Project2Task0Client

```
// imports required for UDP/IP
import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStreamReader;
import java.net.DatagramPacket;
import java.net.DatagramSocket;
import java.net.InetAddress;
import java.net.SocketException;
import java.util.Arrays;

public class EchoClientUDP {
    public static void main(String args[]) {
        // define a Datagram (UDP style) socket
        DatagramSocket aSocket = null;
        try {
            // show the announcement
            System.out.println("The client is running");

            // build an InetAddress object from a DNS name
            InetAddress aHost = InetAddress.getByName("localhost");

            // client sends a message to port 6789
            int serverPort = 6789;

            // define the user's input
            String nextLine;

            // initialize the socket
            aSocket = new DatagramSocket();

            // read user's input
            BufferedReader typed = new BufferedReader(new
InputStreamReader(System.in));

            // loop to receive the input from client
            while ((nextLine = typed.readLine()) != null) {
                // build packet contents by input string
                byte[] m = nextLine.getBytes();

                // build the packet holding the destination address, port and
byte array to contact the server
                DatagramPacket request = new DatagramPacket(m, m.length,
aHost, serverPort);

                // send the Datagram on the socket
                aSocket.send(request);

                // prepare room for the reply
                byte[] buffer = new byte[1000];

                // build a datagram for the reply
                DatagramPacket reply = new DatagramPacket(buffer,
buffer.length);

                // block and wait
```

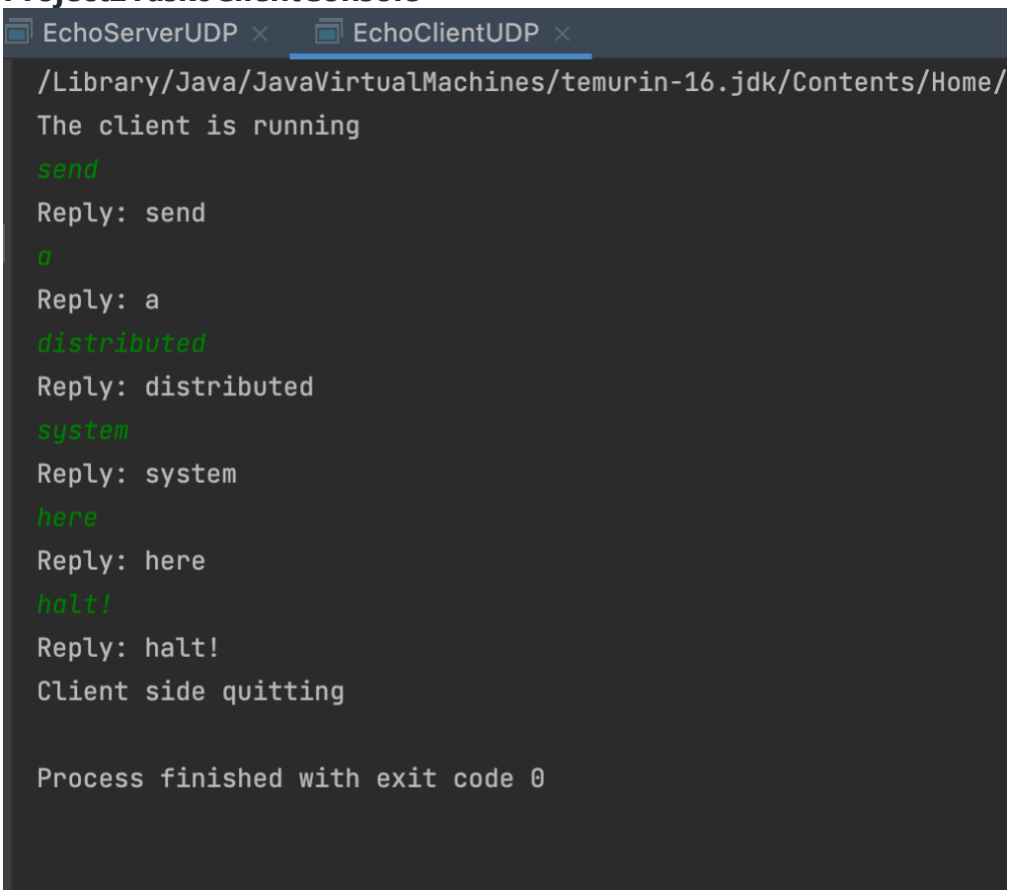
```
                aSocket.receive(reply);

                // get bytes arrays from the reply with correct length
                byte[] reply_bytes = Arrays.copyOf(reply.getData(),
reply.getLength());

                // modify the request data with the correct number of bytes
                reply.setData(reply_bytes);

                // show the result to the client
                System.out.println("Reply: " + new String(reply.getData()));

                //  after hearing the "halt!" message from the server, the
client makes an announcement and then exits
                if (nextLine.equals("halt!")) {
                    System.out.println("Client side quitting");
                    break;
                }
            }
            // handle socket exceptions
        } catch (SocketException e) {
            System.out.println("Socket: " + e.getMessage());
            // handle general I/O exceptions
        } catch (IOException e) {
            System.out.println("IO: " + e.getMessage());
        } finally {
            // always close the socket
            if (aSocket != null) aSocket.close();
        }
    }
}
```

Project2Task0Server

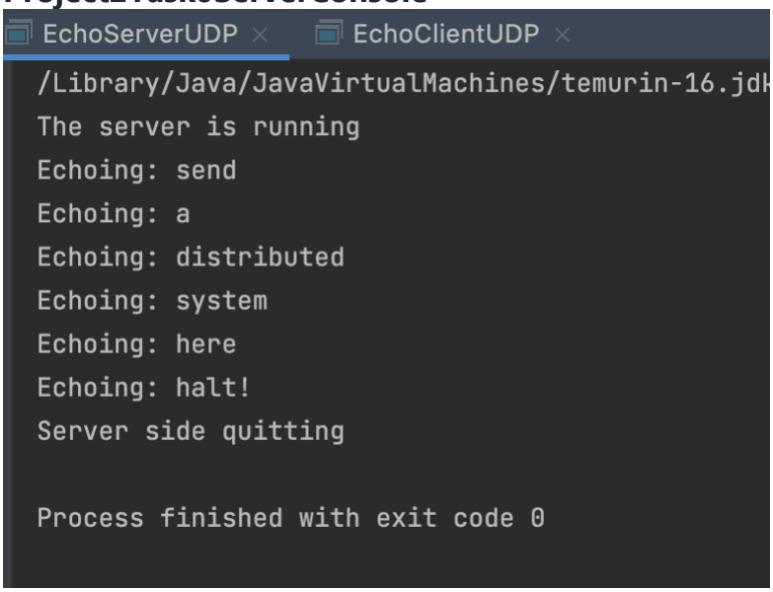
```
// imports required for UDP/IP
import java.io.IOException;
import java.net.DatagramPacket;
import java.net.DatagramSocket;
import java.net.SocketException;
import java.util.Arrays;

public class EchoServerUDP {
    public static void main(String args[]) {
        // define a Datagram (UDP style) socket
        DatagramSocket aSocket = null;
        try {
            // show the announcement
            System.out.println("The server is running");

            // initialize the socket using 6789 port number
            aSocket = new DatagramSocket(6789);

            // loop forever
            while (true) {

                // prepare room for the request
                byte[] buffer = new byte[1000];
```

```
                // initialize the request
                DatagramPacket request = new DatagramPacket(buffer,
buffer.length);

                // receive request data from the socket
                aSocket.receive(request);

                // get bytes arrays from the request with correct length
                byte[] request_bytes = Arrays.copyOf(request.getData(),
request.getLength());

                // modify the request data with the correct number of bytes
                request.setData(request_bytes);

                // build the reply to client
                DatagramPacket reply = new DatagramPacket(request.getData(),
                        request.getLength(), request.getAddress(),
request.getPort());

                // change request to string format
                String requestString = new String(request.getData());

                // show the request string
                System.out.println("Echoing: " + requestString);

                // send reply data to socket
                aSocket.send(reply);

                //  after hearing the "halt!" message from the client, the
server makes an announcement and then exits
                if (new String(request.getData()).equals("halt!")) {
                    System.out.println("Server side quitting");
                    break;
                }
            }
            // handle socket exceptions
        } catch (SocketException e) {
            System.out.println("Socket: " + e.getMessage());
            // handle general I/O exceptions
        } catch (IOException e) {
            System.out.println("IO: " + e.getMessage());
        } finally {
            // always close the socket
            if (aSocket != null) aSocket.close();
        }
    }
}
```

Project2Task0ClientConsole



Project2Task0ServerConsole

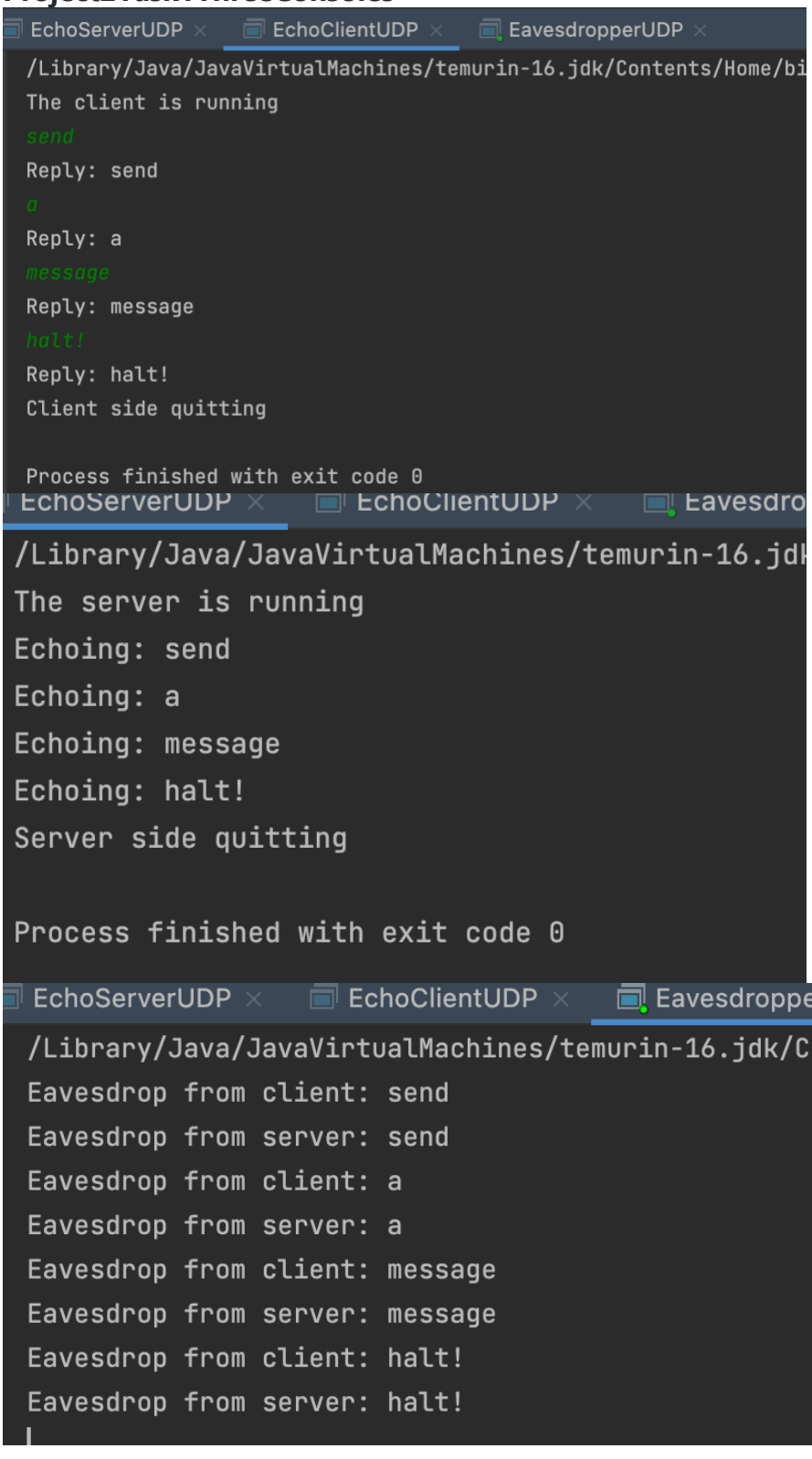


Project2Task1EavesdropperUDP

```
// imports required for UDP/IP

import java.io.IOException;
import java.net.DatagramPacket;
import java.net.DatagramSocket;
import java.net.InetAddress;
import java.net.SocketException;
import java.util.Arrays;

public class EavesdropperUDP {
    public static void main(String args[]) {
        // define a Datagram (UDP style) socket to communicate with client
        DatagramSocket aSocket = null;

        // define another Datagram socket to communicate with server
        DatagramSocket malSocket = null;
        try {
            // malicious player listens on 6798
            aSocket = new DatagramSocket(6798);

            // initialize another socket to connect with server
            malSocket = new DatagramSocket();

            // build an InetAddress object from a DNS name
            InetAddress aHost = InetAddress.getByName("localhost");

            // loop forever
            while (true) {

                // prepare room for the request
                byte[] requestBuffer = new byte[1024];

                // initialize the request from the client
                DatagramPacket request = new DatagramPacket(requestBuffer,
requestBuffer.length);

                // receive request data from the client
                aSocket.receive(request);

                // get bytes arrays from the request with correct length
                byte[] request_bytes = Arrays.copyOf(request.getData(),
request.getLength());

                // modify the request data with the correct number of bytes
                request.setData(request_bytes);

                // display the client's messages through eavesdropping
                System.out.println("Eavesdrop: " + new
String(request.getData()));

                // malicious player contact the server at 6789
                DatagramPacket malRequest = new
DatagramPacket(request.getData(), request.getData().length, aHost, 6789);

                // malicious player forwards the message to Echo serve
```

```
                malSocket.send(malRequest);

                // prepare room for the reply from server
                byte[] replyBuffer = new byte[1000];

                // build a datagram for the reply
                DatagramPacket malReply = new DatagramPacket(replyBuffer,
replyBuffer.length);

                // block and wait
                malSocket.receive(malReply);

                // get bytes arrays from the reply with correct length
                byte[] malReply_bytes = Arrays.copyOf(malReply.getData(),
malReply.getLength());

                // modify the malReply data with the correct number of bytes
                malReply.setData(malReply_bytes);

                // build the reply to client
                DatagramPacket reply = new DatagramPacket(request.getData(),
request.getLength(), request.getAddress(), request.getPort());

                // send server's reply data to the client
                aSocket.send(reply);
            }
            // handle socket exceptions
        } catch (SocketException e) {
            System.out.println("Socket: " + e.getMessage());
            // handle general I/O exceptions
        } catch (IOException e) {
            System.out.println("IO: " + e.getMessage());
        } finally {
            // always close the socket
            if (aSocket != null) aSocket.close();
        }
    }
}
```

Project2Task1ThreeConsoles



Project2Task2Client

```
// imports required for UDP/IP

import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStreamReader;

import java.net.DatagramPacket;
import java.net.DatagramSocket;
import java.net.InetAddress;
import java.net.SocketException;
import java.nio.ByteBuffer;
import java.util.Arrays;

public class AddingClientUDP {
    // create global variables for socket, server port, and destination
address
    static DatagramSocket aSocket = null;
    static int serverPort = 0;
    static InetAddress aHost = null;

    public static void main(String args[]) {
        // define a Datagram (UDP style) socket

        try {
            // show the announcement
            System.out.println("The client is running.");

            aHost = InetAddress.getByName("localhost");

            // define the user's input
            String nextLine;

            // read user's input
            BufferedReader typed = new BufferedReader(new
InputStreamReader(System.in));

            // ask user to input a server port and initialize the server port
            System.out.println("Please enter server port:");
            serverPort = Integer.parseInt(typed.readLine());

            //  prompt the user enter numbers
            System.out.println("Please enter numbers:");

            // loop to receive the input from client
            while ((nextLine = typed.readLine()) != null) {
                //  the client makes an announcement and then exits when user
enter halt!
                if (nextLine.equals("halt!")) {
                    System.out.println("Client side quitting");
                    break;
                }

                // convert string to int
                int i = Integer.parseInt(nextLine);
```

```
                // call the add function related to client server
communications
                int sum = add(i);

                // show the result to the client
                System.out.printf("The server returned %d.\n", sum);
            }
            // handle socket exceptions
        } catch (SocketException e) {
            System.out.println("Socket: " + e.getMessage());
            // handle general I/O exceptions
        } catch (IOException e) {
            System.out.println("IO: " + e.getMessage());
        } finally {
            // always close the socket
            if (aSocket != null) aSocket.close();
        }

    }

    /**
     * client communicates with the server
     *
     * @param i from the user's input
     * @return sum result from the server
     */
    public static int add(int i) {
        // define and initialize the sum result
        int sum = 0;
        try {
            // initialize the socket
            aSocket = new DatagramSocket();

            // build a ByteBuffer with capacity 4 to store the int and then
return a byte array
            byte[] m = ByteBuffer.allocate(4).putInt(i).array();

            // build the packet holding the destination address, port and
byte array to contact the server
            DatagramPacket request = new DatagramPacket(m, m.length, aHost,
serverPort);

            // send the Datagram on the socket
            aSocket.send(request);

            // prepare room for the reply
            byte[] buffer = new byte[1000];

            // build a datagram for the reply
            DatagramPacket reply = new DatagramPacket(buffer, buffer.length);

            // block and wait
            aSocket.receive(reply);

            // get bytes arrays from the reply with correct length
            byte[] reply_bytes = Arrays.copyOf(reply.getData(),
reply.getLength());
```

```
            // wraps the reply byte array into a buffer and then return the
int value
            sum = ByteBuffer.wrap(reply_bytes).getInt();

            // handle socket exceptions
        } catch (SocketException e) {
            System.out.println("Socket: " + e.getMessage());
            // handle general I/O exceptions
        } catch (IOException e) {
            System.out.println("IO: " + e.getMessage());
        }

        return sum;
    }

}
```

Project2Task2Server

```
// imports required for UDP/IP
import java.io.IOException;
import java.net.DatagramPacket;
import java.net.DatagramSocket;
import java.net.SocketException;
import java.nio.ByteBuffer;
import java.util.Arrays;
import java.util.Scanner;

public class AddingServerUDP {
    // create a global variable for socket and sum
    static DatagramSocket aSocket = null;
    static int sum = 0;

    public static void main(String args[]) {
        try {
            // show the announcement
            System.out.println("Server started");

            // prompt the user enter a port number for the server to listen
to
            System.out.println("Please enter server port:");
            int serverPort = new Scanner(System.in).nextInt();

            // initialize the socket using port number by user's input
            aSocket = new DatagramSocket(serverPort);

            // loop forever
            while (true) {

                // prepare room for the request
                byte[] buffer = new byte[1000];

                // initialize the request
                DatagramPacket request = new DatagramPacket(buffer,
buffer.length);

                // receive request data from the socket
```

```
                aSocket.receive(request);

                // get bytes arrays from the request with correct length
                byte[] request_bytes = Arrays.copyOf(request.getData(),
request.getLength());

                // modify the request data with the correct number of bytes
                request.setData(request_bytes);

                // get add int from the request
                int add_num = ByteBuffer.wrap(request_bytes).getInt();

                // show the add process to the server
                System.out.println("Adding: " + add_num + " to " + sum);

                // performs the add operation
                sum = add(add_num);

                // build a ByteBuffer with capacity 4 to store the sum and
then return a byte array
                byte[] sum_bytes =
ByteBuffer.allocate(4).putInt(sum).array();

                // build the reply to client
                DatagramPacket reply = new DatagramPacket(sum_bytes,
sum_bytes.length, request.getAddress(), request.getPort());

                // show the result to the server
                System.out.printf("Returning sum of %d to client\n", sum);

                // send reply data to socket
                aSocket.send(reply);
            }
            // handle socket exceptions
        } catch (SocketException e) {
            System.out.println("Socket: " + e.getMessage());
            // handle general I/O exceptions
        } catch (IOException e) {
            System.out.println("IO: " + e.getMessage());
        } finally {
            // always close the socket
            if (aSocket != null) aSocket.close();
        }
    }

    /**
     * performs the add operation.
     *
     * @param i from the request
     * @return sum result
     */
    public static int add(int i) {
        sum += i;
        return sum;
    }
}
```

Project2Task2ClientConsole

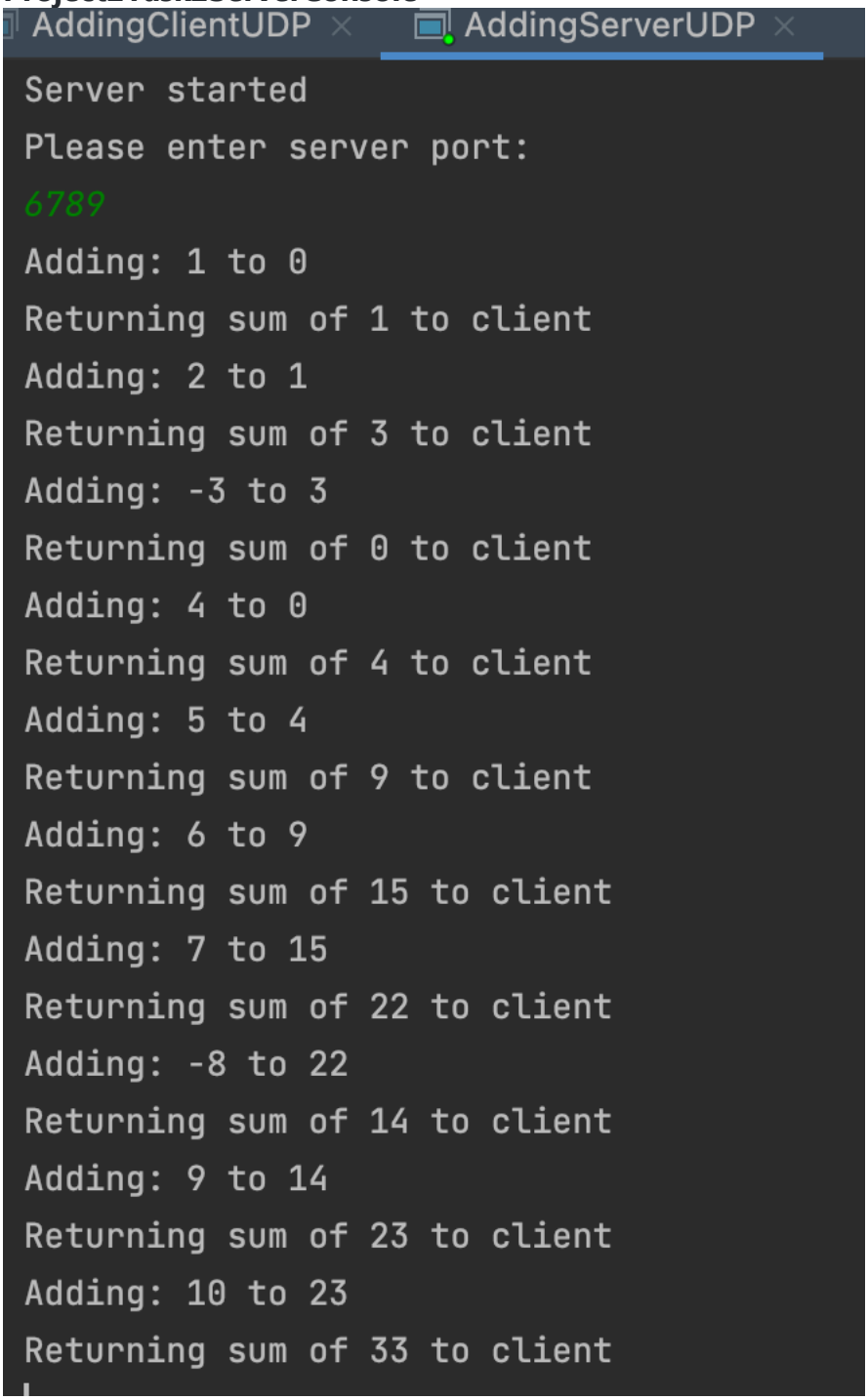
AddingClientUDP | AddingServerUDP

```
/Library/Java/JavaVirtualMachines/temurin-16.jdk
The client is running.
Please enter server port:
6789
Please enter numbers:
6
The server returned 15.
7
The server returned 22.
-8
The server returned 14.
9
The server returned 23.
10
The server returned 33.
halt!
Client side quitting

Process finished with exit code 0
```

AddingClientUDP | AddingServerUDP

```
/Library/Java/JavaVirtualMachines/temurin-16.jdk/Contents/Home/bin/java
The client is running.
Please enter server port:
6789
Please enter numbers:
1
The server returned 1.
2
The server returned 3.
-3
The server returned 0.
4
The server returned 4.
5
The server returned 9.
halt!
Client side quitting

Process finished with exit code 0
```

Project2Task2ServerConsole



Project2Task3Client

```
// imports required for UDP/IP

import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStreamReader;
import java.net.DatagramPacket;
import java.net.DatagramSocket;
import java.net.InetAddress;
import java.net.SocketException;
import java.nio.ByteBuffer;
import java.util.Arrays;

public class RemoteVariableClientUDP {
    // create global variables for socket, server port, and destination
address
    static DatagramSocket aSocket = null;
    static int serverPort = 0;
    static InetAddress aHost = null;

    public static void main(String args[]) {
        try {
            // show the announcement
            System.out.println("The client is running.");

            aHost = InetAddress.getByName("localhost");


            // read user's input
            BufferedReader typed = new BufferedReader(new
InputStreamReader(System.in));

            // ask user to input a server port and initialize the server port
            System.out.println("Please enter server port:");
            serverPort = Integer.parseInt(typed.readLine());

            // loop to receive the input from client
            while (typed.readLine() != null) {
                String operation = null;
                String value = null;
                String ID;

                // show the choice to the client
                System.out.println("1. Add a value to your sum.");
                System.out.println("2. Subtract a value from your sum.");
                System.out.println("3. Get your sum.");
                System.out.println("4. Exit client");

                // initialize the operation
                switch (typed.readLine()) {
                    case "1" -> operation = "add";
                    case "2" -> operation = "subtract";
                    case "3" -> operation = "get";
                    case "4" -> operation = "exit";
                }
```

```
                // if input is 1 or 2, then set the value
                assert operation != null;
                if (operation.equals("add")) {
                    System.out.println("Enter value to add:");
                    value = typed.readLine();
                } else if (operation.equals("subtract")) {
                    System.out.println("Enter value to subtract:");
                    value = typed.readLine();
                    // if input is 4, then exit the client
                } else if (operation.equals("exit")) {
                    System.out.println("Client side quitting. The remote
variable server is still running.");
                    break;
                }

                // get the client ID
                System.out.println("Enter your ID:");
                ID = typed.readLine();

                String combined;
                // combine the  ID, operation if operation is "get";
                // otherwise, combine the  ID, operation, and value
                if (operation.equals("get")) {
                    combined = ID + "," + operation;
                } else {
                    combined = ID + "," + operation + "," + value;
                }

                // call the operate function related to client server
communications
                int result = operate(combined);

                // show the result to the client
                System.out.printf("The result is %d.\n", result);
            }
            // handle socket exceptions
        } catch (SocketException e) {
            System.out.println("Socket: " + e.getMessage());
            // handle general I/O exceptions
        } catch (IOException e) {
            System.out.println("IO: " + e.getMessage());
        } finally {
            // always close the socket
            if (aSocket != null) aSocket.close();
        }

    }

    /**
     * client communicates with the server
     *
     * @param combined information including ID, operation, and value(if the
operation is other than get)
     * @return result from the server
     */
    public static int operate(String combined) {
        // define and initialize the result
```

```
        int result = 0;
        try {
            // initialize the socket
            aSocket = new DatagramSocket();

            // build a ByteBuffer with capacity 4 to store the int and then
return a byte array
            byte[] m = combined.getBytes();

            // build the packet holding the destination address, port and
byte array to contact the server
            DatagramPacket request = new DatagramPacket(m, m.length, aHost,
serverPort);

            // send the Datagram on the socket
            aSocket.send(request);

            // prepare room for the reply
            byte[] buffer = new byte[1000];

            // build a datagram for the reply
            DatagramPacket reply = new DatagramPacket(buffer, buffer.length);

            // block and wait
            aSocket.receive(reply);

            // get bytes arrays from the reply with correct length
            byte[] reply_bytes = Arrays.copyOf(reply.getData(),
reply.getLength());

            // wraps the reply byte array into a buffer and then return the
int value
            result = ByteBuffer.wrap(reply_bytes).getInt();

            // handle socket exceptions
        } catch (SocketException e) {
            System.out.println("Socket: " + e.getMessage());
            // handle general I/O exceptions
        } catch (IOException e) {
            System.out.println("IO: " + e.getMessage());
        }

        return result;
    }

}
```

Project2Task3Server

```
// imports required for UDP/IP

import java.io.IOException;
import java.net.DatagramPacket;
import java.net.DatagramSocket;
import java.net.SocketException;
import java.nio.ByteBuffer;
import java.util.Arrays;
import java.util.Scanner;

public class RemoteVariableServerUDP {
    // create a global variable for socket
    static DatagramSocket aSocket = null;
    // create a result array with 1000 size
    static int[] result = new int[1000];

    public static void main(String args[]) {
        try {
            // show the announcement
            System.out.println("Server started");

            // prompt the user enter a port number for the server to listen
to
            System.out.println("Please enter server port:");
            int serverPort = new Scanner(System.in).nextInt();

            // initialize the socket using port number by user's input
            aSocket = new DatagramSocket(serverPort);

            // loop forever
            while (true) {
                // prepare room for the request
                byte[] buffer = new byte[1000];

                // initialize the request
                DatagramPacket request = new DatagramPacket(buffer,
buffer.length);

                // receive request data from the socket
                aSocket.receive(request);

                // get bytes arrays from the request with correct length
                byte[] request_bytes = Arrays.copyOf(request.getData(),
request.getLength());

                // modify the request data with the correct number of bytes
                request.setData(request_bytes);

                // get combined string from the request
                String combined = new String(request.getData());

                // split the combined information into a string array
                String[] combined_array = combined.split(",");
                int ID = Integer.parseInt(combined_array[0]);
                String operation = combined_array[1];
```

```
                System.out.println("ID: " + ID);

                //if operation is add or subtract, then do the operation;
                //if operation is get, then do nothing
                if (operation.equals("add")) {
                    int value = Integer.parseInt(combined_array[2]);
                    // performs the add operation to the result associated
with the ID
                    result[ID] = add(ID, value);

                    // show the add process to the server
                    System.out.println("Adding: " + value + " to " +
result[ID]);
                } else if (operation.equals("subtract")) {
                    int value = Integer.parseInt(combined_array[2]);
                    // performs the subtract operation to the result
associated with the ID
                    result[ID] = subtract(ID, value);

                    // show the subtract process to the server
                    System.out.println("Subtracting: " + value + " to " +
result[ID]);
                }

                // build a ByteBuffer with capacity 4 to store the result and
then return a byte array
                byte[] sum_bytes =
ByteBuffer.allocate(4).putInt(result[ID]).array();

                // build the reply to client
                DatagramPacket reply = new DatagramPacket(sum_bytes,
sum_bytes.length, request.getAddress(), request.getPort());

                // show the result to the server
                System.out.printf("Returning result of %d to client\n",
result[ID]);

                // send reply data to socket
                aSocket.send(reply);
            }
            // handle socket exceptions
        } catch (SocketException e) {
            System.out.println("Socket: " + e.getMessage());
            // handle general I/O exceptions
        } catch (IOException e) {
            System.out.println("IO: " + e.getMessage());
        } finally {
            // always close the socket
            if (aSocket != null) aSocket.close();
        }
    }

    /**
     * performs the add or subtract operation.
     *
     * @param ID    for choosing the result array's index
     * @param value for add
```

```
     * @return result after operating
     */
    public static int add(int ID, int value) {
        result[ID] += value;
        return result[ID];
    }

    /**
     * performs the add or subtract operation.
     *
     * @param ID    for choosing the result array's index
     * @param value for subtract
     * @return result after operating
     */
    public static int subtract(int ID, int value) {
        result[ID] -= value;
        return result[ID];
    }

}
```

Project2Task3ClientConsole

```
/Library/Java/JavaVirtualMachines/temurin-16.jdk/Co
The client is running.
Please enter server port:
6789

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
1
Enter value to add:
1
Enter your ID:
111
The result is 1.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
2
Enter value to subtract:
2
Enter your ID:
111
The result is -1.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
3
Enter your ID:
111
The result is -1.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
1
```

```
1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
1
Enter value to add:
2
Enter your ID:
222
The result is 2.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
2
Enter value to subtract:
2
Enter your ID:
222
The result is 0.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
3
Enter your ID:
222
The result is 0.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
1
Enter value to add:
3
Enter your ID:
333
The result is 3.
```

```
1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
2
Enter value to subtract:
2
Enter your ID:
333
The result is 1.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
3
Enter your ID:
333
The result is 1.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
4
Client side quitting. The remote variable server is still running.

Process finished with exit code 0
```

```
/Library/Java/JavaVirtualMachines/temurin-16.jdk/C
The client is running.
Please enter server port:
6789

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
3
Enter your ID:
111
The result is -1.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
3
Enter your ID:
222
The result is 0.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
3
Enter your ID:
333
The result is 1.
```

Project2Task3ServerConsole

```
Server started
Please enter server port:
6789

ID: 111
Adding: 1 to 1
Returning result of 1 to client
ID: 111
Subtracting: 2 to -1
Returning result of -1 to client
ID: 111
Getting: -1
Returning result of -1 to client
ID: 222
Adding: 2 to 2
Returning result of 2 to client
ID: 222
Subtracting: 2 to 0
Returning result of 0 to client
ID: 222
Getting: 0
Returning result of 0 to client
ID: 333
Adding: 3 to 3
Returning result of 3 to client
ID: 333
Subtracting: 2 to 1
Returning result of 1 to client
ID: 333
Getting: 1
Returning result of 1 to client
ID: 111
Getting: -1
Returning result of -1 to client
ID: 222
Getting: 0
Returning result of 0 to client
ID: 333
Getting: 1
Returning result of 1 to client
```

Project2Task4Client

```
import java.net.*;
import java.io.*;
import java.nio.ByteBuffer;
import java.util.Arrays;

public class RemoteVariableClientTCP {
    // create global variables for read from and write to the socket
    static Socket clientSocket;
    static BufferedReader in = null;
    static PrintWriter out = null;

    public static void main(String args[]) {
        try {
            // show the announcement
            System.out.println("The client is running.");

            InetAddress aHost = InetAddress.getByName("localhost");

            // read user's input
            BufferedReader typed = new BufferedReader(new
InputStreamReader(System.in));

            // ask user to input a server port and initialize the server port
            System.out.println("Please enter server port:");
            int serverPort = Integer.parseInt(typed.readLine());

            // initialize the socket
            clientSocket = new Socket(aHost, serverPort);

            // loop to receive the input from client
            while (typed.readLine() != null) {
                String operation = null;
                String value = null;
                String ID;

                // show the choice to the client
                System.out.println("1. Add a value to your sum.");
                System.out.println("2. Subtract a value from your sum.");
                System.out.println("3. Get your sum.");
                System.out.println("4. Exit client");

                // initialize the operation
                switch (typed.readLine()) {
                    case "1" -> operation = "add";
                    case "2" -> operation = "subtract";
                    case "3" -> operation = "get";
                    case "4" -> operation = "exit";
                }

                // if input is 1 or 2, then set the value
                assert operation != null;
                if (operation.equals("add")) {
                    System.out.println("Enter value to add:");
                    value = typed.readLine();
                } else if (operation.equals("subtract")) {
```

```
                    System.out.println("Enter value to subtract:");
                    value = typed.readLine();
                    // if input is 4, then exit the client
                } else if (operation.equals("exit")) {
                    System.out.println("Client side quitting. The remote
variable server is still running.");
                    break;
                }

                // get the client ID
                System.out.println("Enter your ID:");
                ID = typed.readLine();

                String combined;
                // combine the  ID, operation if operation is "get";
                // otherwise, combine the  ID, operation, and value
                if (operation.equals("get")) {
                    combined = ID + "," + operation;
                } else {
                    combined = ID + "," + operation + "," + value;
                }

                // call the operate function related to client server
communications
                int result = operate(combined);

                // show the result to the client
                System.out.printf("The result is %d.\n", result);
            }
        } catch (IOException e) {
            System.out.println("IO Exception:" + e.getMessage());
        } finally {
            try {
                if (clientSocket != null) {
                    clientSocket.close();
                }
            } catch (IOException e) {
                // ignore exception on close
            }
        }
    }

    /**
     * client communicates with the server
     *
     * @param data information including ID, operation, and value(if the
operation is other than get)
     * @return result from the server
     */
    public static int operate(String data) {
        // define and initialize the result
        int result = 0;
        try {
            // initialize the read and write for socket
            in = new BufferedReader(new
InputStreamReader(clientSocket.getInputStream()));
            out = new PrintWriter(new BufferedWriter(new
```

```
OutputStreamWriter(clientSocket.getOutputStream()));

            // send message to the server
            out.println(data);
            out.flush();

            // read a line of data from the stream
            result = Integer.parseInt(in.readLine());
        } catch (IOException e) {
            e.printStackTrace();
        }
        return result;
    }
}
```

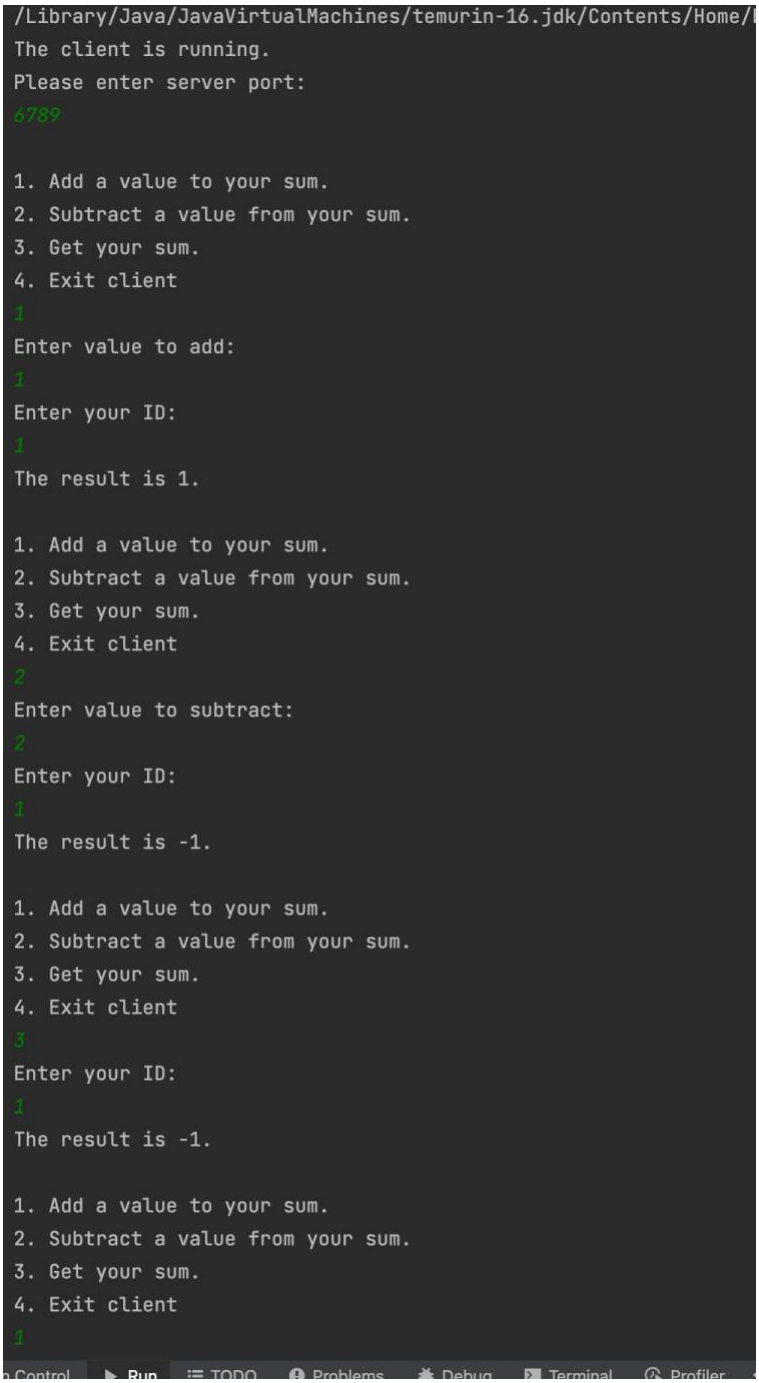
Project2Task4Server

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

public class RemoteVariableServerTCP {
    // create a result array with 1000 size
    static int[] result = new int[1000];

    public static void main(String args[]) {
        Socket clientSocket = null;
        try {
            // show the announcement
            System.out.println("Server started");

            // prompt the user enter a port number for the server to listen
to
            System.out.println("Please enter server port:");
            int serverPort = new Scanner(System.in).nextInt();

            // Create a new server socket
            ServerSocket listenSocket = new ServerSocket(serverPort);

            /*
             * Block waiting for a new connection request from a client.
             * When the request is received, "accept" it, and the rest
             * the tcp protocol handshake will then take place, making
             * the socket ready for reading and writing.
             */
            clientSocket = listenSocket.accept();
            // If we get here, then we are now connected to a client.

            // Set up "in" to read from the client socket
            Scanner in;
            in = new Scanner(clientSocket.getInputStream());

            // Set up "out" to write to the client socket
            PrintWriter out;
            out = new PrintWriter(new BufferedWriter(new
OutputStreamWriter(clientSocket.getOutputStream())));
```

```
            // loop forever to accept the request and return the result to
the client
            while (true) {
                if (in.hasNextLine()) {
                    // read the data from the client
                    String data = in.nextLine();
                    System.out.println("Echoing: " + data);

                    // split the combined information into a string array
                    String[] combined_array = data.split(",");
                    int ID = Integer.parseInt(combined_array[0]);
                    String operation = combined_array[1];
                    System.out.println("ID: " + ID);

                    //if operation is add or subtract, then do the operation;
                    //if operation is get, then do nothing
                    if (operation.equals("add")) {
                        int value = Integer.parseInt(combined_array[2]);
                        // performs the add operation to the result
associated with the ID
                        result[ID] = add(ID, value);

                        // show the add process to the server
                        System.out.println("Adding: " + value + " to " +
result[ID]);
                    } else if (operation.equals("subtract")) {
                        int value = Integer.parseInt(combined_array[2]);
                        // performs the subtract operation to the result
associated with the ID
                        result[ID] = subtract(ID, value);

                        // show the subtract process to the server
                        System.out.println("Subtracting: " + value + " to " +
result[ID]);
                    }

                    // show the result to the server
                    System.out.printf("Returning result of %d to client\n",
result[ID]);


                    // send message to the client
                    out.println(result[ID]);
                    out.flush();
                } else {
                    // continue to accept requests after previous connection
is closed
                    clientSocket = listenSocket.accept();
                    in = new Scanner(clientSocket.getInputStream());
                    out = new PrintWriter(new BufferedWriter(new
OutputStreamWriter(clientSocket.getOutputStream())));
                }
            }

            // Handle exceptions
        } catch (IOException e) {
            System.out.println("IO Exception:" + e.getMessage());
```

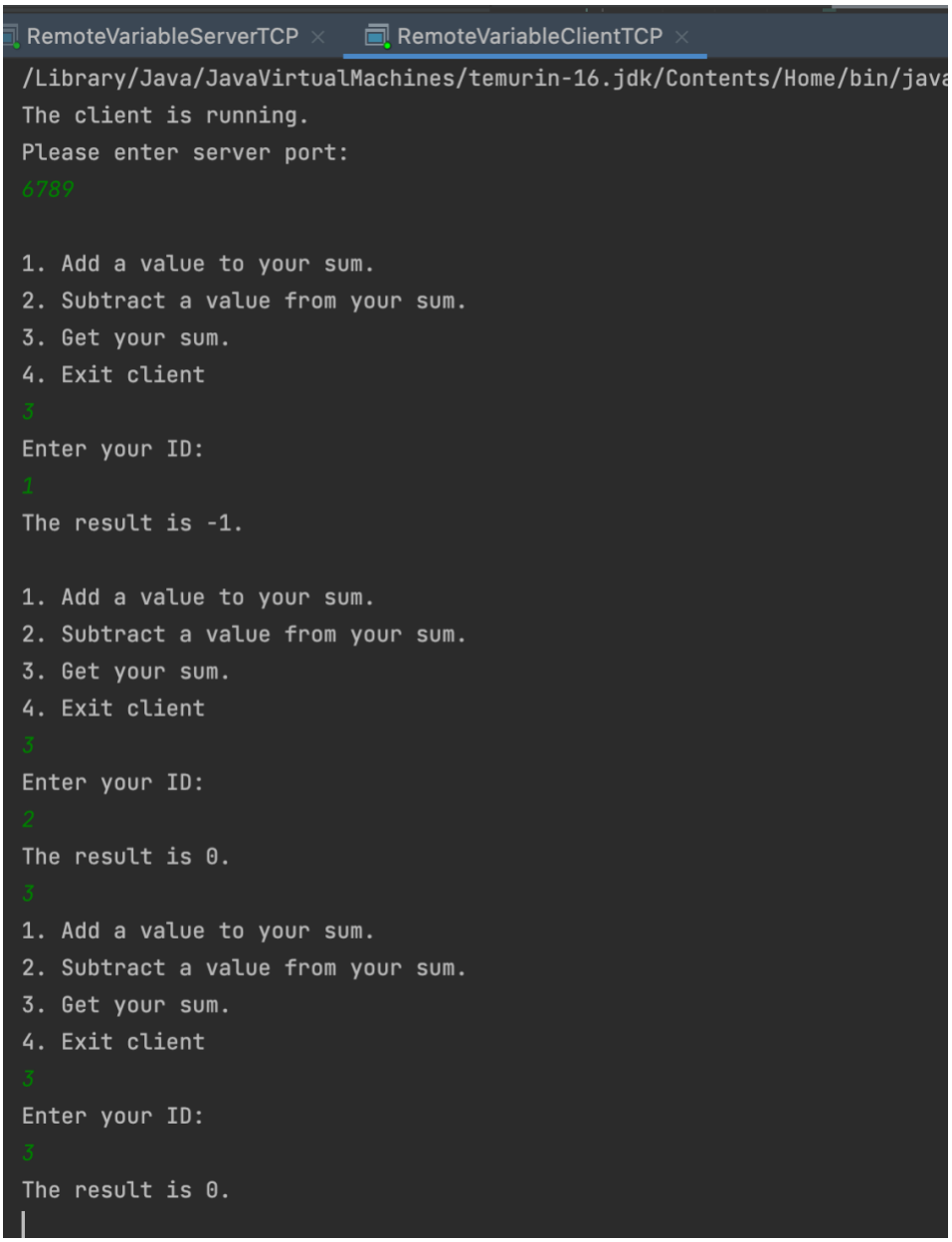
```
            // If quitting (typically by you sending quit signal) clean up
sockets
        } finally {
            try {
                if (clientSocket != null) {
                    clientSocket.close();
                }
            } catch (IOException e) {
                // ignore exception on close
            }
        }
    }

    /**
     * performs the add or subtract operation.
     *
     * @param ID    for choosing the result array's index
     * @param value for add
     * @return result after operating
     */
    public static int add(int ID, int value) {
        result[ID] += value;
        return result[ID];
    }

    /**
     * performs the add or subtract operation.
     *
     * @param ID    for choosing the result array's index
     * @param value for subtract
     * @return result after operating
     */
    public static int subtract(int ID, int value) {
        result[ID] -= value;
        return result[ID];
    }

}
```

Project2Task4ClientConsole



```
1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
1
Enter value to add:
2
Enter your ID:
2
The result is 2.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
2
Enter value to subtract:
2
Enter your ID:
2
The result is 0.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
3
Enter your ID:
2
The result is 0.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
1
Enter value to add:
3
Enter your ID:
3
```

```
1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
1
Enter value to add:
3
Enter your ID:
3
The result is 3.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
2
Enter value to subtract:
3
Enter your ID:
3
The result is 0.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
3
Enter your ID:
3
The result is 0.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
4
Client side quitting. The remote variable server is still running.

Process finished with exit code 0
```


RemoteVariableServerTCP
RemoteVariableClientTCP
/Library/Java/JavaVirtualMachines/temurin-16.jdk/Contents/Home/bin/java
The client is running.
Please enter server port:
6789
1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
3
Enter your ID:
1
The result is -1.
1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
3
Enter your ID:
2
The result is 0.
3
1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
3
Enter your ID:
3
The result is 0.

Project2Task4ServerConsole

```
/Library/Java/JavaVirtualMachines/temurin-16.jdk/Conte
Server started
Please enter server port:
6789
ID: 1
Adding: 1 to 1
Returning result of 1 to client
ID: 1
Subtracting: 2 to -1
Returning result of -1 to client
ID: 1
Getting: -1
Returning result of -1 to client
ID: 2
Adding: 2 to 2
Returning result of 2 to client
ID: 2
Subtracting: 2 to 0
Returning result of 0 to client
ID: 2
Getting: 0
Returning result of 0 to client
ID: 3
Adding: 3 to 3
Returning result of 3 to client
ID: 3
Subtracting: 3 to 0
Returning result of 0 to client
ID: 3
Getting: 0
Returning result of 0 to client
ID: 1
Getting: -1
Returning result of -1 to client
ID: 2
Getting: 0
Returning result of 0 to client
ID: 3
Getting: 0
Returning result of 0 to client
```

Project2Task5Client

```
import java.io.*;
import java.lang.reflect.Array;
import java.math.BigInteger;
import java.net.InetAddress;
import java.net.Socket;
import java.security.MessageDigest;
import java.security.NoSuchAlgorithmException;
import java.util.Arrays;

public class SigningClientTCP {
    // create global variables for read from and write to the socket
    static Socket clientSocket;
    static BufferedReader in = null;
    static PrintWriter out = null;

    public static void main(String args[]) {
        // define the client's ID
        BigInteger ID;
        try {
            // show the announcement
            System.out.println("The client is running.");

            InetAddress aHost = InetAddress.getByName("localhost");

            // read user's input
            BufferedReader typed = new BufferedReader(new
InputStreamReader(System.in));

            // ask user to input a server port and initialize the server port
            System.out.println("Please enter server port:");
            int serverPort = Integer.parseInt(typed.readLine());

            // initialize the socket
            clientSocket = new Socket(aHost, serverPort);

            // create new RSA public and private keys, and initialize e, d, n
            BigInteger[] pairs = RSAAlgorithm.createKeys();
            BigInteger e = pairs[0];
            BigInteger d = pairs[1];
            BigInteger n = pairs[2];
            String public_key = e + "," + n;
            String private_key = d+ "," + n;
            // display these keys to the user
            System.out.println("public key: " + public_key);
            System.out.println("private key: " + private_key);

            // concatenate e and n to generate a public key
            // and then hash the client's public key
            MessageDigest md = MessageDigest.getInstance("SHA-256");
            md.update(public_key.getBytes());

            // take the last 20 bytes of the hash to generate client's ID
            ID = new BigInteger(Arrays.copyOfRange(md.digest(),
md.digest().length-20, md.digest().length));
```

```
            System.out.println("ID: " + ID);

            // loop to receive the input from client
            while (typed.readLine() != null) {
                String operation = null;
                String operand = null;

                // show the choice to the client
                System.out.println("1. Add a value to your sum.");
                System.out.println("2. Subtract a value from your sum.");
                System.out.println("3. Get your sum.");
                System.out.println("4. Exit client");

                // initialize the operation
                switch (typed.readLine()) {
                    case "1" -> operation = "add";
                    case "2" -> operation = "subtract";
                    case "3" -> operation = "get";
                    case "4" -> operation = "exit";
                }

                // if input is 1 or 2, then set the value
                if (operation.equals("add")) {
                    System.out.println("Enter value to add:");
                    operand = typed.readLine();
                } else if (operation.equals("subtract")) {
                    System.out.println("Enter value to subtract:");
                    operand = typed.readLine();
                    // if input is 4, then exit the client
                } else if (operation.equals("exit")) {
                    System.out.println("Client side quitting. The remote
variable server is still running.");
                    break;
                }

                // define message, signature, and data sent to the server
                String data;
                String message;
                String signature;

                // combine message m = id, the public key (e and n), the
operation, the operand
                message = ID + "," + public_key + "," + operation + "," +
operand;
//                System.out.println("Message :" + message);

                // use MessageSign function
                MessageSign sov = new MessageSign(e, d, n);

                // set the leftmost byte as 0 makes the value positive.
                // RSA only works with positive values

                signature = sov.sign(message);
//                System.out.println("Signature :" + signature);

                // combine message and signature
                data = message + "," + signature;
```

```
                // call the operate function related to client server
communications
                String result = operate(data);

                // show the result to the client
                if (!result.equals("Error in request")) {
                    System.out.printf("The result is %s.\n", result);
                } else {
                    System.out.println(result);
                }

            }
        } catch (IOException e) {
            System.out.println("IO Exception:" + e.getMessage());
        } catch (Exception e) {
            e.printStackTrace();
        } finally {
            try {
                if (clientSocket != null) {
                    clientSocket.close();
                }
            } catch (IOException e) {
                // ignore exception on close
            }
        }
    }

    /**
     * client communicates with the server
     *
     * @param data information including ID, operation, and value(if the
operation is other than get)
     * @return result from the server
     */
    public static String operate(String data) {
        // define and initialize the result
        String result = null;
        try {
            // initialize the read and write for socket
            in = new BufferedReader(new
InputStreamReader(clientSocket.getInputStream()));
            out = new PrintWriter(new BufferedWriter(new
OutputStreamWriter(clientSocket.getOutputStream())));

            // send message to the server
            out.println(data);
            out.flush();

            // read a line of data from the stream

            result = in.readLine();
        } catch (IOException e) {
            e.printStackTrace();
        }
        return result;
```

```
    }
}
```

Project2Task5Server

```
import java.math.BigInteger;
import java.net.*;
import java.io.*;
import java.security.MessageDigest;
import java.util.Arrays;
import java.util.Scanner;

public class VerifyingServerTCP {
    // create a result array with 1000 size
    static int result = 0;

    public static void main(String args[]) {
        Socket clientSocket = null;
        try {
            // show the announcement
            System.out.println("Server started");

            // prompt the user enter a port number for the server to listen
to
            System.out.println("Please enter server port:");
            int serverPort = new Scanner(System.in).nextInt();

            // Create a new server socket
            ServerSocket listenSocket = new ServerSocket(serverPort);

            /*
             * Block waiting for a new connection request from a client.
             * When the request is received, "accept" it, and the rest
             * the tcp protocol handshake will then take place, making
             * the socket ready for reading and writing.
             */
            clientSocket = listenSocket.accept();
            // If we get here, then we are now connected to a client.

            // Set up "in" to read from the client socket
            Scanner in;
            in = new Scanner(clientSocket.getInputStream());

            // Set up "out" to write to the client socket
            PrintWriter out;
            out = new PrintWriter(new BufferedWriter(new
OutputStreamWriter(clientSocket.getOutputStream())));

            // loop forever to accept the request and return the result to
the client
            while (true) {
                if (in.hasNextLine()) {
                    // read the data from the client
                    String data = in.nextLine();
                    System.out.println("Echoing: " + data);

                    // split the combined information into a string array
```

```
                    String[] data_array = data.split(",");

                    // extract information
                    BigInteger ID = new BigInteger(data_array[0]);
                    BigInteger e = new BigInteger(data_array[1]);
                    BigInteger n = new BigInteger(data_array[2]);
                    String public_key = e + "," + n;
                    System.out.println("public key: " + public_key);
                    String operation = data_array[3];
                    int operand = 0;
                    String ori_message;
                    if (! operation.equals("get")) {
                        operand = Integer.parseInt(data_array[4]);
                        // get the original message sent by the client
                        ori_message = ID + "," + e + "," + n + "," +
operation + "," + operand;
                    } else {
                        ori_message = ID + "," + e + "," + n + "," +
operation + "," + null;
                    }

                    // get the signature
                    String signature = data_array[5];

                    // check if the public key hash to the ID
                    boolean isSameID;
                    // hash the client's public key
                    MessageDigest md = MessageDigest.getInstance("SHA-256");
                    md.update(public_key.getBytes());

                    // take the last 20 bytes of the hash of public ket to
generate client's ID
                    BigInteger check_ID = new
BigInteger(Arrays.copyOfRange(md.digest(), md.digest().length-20,
md.digest().length));
                    isSameID = check_ID.equals(ID);
                    System.out.println("Is ID verified: " + isSameID);

                    // check if the request properly signed
                    boolean isSignedValid;
                    MessageVerify verifySig = new MessageVerify(e, n);
                    isSignedValid = verifySig.verify(ori_message, signature);
                    System.out.println("Is signature verified: " +
isSignedValid);



                    // if verify correctly, then the server do the operation;
                    // otherwise, the server returns the message "Error in
request".
                    if (isSameID && isSignedValid) {
                        //if operation is add or subtract, then do the
operation;
                        //if operation is get, then do nothing
                        if (operation.equals("add")) {
                            // performs the add operation to the result
associated with the ID
                            result = add(operand);
```

```
                            // show the add process to the server
                            System.out.println("Adding: " + operand + " to "
+ result);
                        } else if (operation.equals("subtract")) {
                            // performs the subtract operation to the result
associated with the ID
                            result = subtract(operand);
                            // show the subtract process to the server
                            System.out.println("Subtracting: " + operand + "
to " + result);
                        } else if (operation.equals("get")) {
                            // show the subtract process to the server
                            System.out.println("Getting: " + result);
                        }

                        // show the result to the server
                        System.out.printf("Returning result of %d to
client\n", result);

                        // send message to the client
                        out.println(result);
                        out.flush();
                    } else {
                        // send error message to the client
                        out.println("Error in request");
                        out.flush();
                    }
                } else {
                    // continue to accept requests after previous connection
is closed
                    clientSocket = listenSocket.accept();
                    in = new Scanner(clientSocket.getInputStream());
                    out = new PrintWriter(new BufferedWriter(new
OutputStreamWriter(clientSocket.getOutputStream())));
                }

            }

            // Handle exceptions
        } catch (IOException e) {
            System.out.println("IO Exception:" + e.getMessage());

            // If quitting (typically by you sending quit signal) clean up
sockets
        } catch (Exception e) {
            e.printStackTrace();
        } finally {
            try {
                if (clientSocket != null) {
                    clientSocket.close();
                }
            } catch (IOException e) {
                // ignore exception on close
            }
        }
    }
```

```java
    /**
     * performs the add or subtract operation.
     *
     * @param value for add
     * @return result after operating
     */
    public static int add(int value) {
        result += value;
        return result;
    }

    /**
     * performs the add or subtract operation.
     *
     * @param value for subtract
     * @return result after operating
     */
    public static int subtract(int value) {
        result -= value;
        return result;
    }

}
```

Project2Task5ClientConsole

```
The client is running.
Please enter server port:
6789
public key: 65537,4107567948207768178474797666272779533641299421650548726244282524072161168909914703754409608499315192707402221074845488060640362300268377022394
private key: 1060345065349024551679762987594837788579634460159665278401525424451116509080640507776021205679103627419989178267913330897201789056501524367378298711
ID: -567310959520920937663730460602330451695328860018

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
1
Enter value to add:
1
The result is 1.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
2
Enter value to subtract:
2
The result is -1.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
3
The result is -1.

1. Add a value to your sum.
2. Subtract a value from your sum.
3. Get your sum.
4. Exit client
4
Client side quitting. The remote variable server is still running.

Process finished with exit code 0
```

Project2Task5ServerConsole