Network and Distributed Systems Laboratory Session

Session 5

Development of a basic client and server over TCP in Java. The server will provide a basic text capitalisation service.

Task 1: Server Specification (class ServerTCP.java)

The server specifications:

- The port on which you will receive requests will be passed as an argument on the command line. For example: java `ServerTCP 12345`
- Once a connection to a client has been established, it waits to receive text to be modified (read it with `readLine`) from the connected socket.
- The server's reply will depend on the request:
  - If it receives `END` it will return `OK` and close the connection.
  - Otherwise it will return the text capitalised.
- Once the connection is closed, the server will again wait for a new connection and service request.
- The server shall report its current status on the standard output (screen).
- The server must be able to recover (correctly release resources and re-host another client) if the client terminates the connection incorrectly.
- The server can only have one client waiting (**the queue of pending clients must be 1**).

Task 2: Client Specification (class ClientTCP.java)

Customer specifications:

- The IP address and port of the server to which the client should connect will be passed as an argument on the command line. For example:
  `java ClientTCP 192.168.1.2 12345`
- Once the client is connected, it should continuously request the user for the text to capitalise (a line of text) and send it to the server (using `println`).
- After each sending of the text to be processed, the client must wait for the response from the server containing the modified text.
- When the user wants to terminate, he/she will type with the value `TERMINATE.`
- When the client detects that the user wants to terminate it will send the text `END`, wait for the server's response (`OK`) and close the connection.
- During the whole execution the client must inform the user (by typing on the screen) its status (e.g.: `Connected to 192.168.1.2:12345, Waiting for response...`).
- If the client sends data and the connection is found to be closed, it **closes the client in an orderly manner**.

Task 3: Trace capture

Simulate the following behaviours by taking the generated traffic trace with Wireshark. If the client and server are on the same machine, use the `loopback` IP (`127.0.0.1`) as the IP of the server. As interface to capture you should use the interface called `Adapter for loopback traffic capture`.

TCP1 behaviour (trace 1 - **p5e1-4.pcapng**):

- Start the server and then the client.
- In the client send a single message and then type `TERMINATE` to end it.

TCP2 behaviour (trace 2 - **p5e5.pcapng**):

- Without having any server active, try to start the client.

TCP3 behaviour (trace 3 - **p5e6-7 .pcapng**):

- Start the server.
- Then start 3 clients trying to connect to that server.
- Write `TERMINATE` on clients who have successfully logged in to finalise shipments.

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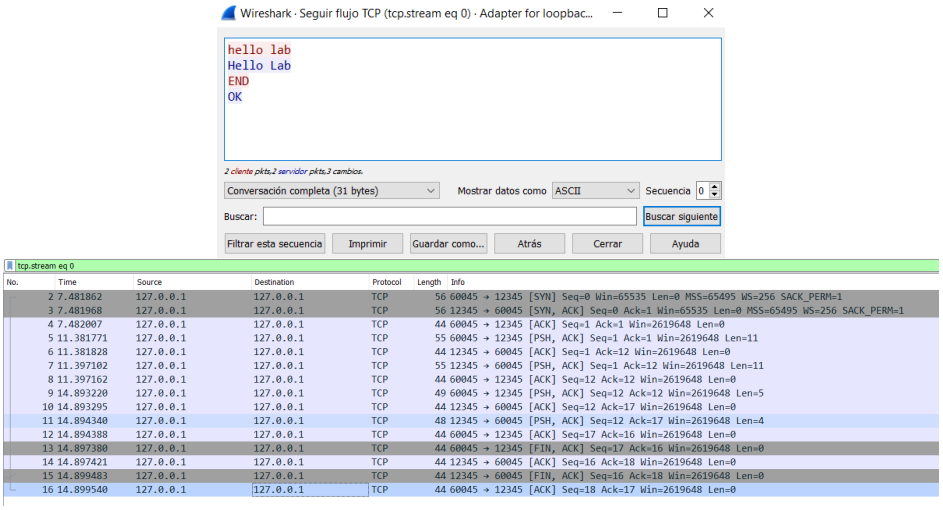
Task 4: Analysis of our TCP protocol

Answer the following questions using the traces captured above.

Using the TCP1 trace (**p5e1-4.pcapng**):

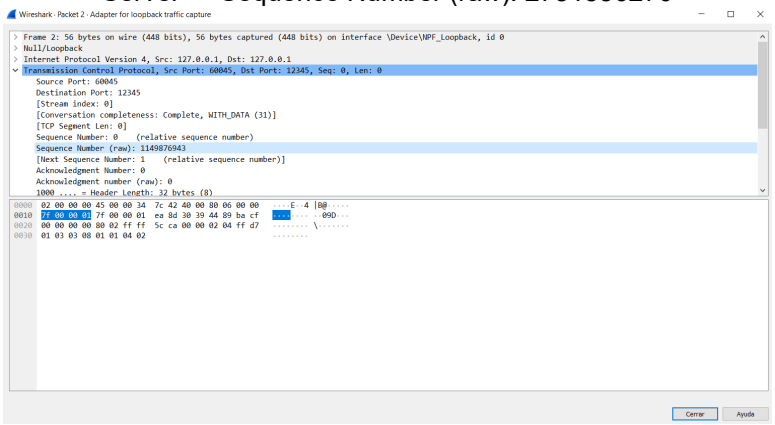
Exercise 1. Identify a frame of the communication and use the "`Follow TCP stream`" option to see the information exchange between client and server. Which port is the client using? And the server?

Server: 12345
Client: 60455



Exercise 2. What is the number of the sequence number (absolute) used by the TCP client to the server? And the responses from the server to the client?

Client -> Sequence Number (raw): 1149876943
Server -> Sequence Number (raw): 2781886270



Exercise 3. Specify the segments related to the following activities and which `Socket` and `ServerSocket` methods are responsible for the exchange of these segments:

a) Initialisation of the connection.
b) Sending data.
(c) Close of the connection.

2 7.481862	127.0.0.1	127.0.0.1	TCP	56 60045 → 12345 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM=1
3 7.481968	127.0.0.1	127.0.0.1	TCP	56 12345 → 60045 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM=1
4 7.482007	127.0.0.1	127.0.0.1	TCP	44 60045 → 12345 [ACK] Seq=1 Ack=1 Win=2619648 Len=0
5 11.381771	127.0.0.1	127.0.0.1	TCP	55 60045 → 12345 [PSH, ACK] Seq=1 Ack=1 Win=2619648 Len=11
6 11.381828	127.0.0.1	127.0.0.1	TCP	44 12345 → 60045 [ACK] Seq=1 Ack=12 Win=2619648 Len=0
7 11.397102	127.0.0.1	127.0.0.1	TCP	55 12345 → 60045 [PSH, ACK] Seq=1 Ack=12 Win=2619648 Len=11
8 11.397162	127.0.0.1	127.0.0.1	TCP	44 60045 → 12345 [ACK] Seq=12 Ack=12 Win=2619648 Len=0
9 14.893220	127.0.0.1	127.0.0.1	TCP	49 60045 → 12345 [PSH, ACK] Seq=12 Ack=12 Win=2619648 Len=5
10 14.893295	127.0.0.1	127.0.0.1	TCP	44 12345 → 60045 [ACK] Seq=12 Ack=17 Win=2619648 Len=0
11 14.894340	127.0.0.1	127.0.0.1	TCP	48 12345 → 60045 [PSH, ACK] Seq=12 Ack=17 Win=2619648 Len=4
12 14.894388	127.0.0.1	127.0.0.1	TCP	44 60045 → 12345 [ACK] Seq=17 Ack=16 Win=2619648 Len=0
13 14.897380	127.0.0.1	127.0.0.1	TCP	44 60045 → 12345 [FIN, ACK] Seq=17 Ack=16 Win=2619648 Len=0
14 14.897421	127.0.0.1	127.0.0.1	TCP	44 12345 → 60045 [ACK] Seq=16 Ack=18 Win=2619648 Len=0
15 14.899483	127.0.0.1	127.0.0.1	TCP	44 12345 → 60045 [FIN, ACK] Seq=16 Ack=18 Win=2619648 Len=0
16 14.899540	127.0.0.1	127.0.0.1	TCP	44 60045 → 12345 [ACK] Seq=18 Ack=17 Win=2619648 Len=0

Gray initialization, blue exchange of messages; gray again, end of the connection.

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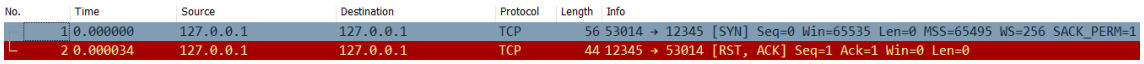
Exercise 4. How many sequence numbers are consumed on each side (client and server) during connection initiation and closure?

Initialization 1 Server 1 client.
Closure 1 Server 1 client. Unless we count END/OK as the closure and have three bytes and 2 to transmit more.
Due to the difference of the difference od END-OK and flags message

Using the TCP2 trace (**p5e5 .pcapng**):

Exercise 5. Does the client's connection attempt receive any kind of reply? If so, does it have any special characteristics?



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	127.0.0.1	127.0.0.1	TCP	56	53014 → 12345 [SYN] Seq=0 Win=65535 Len=0 MSS=65495 WS=256 SACK_PERM=1
2	0.000034	127.0.0.1	127.0.0.1	TCP	44	12345 → 53014 [RST, ACK] Seq=1 Ack=1 Win=0 Len=0

RST

Using the TCP3 trace (**p5e6-7.pcapng**):

Exercise 6. Are all 3 clients able to connect? If any of them failed to connect, is there any indication that the queue is full?

No, only the first one (connected) and the second (queue); the third receives RST answer.

Exercise 7. Are waiting clients (i.e. those in the queue) initialised or is this initialisation done when they are freed from the queue (with the `accept` method)?

The clients stop at the readline from their code and won't be released until the server releases its current client.

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Server

```
import java.io.*;
import java.net.*;

class ServerTCP {
	public static String capitalize(String s) {
		String words[] = s.split("\\s");
		String res = "";
		for (String w : words) {
			if (!res.isEmpty()) {
				res += " ";
			}
			res += w.substring(0, 1).toUpperCase() + w.substring(1);
		}
		return res;
	}

	public static void main(String[] args) {
		// SERVER DATA
		// * FIXED: If read from command line must be commented out
		// int port = 12345; // server port
		// * VARIABLE: If read from command line it must be uncommented
		int port = Integer.parseInt(args[0]); // 12345

		// SOCKETS
		ServerSocket server = null; // Passive (receiving requests)

		Socket client = null; // Active (client service)

		// FLOWS FOR SENDING AND RECEIVING
		BufferedReader in = null;
		PrintWriter out = null;

		// Create and initialise server socket (passive socket)
		try {
			server = new ServerSocket(port, 1); // Queue Size = 1 / Backlog
		} catch (IOException e) {
			System.err.println("Error: cannot connnect to port " + port);
			System.exit(1);
		}

		while (true) // Loop to receive incoming connections
		{
			// Waiting for incoming connections
			System.out.println("STATUS: Waiting for clients");
			try {
				client = server.accept(); // Blocks until a connection is binded
			} catch (IOException e) {
				System.err.println("Error: could not accept a client on port:" +
port);
				System.exit(1);
			}

			SocketAddress clientAddress = client.getRemoteSocketAddress();

			System.out.println("STATUS: Client " + clientAddress + "accepted.");
			// Once a connection is accepted, initialise input/output streams of the
			// connected socket

			try {
				out = new PrintWriter(client.getOutputStream(), true);
				in = new BufferedReader(new
InputStreamReader(client.getInputStream()));
			} catch (IOException e) {
				System.err.println("Error: could not get I/O for  client " +
clientAddress);
				System.exit(1);
			}

			System.out.println("STATUS: Client connected from " + clientAddress);

			boolean exit = false;
			while (!exit) // Start loop of a client service
```

```
                        {
                                String line = null;
                                // Receive inline text sent by the client via the input stream
of the
                                // connected socket
                                try {
                                        line = in.readLine();
                                } catch (IOException e) {
                                        System.err.println("Error: Could not get the input from
client " + clientAddress);
                                        System.exit(1);
                                }
                                System.out.println("STATUS: Received " + line + " from the
client");
                                // Check if it is the end of connection - REPLACE WITH 'END'
STATEMENT
                                if (line.compareTo("END") != 0) {
                                        line = capitalize(line);

                                        // Send text to the client via the outgoing stream of
the connected
                                        // socket
                                        out.println(line);
                                        System.out.println("STATUS: Sending to the client: " +
line);
                                } else { // Client wants to close connection, has sent END
                                        exit = true;
                                        out.println("OK");
                                }
                        } // end of service
                        System.out.println("STATUS: Closing the connection with " +
clientAddress);
                        // Close flows and socket
                        try {
                                in.close();
                                out.close();
                                client.close();
                        } catch (IOException e) {
                                System.err.println("Error: Closing the connection");
                                System.exit(1);
                        }

                        System.out.println("STATUS: Connection closed");
                } // end of loop
        } // end of method
}
```

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Client

```
import java.io.*;
import java.net.*;

public class ClientTCP {

	public static void main(String[] args) throws IOException {
		// SERVER DATA:
		// * FIXED: comment them out if you read them from the command line.
		// String serverName = "127.0.0.1"; // local address
		// int serverPort = 12345;
		// * VARIABLES: uncomment them if you read them from the command line
		String serverName = args[0];
		int serverPort = Integer.parseInt(args[1]);

		// SOCKET
		Socket serviceSocket = null;

		// FLOWS FOR SENDING AND RECEIVING
		PrintWriter out = null;
		BufferedReader in = null;

		// * TODO: Create socket and connect to server
		try {
			System.out.println("STATUS: Connecting to the server");
			serviceSocket = new Socket(serverName, serverPort);
		} catch (IOException e) {
			System.err.println("Error: cannot connnect to " + serverName);
			System.exit(1);
		}
		// Initialise input/output streams of connected socket in PrintWriter
		// and BufferedReader variables
		try {
			out = new PrintWriter(serviceSocket.getOutputStream(), true);
			in = new BufferedReader(new
InputStreamReader(serviceSocket.getInputStream()));
		} catch (IOException e) {
			System.err.println("Error: could not get I/O for  " + serverName);
			System.exit(1);
		}

		// Receive welcome message from server and display it
		System.out.println("STATUS: Connected to the server");
		// Get text from keyboard
		BufferedReader stdIn = new BufferedReader(new InputStreamReader(System.in));
		String userInput;

		System.out.println("Enter a text to be sent (TERMINATE to finish)");
		userInput = stdIn.readLine();

		// * TODO: Check if the user has started the end of the interaction
		while (userInput.compareTo("TERMINATE") != 0) { // service loop
			// Send text in userInput to the server via the output stream of the
			// connected socket
			out.println(userInput);
			System.out.println("STATUS: Sending " + userInput);
			System.out.println("STATUS: Waiting for a reply");
			// Receive text sent by the server via the input stream of the connected
socket
			String line = null;
			try {
				line = in.readLine(); // If it is waiting at the queue this is
the last line waiting
			} catch (IOException e) {
				System.err.println("Error: could not read the message of server
" + serverName);
				System.exit(1);
			}

			System.out.println("Reply received: " + line);

			// Read user text by keyboard
			System.out.println("Enter a text to be sent (TERMINATE to finish)");
```

```
                        userInput = stdIn.readLine();
                } // End of client service loop

                System.out.println("STATUS: Closing the connection to the server");
                // We exit because the client wants to end the interaction, it has entered
                // TERMINATE.
                // Send END to the server to indicate the end of the service.
                out.println("END");
                // * TODO: Receive OK from Server
                String ok = in.readLine();
                System.out.println("STATUS: Closing . . .");
                // Close flows and socket
                out.close();
                in.close();
                stdIn.close();
                serviceSocket.close();
                System.out.println("STATUS: Connection closed");
        }
}
```