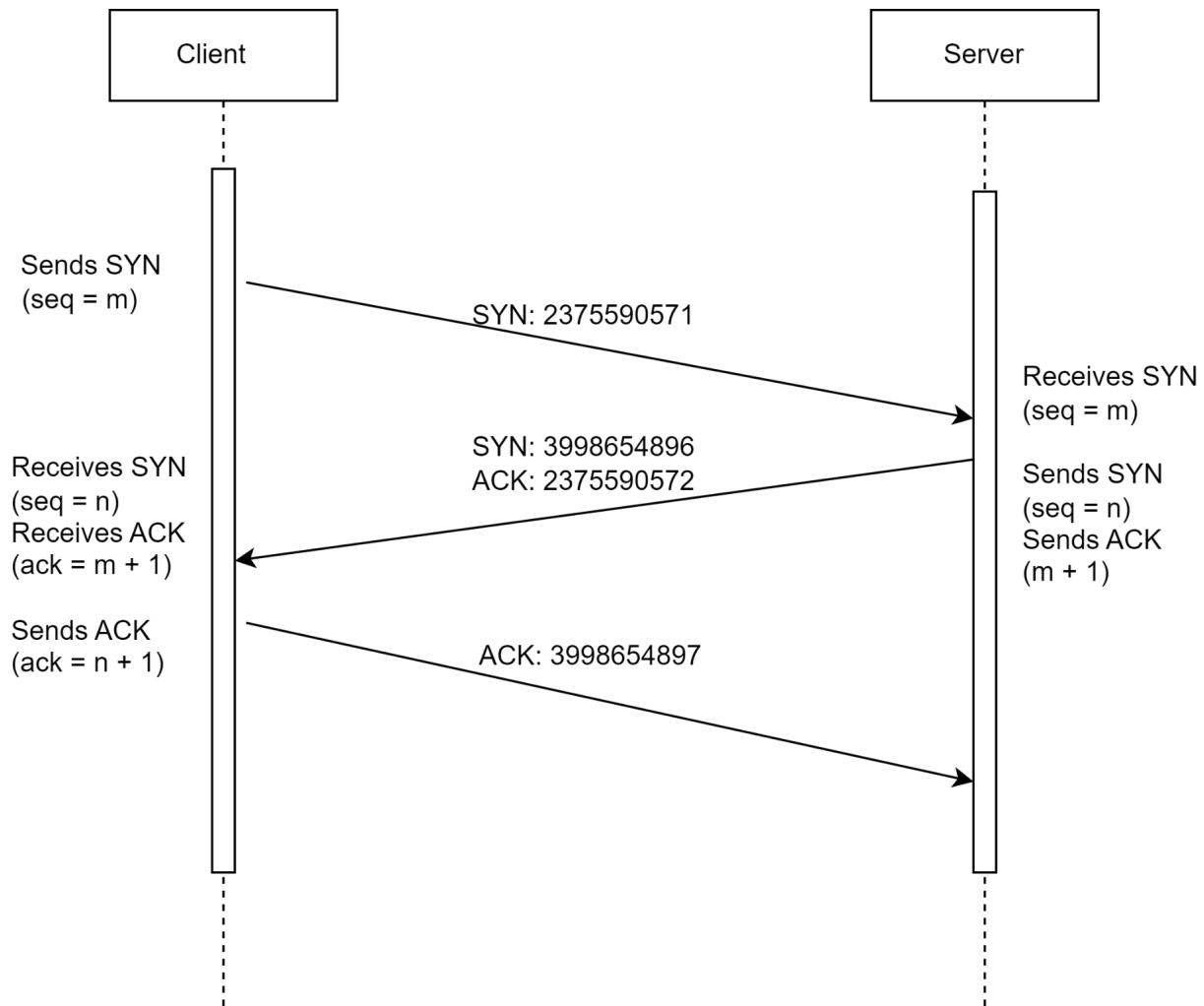


Figure 9: 3-way handshake connection establishment phase (client 2/server)

3. TCP Data Transfer →

3.1 Client 1 - server →

- The following are records of TCP data transfer phase from client 1 to server.
- Client 1 sends a PSH, ACK packet ($50694 \rightarrow 7000$) with sequence no: 511024207 and acknowledge no: 1880225551
- Server sends a ACK packet ($7000 \rightarrow 50694$) with sequence no: 1880225551 and acknowledge no: 511024243
- Server sends a PSH, ACK packet ($7000 \rightarrow 50694$) with sequence no: 1880225551 and acknowledge no: 511024243
- Client 1 sends a ACK packet ($50694 \rightarrow 7000$) with sequence no: 511024243 and acknowledge no: 1880225597

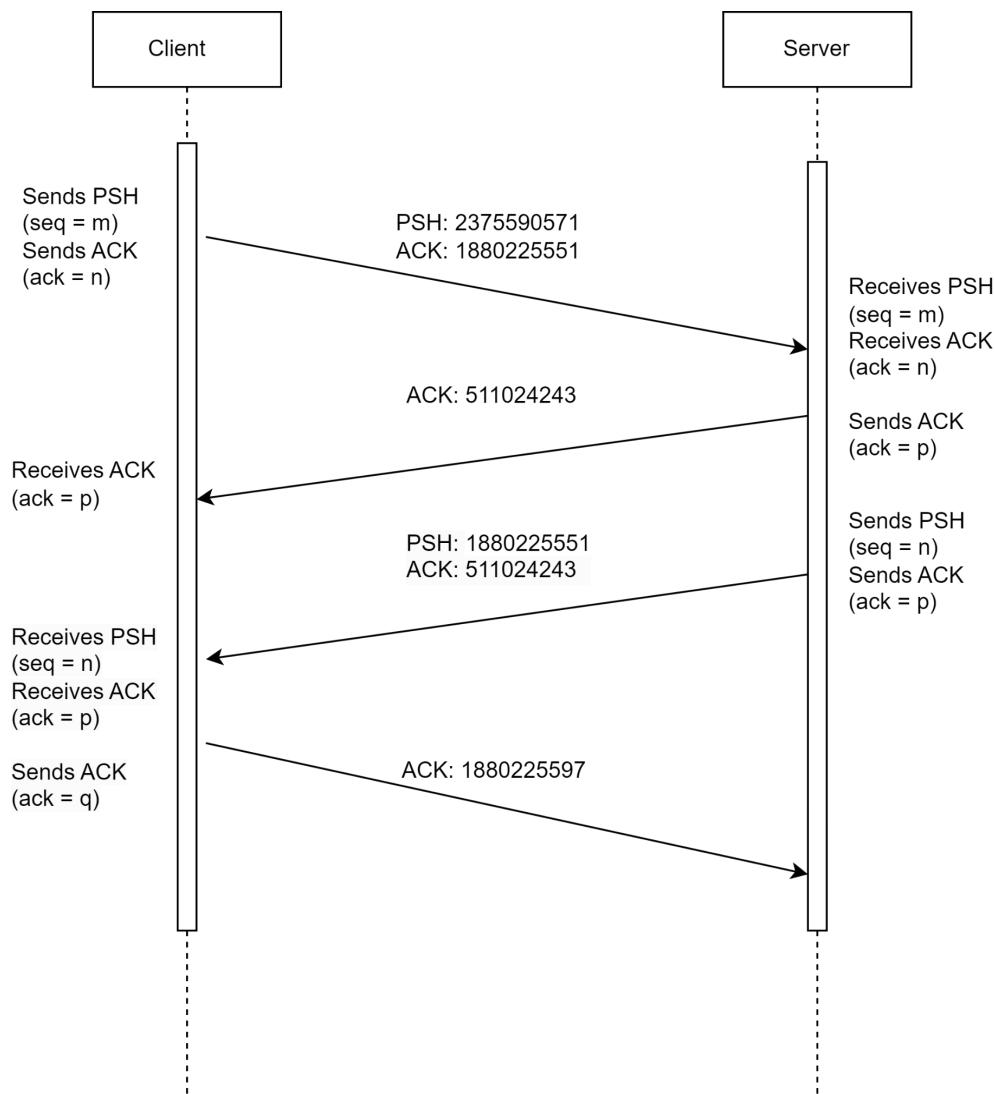


Figure 10: Sequence diagram TCP data-transfer phase (client 1/server)

ip.addr==192.168.0.200 and tcp.port == 7000						
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.0.200	192.168.0.200	TCP	56	50694 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
2	0.000053	192.168.0.200	192.168.0.200	TCP	56	7000 → 50694 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
3	0.000096	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
5	2.888328	192.168.0.200	192.168.0.200	TCP	56	50713 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
6	2.888371	192.168.0.200	192.168.0.200	TCP	56	7000 → 50713 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
7	2.888396	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
8	5.835664	192.168.0.200	192.168.0.200	TCP	88	50694 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment of a reassembled PDU]
9	5.835694	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
10	5.835987	192.168.0.200	192.168.0.200	TCP	90	7000 → 50694 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=46 [TCP segment of a reassembled PDU]
11	5.836006	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=47 Win=327424 Len=0
12	5.836032	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [FIN, ACK] Seq=47 Ack=37 Win=2161152 Len=0
13	5.836043	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=48 Win=327424 Len=0
14	5.836333	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [FIN, ACK] Seq=37 Ack=48 Win=327424 Len=0
15	5.836367	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=48 Ack=38 Win=2161152 Len=0
16	9.390218	192.168.0.200	192.168.0.200	TCP	88	50713 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment of a reassembled PDU]
17	9.390241	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
18	9.390553	192.168.0.200	192.168.0.200	TCP	118	7000 → 50713 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=74 [TCP segment of a reassembled PDU]
19	9.390583	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=75 Win=327168 Len=0
20	9.390602	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [FIN, ACK] Seq=75 Ack=37 Win=2161152 Len=0
21	9.390611	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=76 Win=327168 Len=0
22	9.390815	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [FIN, ACK] Seq=37 Ack=76 Win=327168 Len=0
23	9.390844	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=76 Ack=38 Win=2161152 Len=0

> Frame 8: 80 bytes on wire (640 bits), 80 bytes captured (640 bits)
> Null/Loopback
> Internet Protocol Version 4, Src: 192.168.0.200, Dst: 192.168.0.200
Transmission Control Protocol, Src Port: 50694, Dst Port: 7000, Seq: 0, Ack: 0, Len: 80
Source Port: 50694
Destination Port: 7000
[Stream index: 0]
[Conversation completeness: Complete, WITH_DATA (31)]
[TCP Segment Len: 36]
Sequence Number: 1 (relative sequence number)
Sequence Number (raw): 511024207
[Next Sequence Number: 37 (relative sequence number)]
Acknowledgment Number: 1 (relative ack number)
Acknowledgment number (raw): 1880225551
0101 = Header Length: 20 bytes (5)

0000 02 00 00 00 45 00 00 4c d9 09 40 00 80 06 00 00E..L ..@....
0010 c0 a8 00 c8 c0 a8 00 c8 c6 06 1b 58 1e 75 9c 4fX u O
0020 80 11 f7 0f 50 18 04 ff b6 48 00 00 7b 22 6d 65	p...P... .H [{"me
0030 74 68 6f 64 22 3a 20 22 47 45 54 22 2c 20 22 6d	thod": "GET", "m
0040 73 67 22 3a 20 22 47 65 74 20 74 69 6d 65 22 6d	sg": "Ge t time"}]

Figure 11.1: Sequence diagram TCP data-transfer phase (client 1/server) step 1

ip.addr==192.168.0.200 and tcp.port == 7000						
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.0.200	192.168.0.200	TCP	56	50694 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
2	0.000053	192.168.0.200	192.168.0.200	TCP	56	7000 → 50694 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
3	0.000096	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
5	2.888328	192.168.0.200	192.168.0.200	TCP	56	50713 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
6	2.888371	192.168.0.200	192.168.0.200	TCP	56	7000 → 50713 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
7	2.888396	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
8	5.835664	192.168.0.200	192.168.0.200	TCP	88	50694 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment of a reassembled PDU]
9	5.835694	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
10	5.835987	192.168.0.200	192.168.0.200	TCP	90	7000 → 50694 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=46 [TCP segment of a reassembled PDU]
11	5.836006	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=47 Win=327424 Len=0
12	5.836032	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [FIN, ACK] Seq=47 Ack=37 Win=2161152 Len=0
13	5.836043	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=48 Win=327424 Len=0
14	5.836333	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [FIN, ACK] Seq=37 Ack=48 Win=327424 Len=0
15	5.836367	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=48 Ack=38 Win=2161152 Len=0
16	9.390218	192.168.0.200	192.168.0.200	TCP	88	50713 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment of a reassembled PDU]
17	9.390241	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
18	9.390553	192.168.0.200	192.168.0.200	TCP	118	7000 → 50713 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=74 [TCP segment of a reassembled PDU]
19	9.390583	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=75 Win=327168 Len=0
20	9.390602	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [FIN, ACK] Seq=75 Ack=37 Win=2161152 Len=0
21	9.390611	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=76 Win=327168 Len=0
22	9.390815	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [FIN, ACK] Seq=37 Ack=76 Win=327168 Len=0
23	9.390844	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=76 Ack=38 Win=2161152 Len=0

> Frame 9: 44 bytes on wire (352 bits), 44 bytes captured (352 bits)
> Null/Loopback
> Internet Protocol Version 4, Src: 192.168.0.200, Dst: 192.168.0.200
Transmission Control Protocol, Src Port: 7000, Dst Port: 50694, Seq: 0, Ack: 0, Len: 44
Source Port: 7000
Destination Port: 50694
[Stream index: 0]
[Conversation completeness: Complete, WITH_DATA (31)]
[TCP Segment Len: 0]
Sequence Number: 1 (relative sequence number)
Sequence Number (raw): 1880225551
[Next Sequence Number: 1 (relative sequence number)]
Acknowledgment Number: 37 (relative ack number)
Acknowledgment number (raw): 511024243
0101 = Header Length: 20 bytes (5)
^ Flags: 0x010 (ACK)

0000 02 00 00 00 45 00 00 28 d9 0a 40 00 80 06 00 00E..(..@....
0010 c0 a8 00 c8 c0 a8 00 c8 b1 58 c6 06 70 11 f7 0fX.p...
0020 1e 75 9c 73 50 10 20 fa 08 91 00 00	.u.sP.

Figure 11.2: Sequence diagram TCP data-transfer phase (client 1/server) step 2

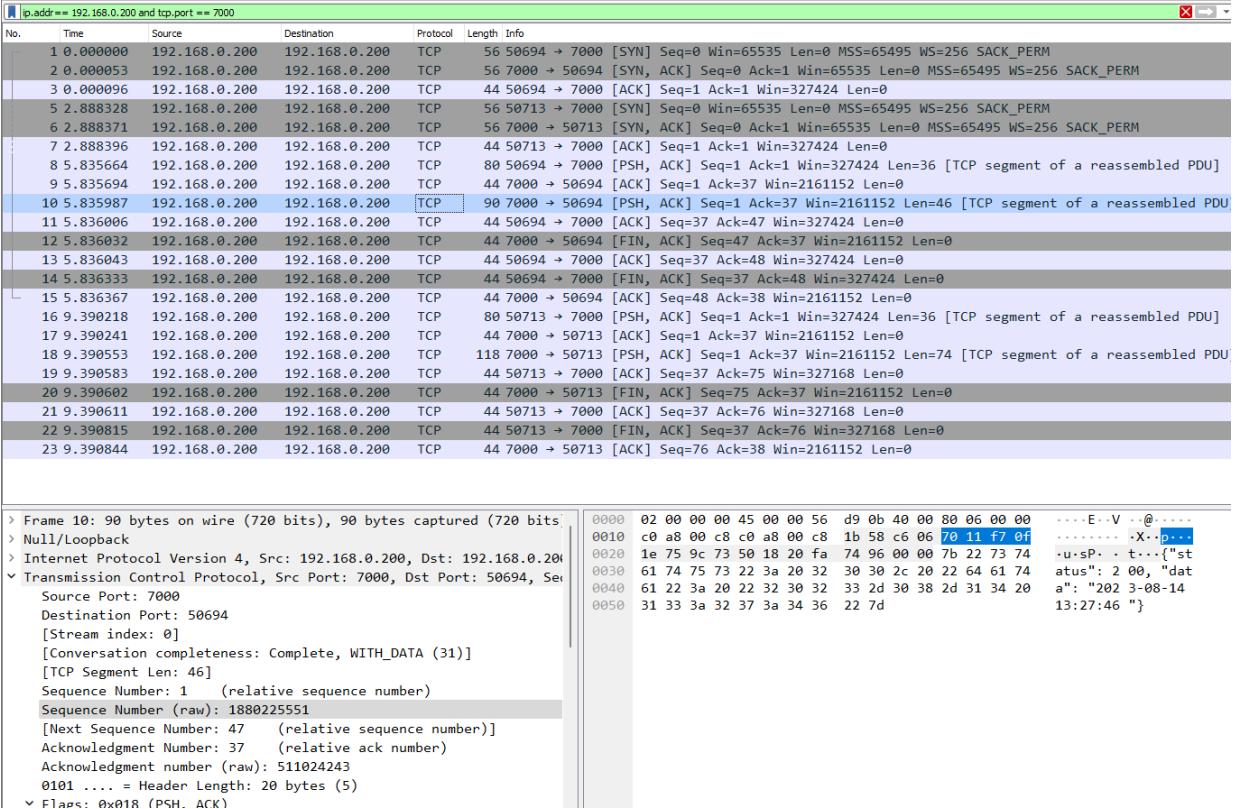


Figure 11.3: Sequence diagram TCP data-transfer phase (client 1/server) step 3

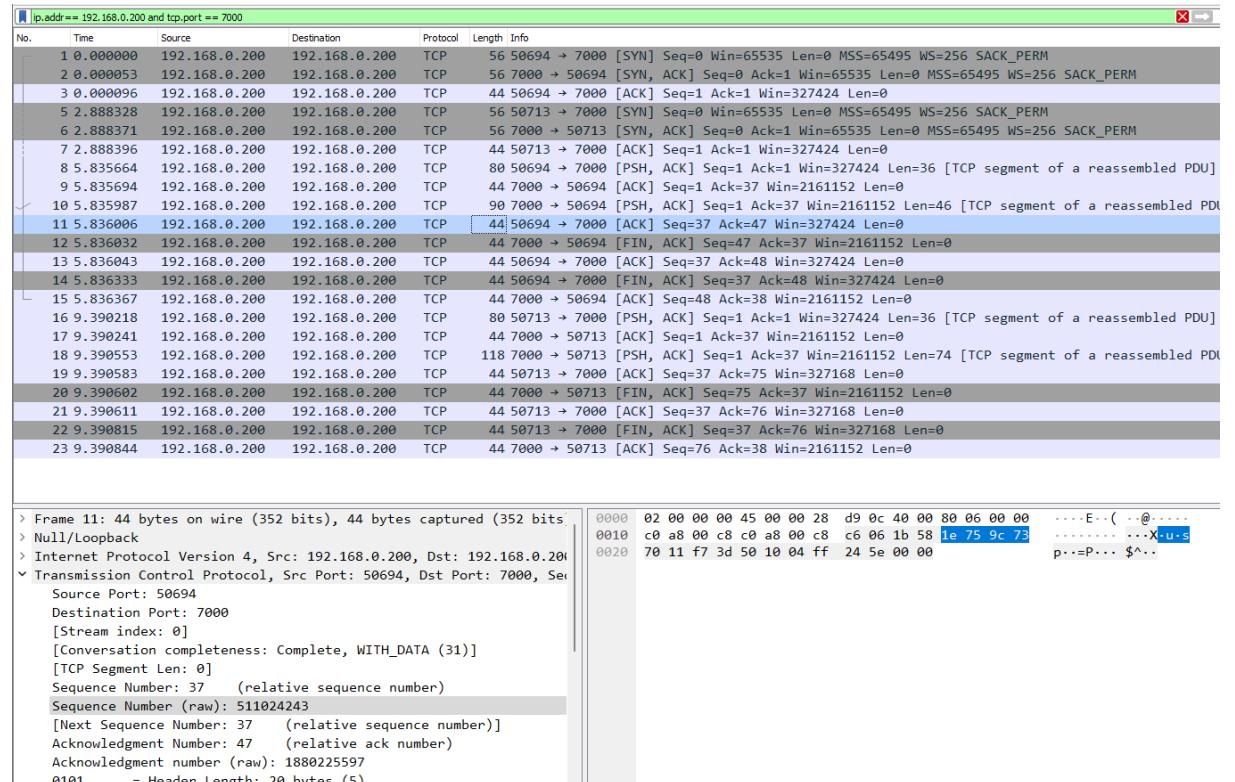


Figure 11.4: Sequence diagram TCP data-transfer phase (client 1/server) step 4

3.2 Client 2 - server →

- The following are records of TCP data transfer phase from client 1 to server.
- Client 1 sends a PSH, ACK packet ($50713 \rightarrow 7000$) with sequence no: 2375590572 and acknowledge no: 3998654897
- Server sends a ACK packet ($7000 \rightarrow 50713$) with sequence no: 3998654897 and acknowledge no: 2375590608
- Server sends a PSH, ACK packet ($7000 \rightarrow 50694$) with sequence no: 3998654897 and acknowledge no: 2375590608
- Client 1 sends a ACK packet ($50694 \rightarrow 7000$) with sequence no: 2375590608 and acknowledge no: 3998654971

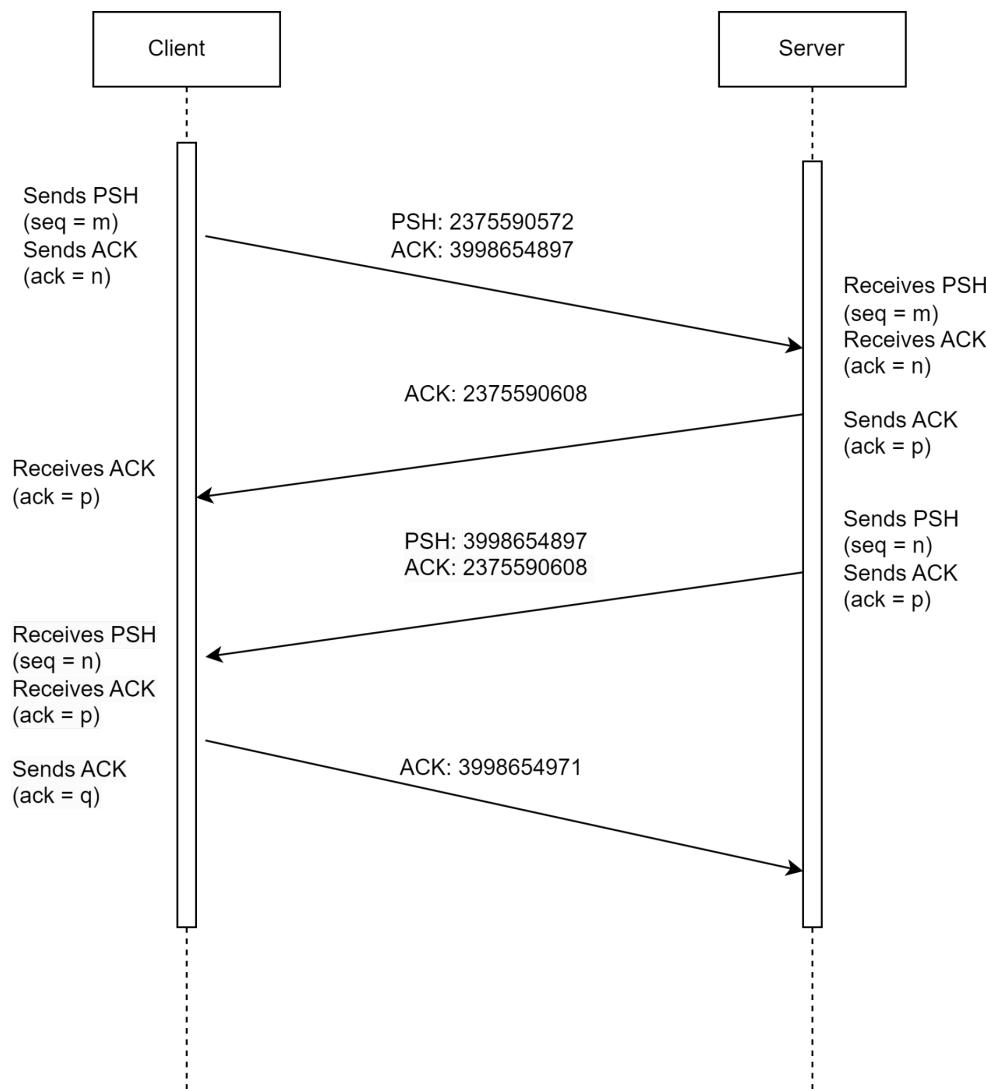


Figure 12: Sequence diagram TCP data-transfer phase (client 2/server)

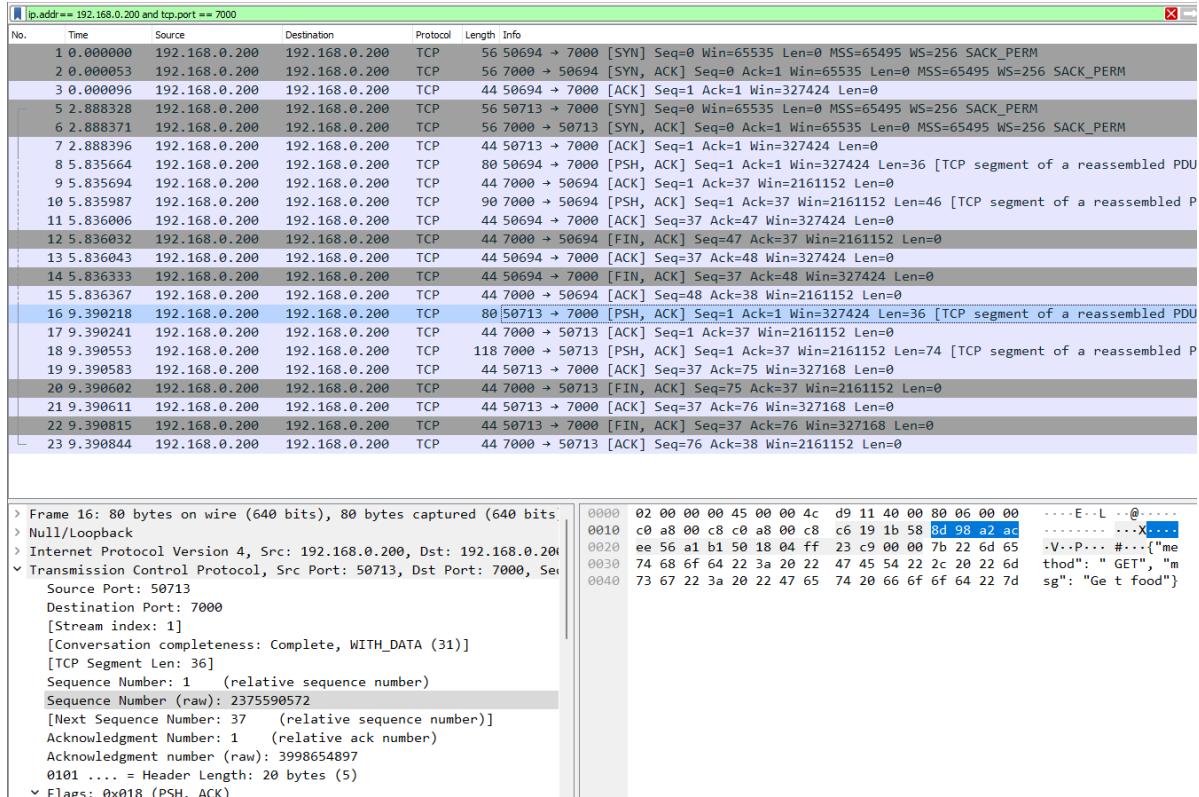


Figure 13.1: Sequence diagram TCP data-transfer phase (client 2/server) step 1

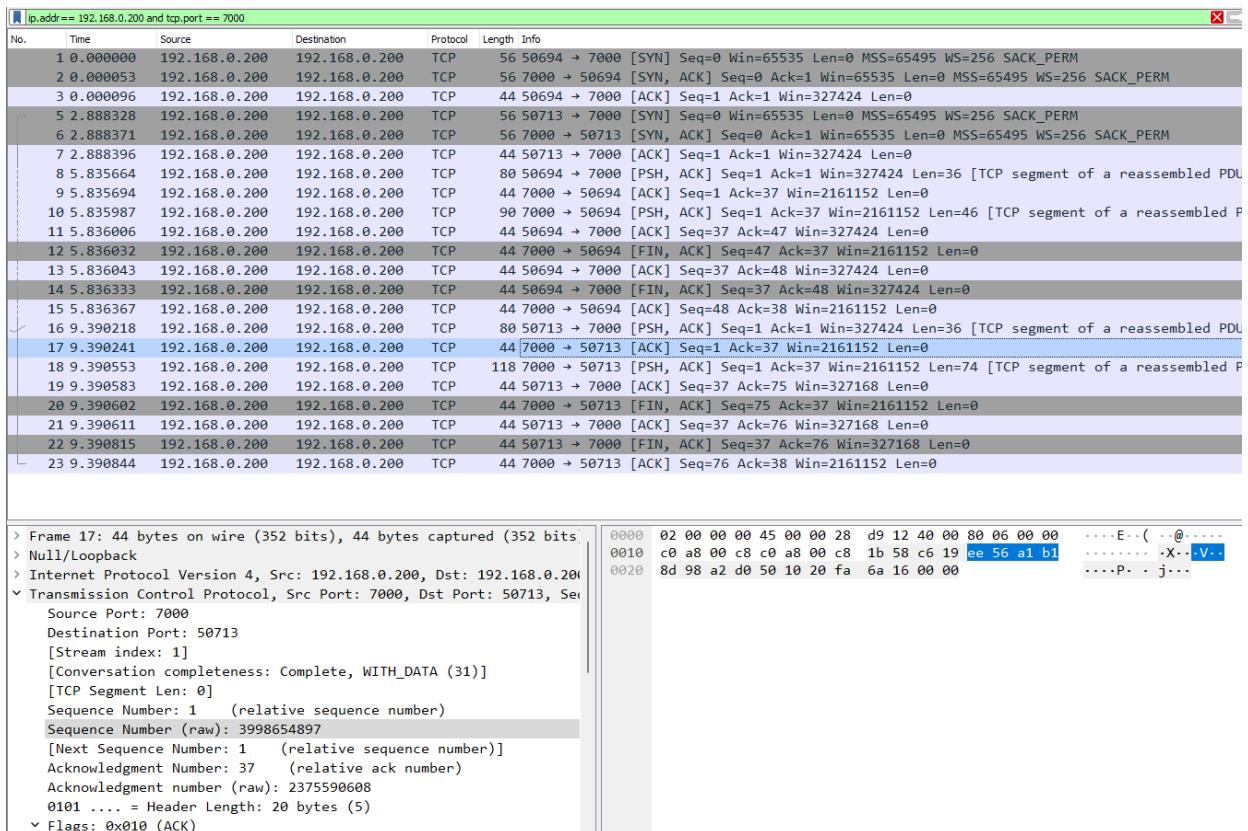


Figure 13.2: Sequence diagram TCP data-transfer phase (client 2/server) step 2

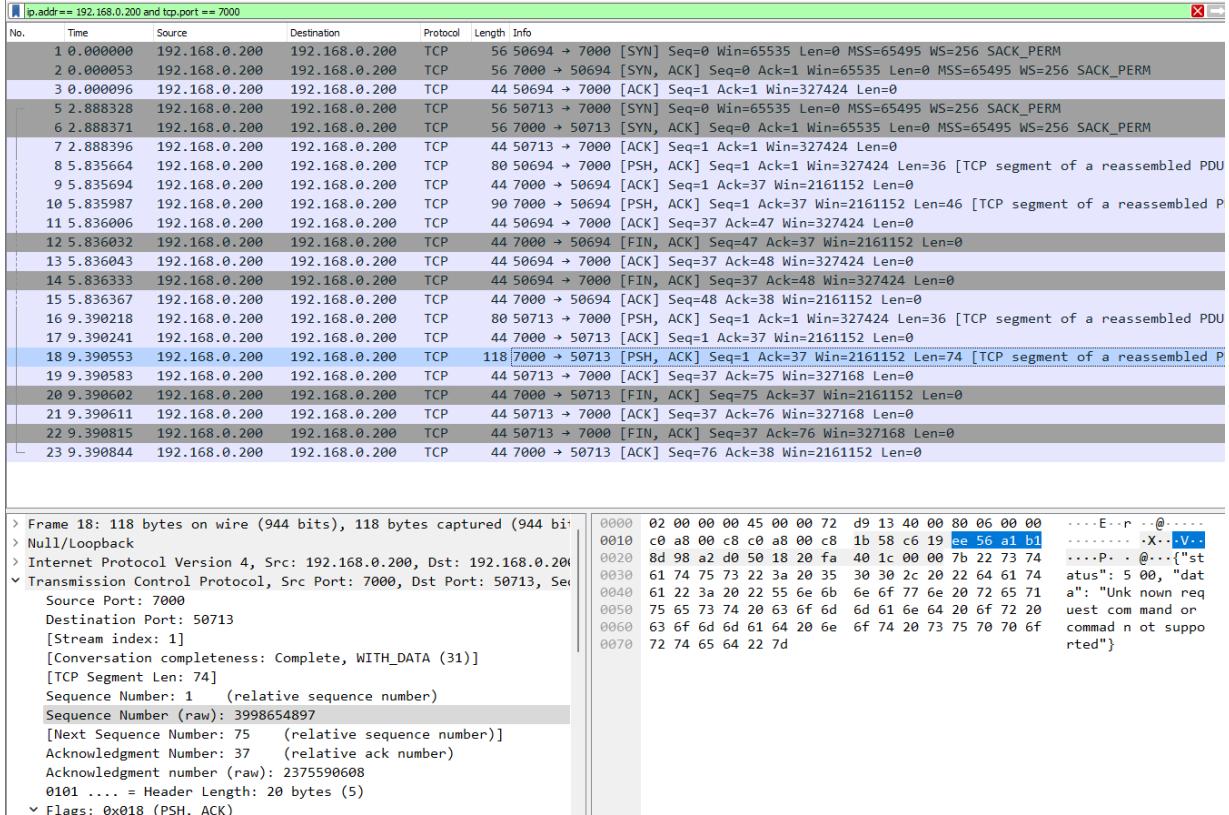


Figure 13.3: Sequence diagram TCP data-transfer phase (client 2/server) step 3

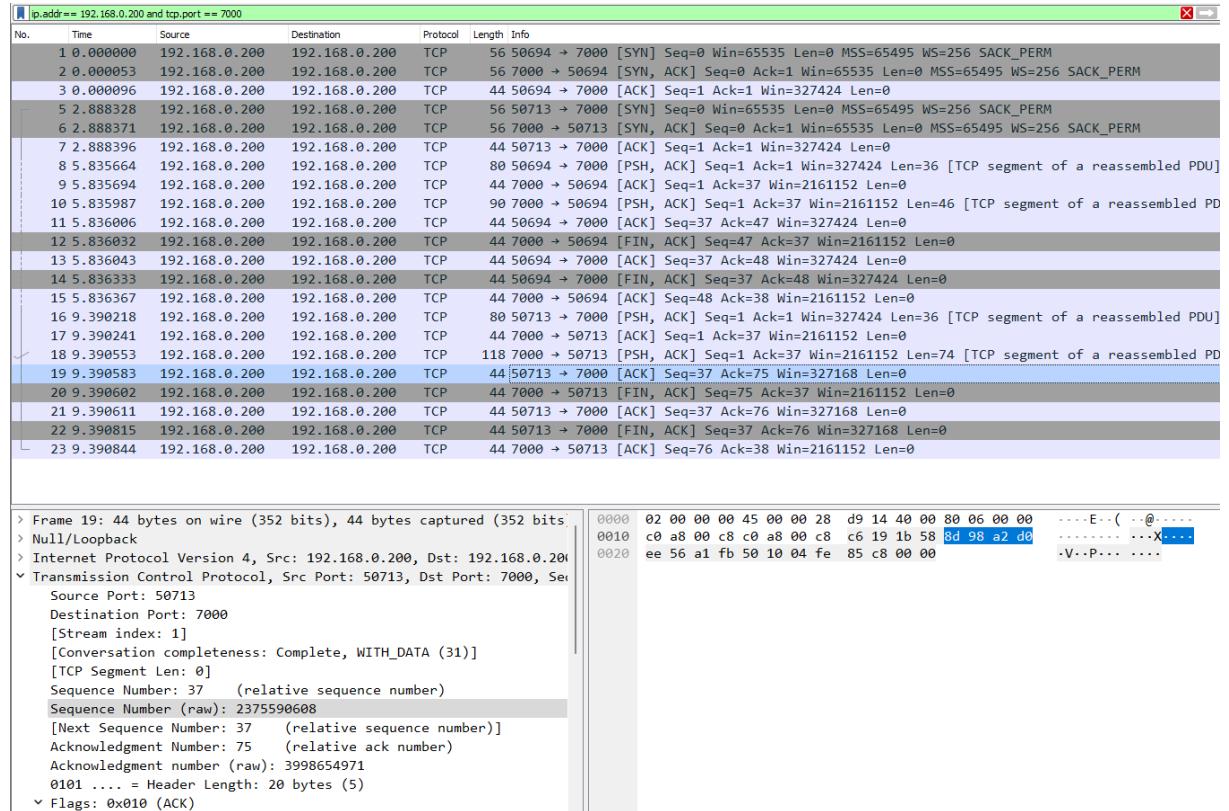


Figure 13.4: Sequence diagram TCP data-transfer phase (client 2/server) step 4

4. TCP Connection Termination

4.1 Client 1 - server

- Server sends FIN, ACK packet to client 1 ($7000 \rightarrow 50694$) with sequence no: 1880225597 and acknowledge no: 511024243
- Client 1 sends back an ACK packet in response ($50694 \rightarrow 7000$) with sequence no: 511024243, acknowledge no: 1880225598
- Client 1 send a FIN, ACK packet to server ($50694 \rightarrow 7000$) which signifies that client wants to close the connection with sequence no: 511024243, acknowledge no: 1880225598
- Server sends ACK packet to client 1 ($7000 \rightarrow 50694$) in response with sequence no: 1880225598, acknowledge no: 511024244

ip.addr == 192.168.0.200 and tcp.port == 7000						
No.	Time	Source	Destination	Protocol	Length	Info
1 0.000000	192.168.0.200	192.168.0.200	TCP	56 50694 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM		
2 0.000053	192.168.0.200	192.168.0.200	TCP	56 7000 → 50694 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=2...		
3 0.000096	192.168.0.200	192.168.0.200	TCP	44 50694 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0		
5 2.888328	192.168.0.200	192.168.0.200	TCP	56 50713 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM		
6 2.888371	192.168.0.200	192.168.0.200	TCP	56 7000 → 50713 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=2...		
7 2.888396	192.168.0.200	192.168.0.200	TCP	44 50713 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0		
8 5.835664	192.168.0.200	192.168.0.200	TCP	80 50694 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment...		
9 5.835694	192.168.0.200	192.168.0.200	TCP	44 7000 → 50694 [ACK] Seq=1 Ack=37 Win=2161152 Len=0		
10 5.835987	192.168.0.200	192.168.0.200	TCP	90 7000 → 50694 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=46 [TCP segme...		
11 5.836006	192.168.0.200	192.168.0.200	TCP	44 50694 → 7000 [ACK] Seq=37 Ack=47 Win=327424 Len=0		
12 5.836032	192.168.0.200	192.168.0.200	TCP	44 7000 → 50694 [FIN, ACK] Seq=47 Ack=37 Win=2161152 Len=0		
13 5.836043	192.168.0.200	192.168.0.200	TCP	44 50694 → 7000 [ACK] Seq=37 Ack=48 Win=327424 Len=0		
14 5.836333	192.168.0.200	192.168.0.200	TCP	44 50694 → 7000 [FIN, ACK] Seq=37 Ack=48 Win=327424 Len=0		
15 5.836367	192.168.0.200	192.168.0.200	TCP	44 7000 → 50694 [ACK] Seq=48 Ack=38 Win=2161152 Len=0		
16 9.390218	192.168.0.200	192.168.0.200	TCP	80 50713 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment...		
17 9.390241	192.168.0.200	192.168.0.200	TCP	44 7000 → 50713 [ACK] Seq=1 Ack=37 Win=2161152 Len=0		
18 9.390553	192.168.0.200	192.168.0.200	TCP	118 7000 → 50713 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=74 [TCP segme...		
19 9.390583	192.168.0.200	192.168.0.200	TCP	44 50713 → 7000 [ACK] Seq=37 Ack=75 Win=327168 Len=0		
20 9.390602	192.168.0.200	192.168.0.200	TCP	44 7000 → 50713 [FIN, ACK] Seq=75 Ack=37 Win=2161152 Len=0		
21 9.390611	192.168.0.200	192.168.0.200	TCP	44 50713 → 7000 [ACK] Seq=37 Ack=76 Win=327168 Len=0		
22 9.390815	192.168.0.200	192.168.0.200	TCP	44 50713 → 7000 [FIN, ACK] Seq=37 Ack=76 Win=327168 Len=0		
23 9.390844	192.168.0.200	192.168.0.200	TCP	44 7000 → 50713 [ACK] Seq=76 Ack=38 Win=2161152 Len=0		

[Stream index: 0] [Conversation completeness: Complete, WITH_DATA (31)] [TCP Segment Len: 0] Sequence Number: 47 (relative sequence number) Sequence Number (raw): 1880225597 [Next Sequence Number: 48 (relative sequence number)] Acknowledgment Number: 37 (relative ack number) Acknowledgment number (raw): 511024243 0101 = Header Length: 20 bytes (5)	0000 02 00 00 00 45 00 00 28 d9 0d 40 00 80 06 00 00 ... 0010 c0 a8 00 c8 c0 a8 00 c8 1b 58 c6 06 70 11 f7 3d ... 0020 1e 75 9c 73 50 11 20 fa 08 62 00 00 ..-u-
--	--

Figure 14.1: TCP termination phase (client 1/server) step 1

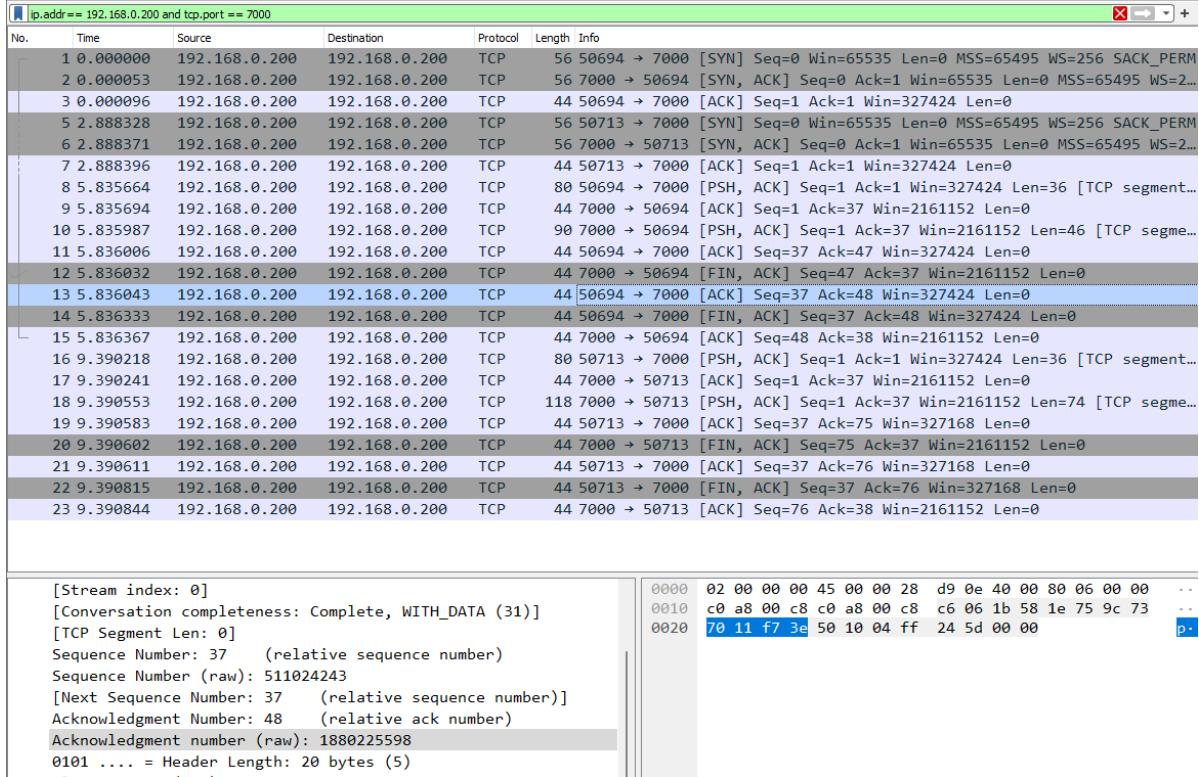


Figure 14.2: TCP termination phase (client 1/server) step 2

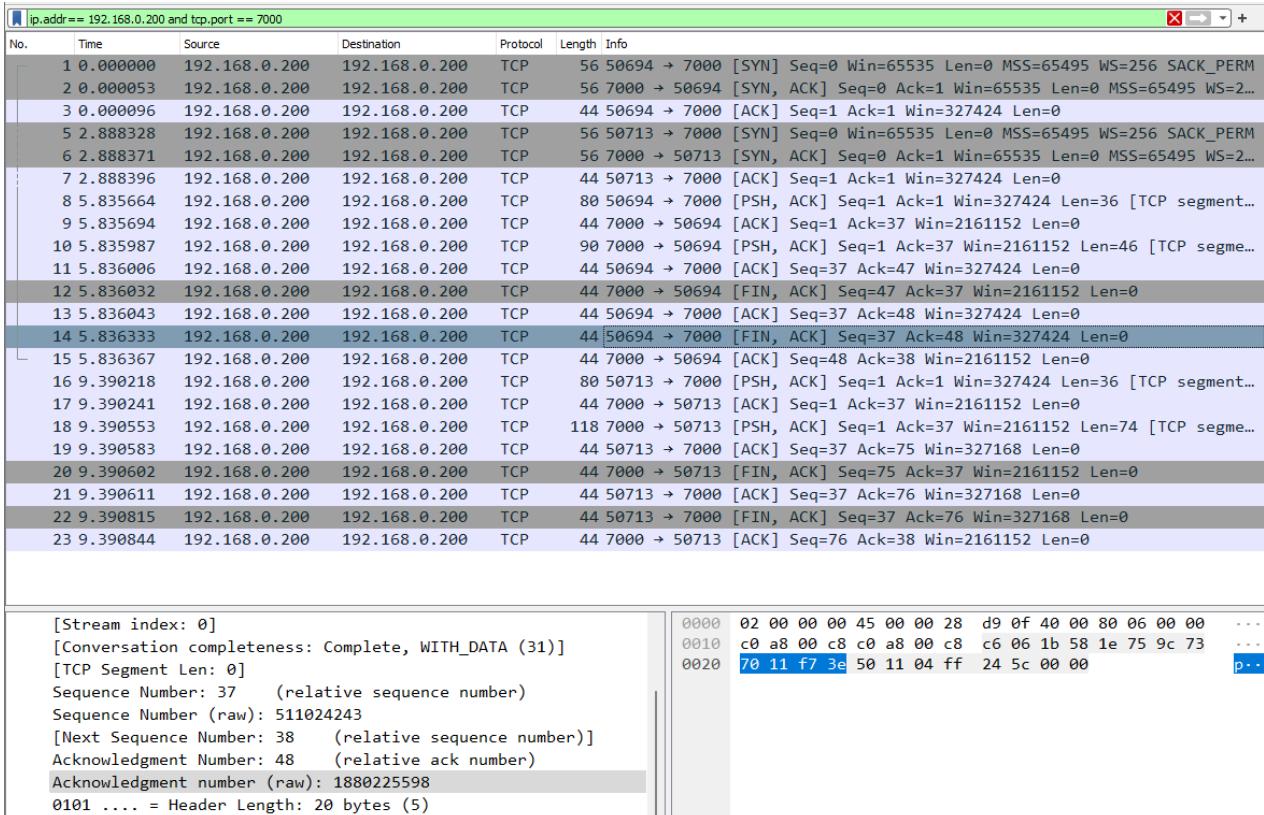


Figure 14.3: TCP termination phase (client 1/server) step 3

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.0.200	192.168.0.200	TCP	56	50694 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
2	0.000053	192.168.0.200	192.168.0.200	TCP	56	7000 → 50694 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=2...
3	0.000096	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
5	2.888328	192.168.0.200	192.168.0.200	TCP	56	50713 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
6	2.888371	192.168.0.200	192.168.0.200	TCP	56	7000 → 50713 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=2...
7	2.888396	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
8	5.835664	192.168.0.200	192.168.0.200	TCP	80	50694 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment ...]
9	5.835694	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
10	5.835987	192.168.0.200	192.168.0.200	TCP	90	7000 → 50694 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=46 [TCP segme...
11	5.836006	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=47 Win=327424 Len=0
12	5.836032	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [FIN, ACK] Seq=47 Ack=37 Win=2161152 Len=0
13	5.836043	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=48 Win=327424 Len=0
14	5.836333	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [FIN, ACK] Seq=37 Ack=48 Win=327424 Len=0
15	5.836367	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=48 Ack=38 Win=2161152 Len=0
16	9.390218	192.168.0.200	192.168.0.200	TCP	80	50713 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment ...]
17	9.390241	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
18	9.390553	192.168.0.200	192.168.0.200	TCP	118	7000 → 50713 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=74 [TCP segme...
19	9.390583	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=75 Win=327168 Len=0
20	9.390602	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [FIN, ACK] Seq=75 Ack=37 Win=2161152 Len=0
21	9.390611	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=76 Win=327168 Len=0
22	9.390815	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [FIN, ACK] Seq=37 Ack=76 Win=327168 Len=0
23	9.390844	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=76 Ack=38 Win=2161152 Len=0

[Stream index: 0] [Conversation completeness: Complete, WITH_DATA (31)] [TCP Segment Len: 0] Sequence Number: 48 (relative sequence number) Sequence Number (raw): 1880225598 [Next Sequence Number: 48 (relative sequence number)] Acknowledgment Number: 38 (relative ack number) Acknowledgment number (raw): 511024244 0101 = Header Length: 20 bytes (5)	0000 02 00 00 00 45 00 00 28 d9 10 40 00 80 06 00 00 ... 0010 c0 a8 00 c8 c0 a8 00 c8 1b 58 c6 06 70 11 f7 3e ... 0020 1e 75 9c 74 50 10 20 fa 08 61 00 00
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Figure 14.4: TCP termination phase (client 1/server) step 4

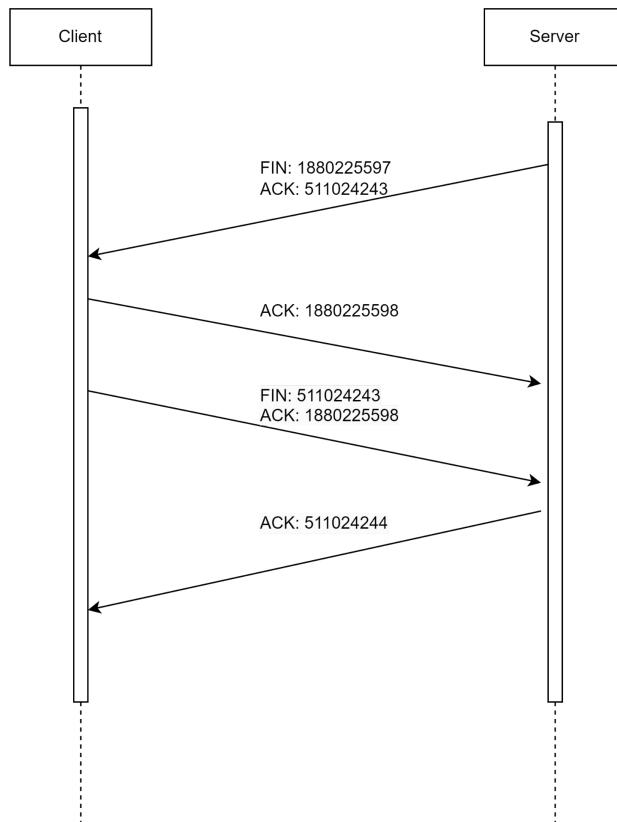


Figure 15: Sequence diagram TCP termination phase (client 1/server)

4.2 Client 2 - server

- Server sends FIN, ACK packet to client 2 ($7000 \rightarrow 50713$) with sequence no: 3998654971 and acknowledge no: 2375590608
- Client 1 sends back an ACK packet in response ($50713 \rightarrow 7000$) with sequence no: 2375590608, acknowledge no: 3998654972
- Client 1 send a FIN, ACK packet to server ($50713 \rightarrow 7000$) which signifies that client wants to close the connection with sequence no: 2375590608, acknowledge no: 3998654972
- Server sends ACK packet to client 2 ($7000 \rightarrow 50713$) in response with sequence no: 399865972, acknowledge no: 2375590609

ip.addr == 192.168.0.200 and tcp.port == 7000						
No.	Time	Source	Destination	Protocol	Length	Info
1 0.000000	192.168.0.200	192.168.0.200	TCP	56 50694 → 7000	[SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM	
2 0.000053	192.168.0.200	192.168.0.200	TCP	56 7000 → 50694	[SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=2...	
3 0.000096	192.168.0.200	192.168.0.200	TCP	44 50694 → 7000	[ACK] Seq=1 Ack=1 Win=327424 Len=0	
5 2.888328	192.168.0.200	192.168.0.200	TCP	56 50713 → 7000	[SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM	
6 2.888371	192.168.0.200	192.168.0.200	TCP	56 7000 → 50713	[SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=2...	
7 2.888396	192.168.0.200	192.168.0.200	TCP	44 50713 → 7000	[ACK] Seq=1 Ack=1 Win=327424 Len=0	
8 5.835664	192.168.0.200	192.168.0.200	TCP	80 50694 → 7000	[PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment ...]	
9 5.835694	192.168.0.200	192.168.0.200	TCP	44 7000 → 50694	[ACK] Seq=1 Ack=37 Win=2161152 Len=0	
10 5.835987	192.168.0.200	192.168.0.200	TCP	90 7000 → 50694	[PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=46 [TCP segme...	
11 5.836006	192.168.0.200	192.168.0.200	TCP	44 50694 → 7000	[ACK] Seq=37 Ack=47 Win=327424 Len=0	
12 5.836032	192.168.0.200	192.168.0.200	TCP	44 7000 → 50694	[FIN, ACK] Seq=47 Ack=37 Win=2161152 Len=0	
13 5.836043	192.168.0.200	192.168.0.200	TCP	44 50694 → 7000	[ACK] Seq=37 Ack=48 Win=327424 Len=0	
14 5.836333	192.168.0.200	192.168.0.200	TCP	44 50694 → 7000	[FIN, ACK] Seq=37 Ack=48 Win=327424 Len=0	
15 5.836367	192.168.0.200	192.168.0.200	TCP	44 7000 → 50694	[ACK] Seq=48 Ack=38 Win=2161152 Len=0	
16 9.390218	192.168.0.200	192.168.0.200	TCP	80 50713 → 7000	[PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment ...]	
17 9.390241	192.168.0.200	192.168.0.200	TCP	44 7000 → 50713	[ACK] Seq=1 Ack=37 Win=2161152 Len=0	
18 9.390553	192.168.0.200	192.168.0.200	TCP	118 7000 → 50713	[PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=74 [TCP segme...	
19 9.390583	192.168.0.200	192.168.0.200	TCP	44 50713 → 7000	[ACK] Seq=37 Ack=75 Win=327168 Len=0	
20 9.390602	192.168.0.200	192.168.0.200	TCP	44 7000 → 50713	[FIN, ACK] Seq=75 Ack=37 Win=2161152 Len=0	
21 9.390611	192.168.0.200	192.168.0.200	TCP	44 50713 → 7000	[ACK] Seq=37 Ack=76 Win=327168 Len=0	
22 9.390815	192.168.0.200	192.168.0.200	TCP	44 50713 → 7000	[FIN, ACK] Seq=37 Ack=76 Win=327168 Len=0	
23 9.390844	192.168.0.200	192.168.0.200	TCP	44 7000 → 50713	[ACK] Seq=76 Ack=38 Win=2161152 Len=0	

[Stream index: 1] [Conversation completeness: Complete, WITH_DATA (31)] [TCP Segment Len: 0] Sequence Number: 75 (relative sequence number) Sequence Number (raw): 3998654971 [Next Sequence Number: 76 (relative sequence number)] Acknowledgment Number: 37 (relative ack number) Acknowledgment number (raw): 2375590608 0101 = Header Length: 20 bytes (5)	0000 02 00 00 00 45 00 00 28 d9 15 40 00 80 06 00 00 0010 c0 a8 00 c8 c0 a8 00 c8 1b 58 c6 19 ee 56 a1 fb 0020 8d 98 a2 d0 50 11 20 fa 69 cb 00 00	...
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Figure 16.1: TCP termination phase (client 2/server) step 1

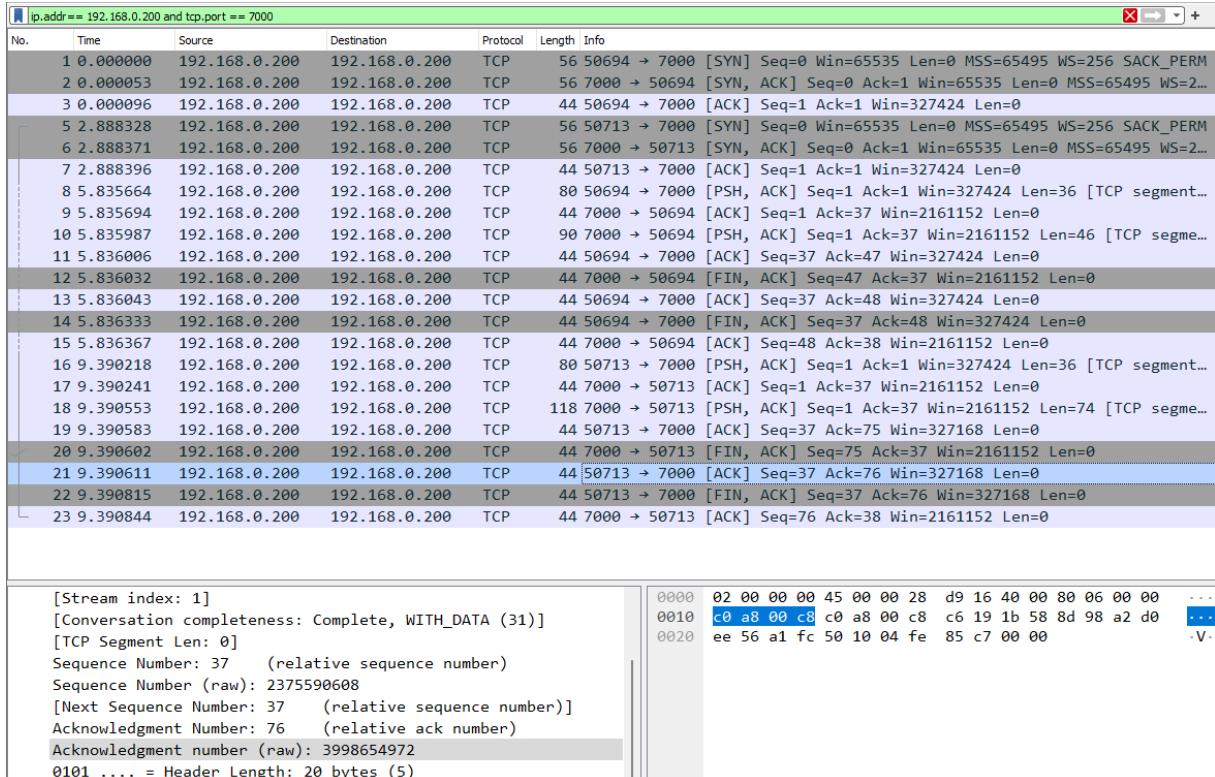


Figure 16.2: TCP termination phase (client 2/server) step 2

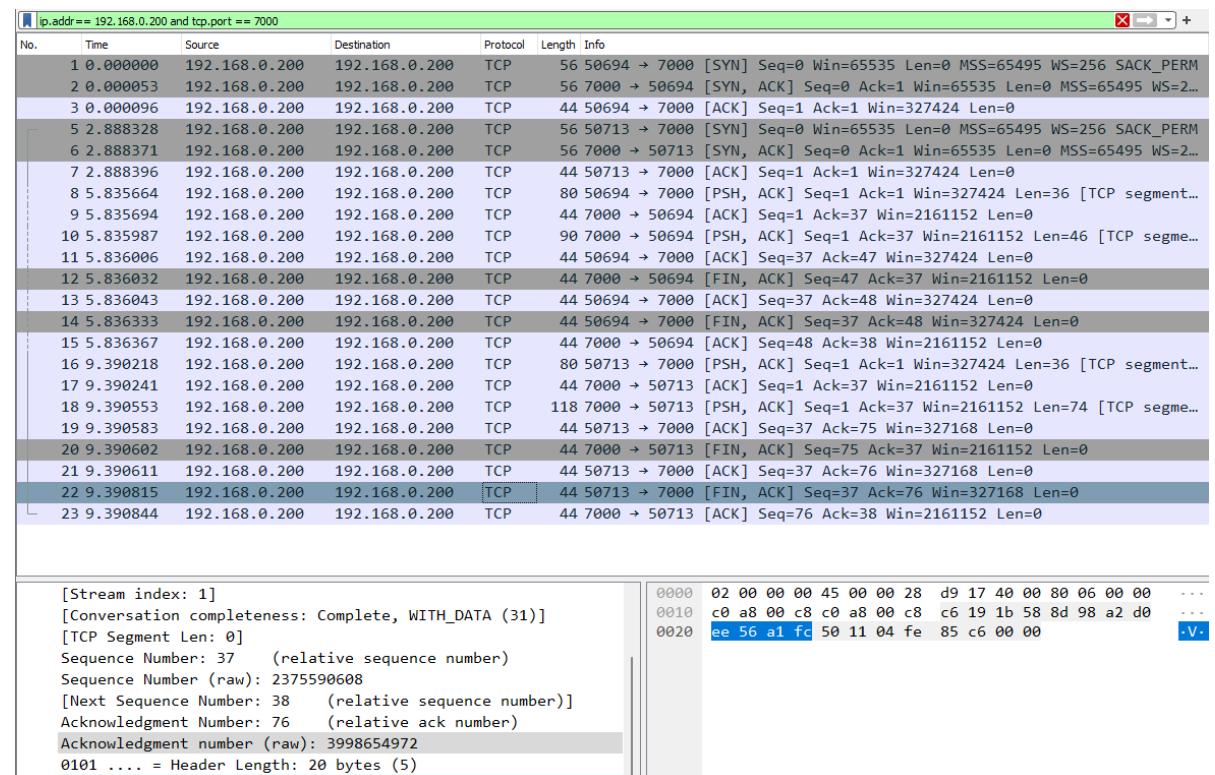


Figure 16.3: TCP termination phase (client 2/server) step 3

ip.addr == 192.168.0.200 and tcp.port == 7000						
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.0.200	192.168.0.200	TCP	56	50694 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
2	0.000053	192.168.0.200	192.168.0.200	TCP	56	7000 → 50694 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=2...
3	0.000096	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
5	2.888328	192.168.0.200	192.168.0.200	TCP	56	50713 → 7000 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM
6	2.888371	192.168.0.200	192.168.0.200	TCP	56	7000 → 50713 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=2...
7	2.888396	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=1 Ack=1 Win=327424 Len=0
8	5.835664	192.168.0.200	192.168.0.200	TCP	80	50694 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment ...]
9	5.835694	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
10	5.835987	192.168.0.200	192.168.0.200	TCP	90	7000 → 50694 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=46 [TCP segme...]
11	5.836006	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=47 Win=327424 Len=0
12	5.836032	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [FIN, ACK] Seq=47 Ack=37 Win=2161152 Len=0
13	5.836043	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [ACK] Seq=37 Ack=48 Win=327424 Len=0
14	5.836333	192.168.0.200	192.168.0.200	TCP	44	50694 → 7000 [FIN, ACK] Seq=37 Ack=48 Win=327424 Len=0
15	5.836367	192.168.0.200	192.168.0.200	TCP	44	7000 → 50694 [ACK] Seq=48 Ack=38 Win=2161152 Len=0
16	9.390218	192.168.0.200	192.168.0.200	TCP	80	50713 → 7000 [PSH, ACK] Seq=1 Ack=1 Win=327424 Len=36 [TCP segment ...]
17	9.390241	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=1 Ack=37 Win=2161152 Len=0
18	9.390553	192.168.0.200	192.168.0.200	TCP	118	7000 → 50713 [PSH, ACK] Seq=1 Ack=37 Win=2161152 Len=74 [TCP segme...]
19	9.390583	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=75 Win=327168 Len=0
20	9.390602	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [FIN, ACK] Seq=75 Ack=37 Win=2161152 Len=0
21	9.390611	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [ACK] Seq=37 Ack=76 Win=327168 Len=0
22	9.390815	192.168.0.200	192.168.0.200	TCP	44	50713 → 7000 [FIN, ACK] Seq=37 Ack=76 Win=327168 Len=0
23	9.390844	192.168.0.200	192.168.0.200	TCP	44	7000 → 50713 [ACK] Seq=76 Ack=38 Win=2161152 Len=0

[Stream index: 1] [Conversation completeness: Complete, WITH_DATA (31)] [TCP Segment Len: 0] Sequence Number: 76 (relative sequence number) Sequence Number (raw): 3998654972 [Next Sequence Number: 76 (relative sequence number)] Acknowledgment Number: 38 (relative ack number) Acknowledgment number (raw): 2375590609 0101 = Header Length: 20 bytes (5)	0000 02 00 00 00 45 00 00 28 d9 18 40 00 80 06 00 00 ... 0010 c0 a8 00 c8 c0 a8 00 c8 1b 58 c6 19 ee 56 a1 fc ... 0020 8d 98 a2 d1 50 10 20 fa 69 ca 00 00 ...
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Figure 16.4: TCP termination phase (client 2/server) step 4

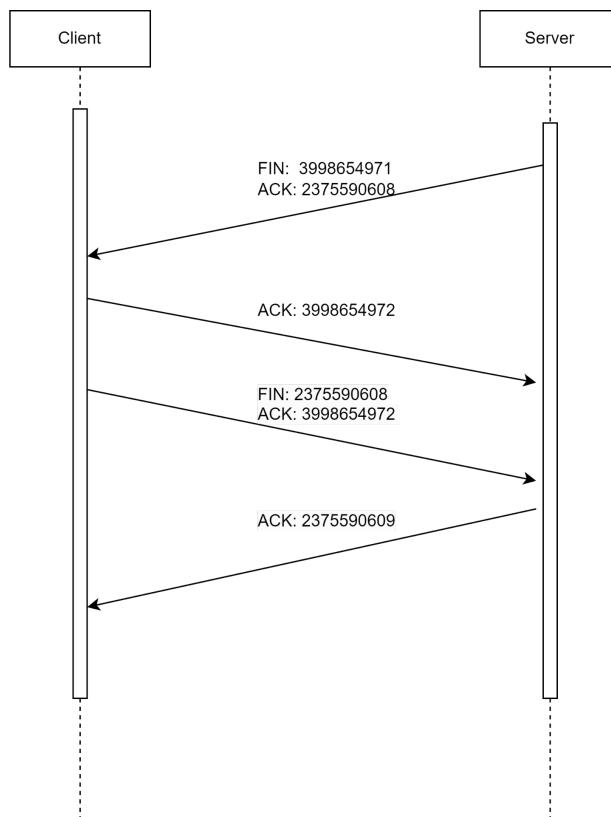


Figure 17: Sequence diagram TCP termination phase (client 2/server)