LAB 2 (Network Programming with Java)

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D7001D Network Programming and Distributed Applications

LAB 2 (Network Programming with Java)

by

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Contents

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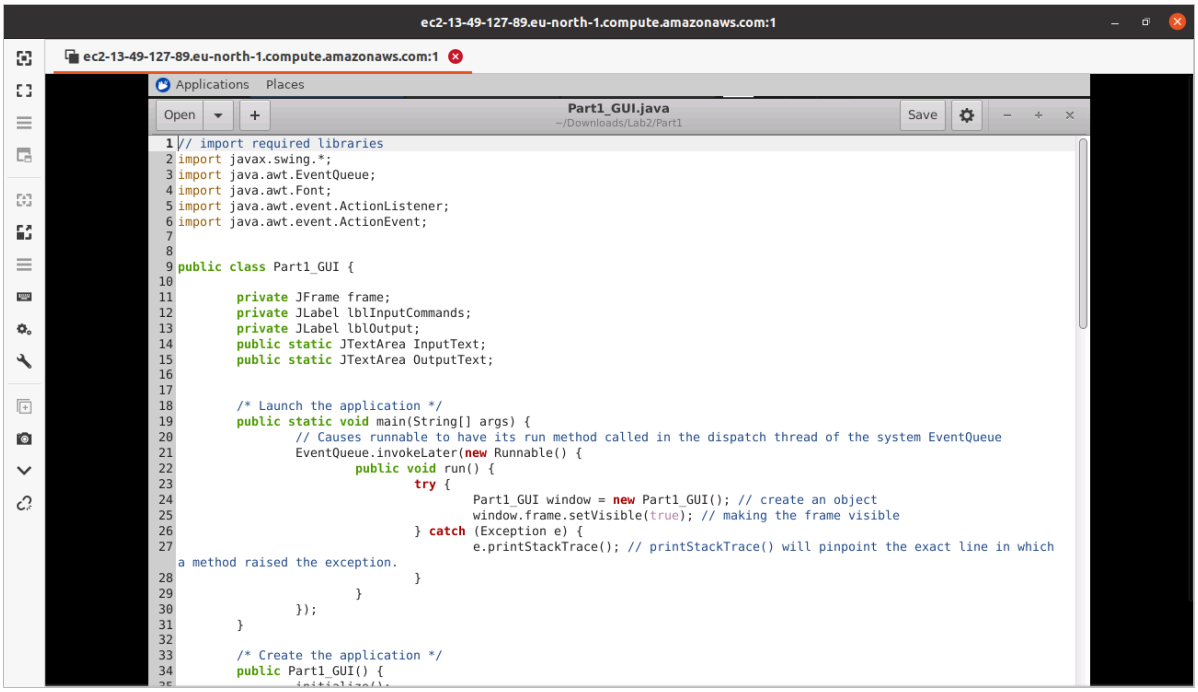
Part I: Java GUI (To be performed either on a local machine or on an AWS instance)

Write a simple java GUI with two fields and one button, where first field is used to input command and the second one is to display output. The application should be capable of executing the following Unix commands (or their counterparts in Windows):

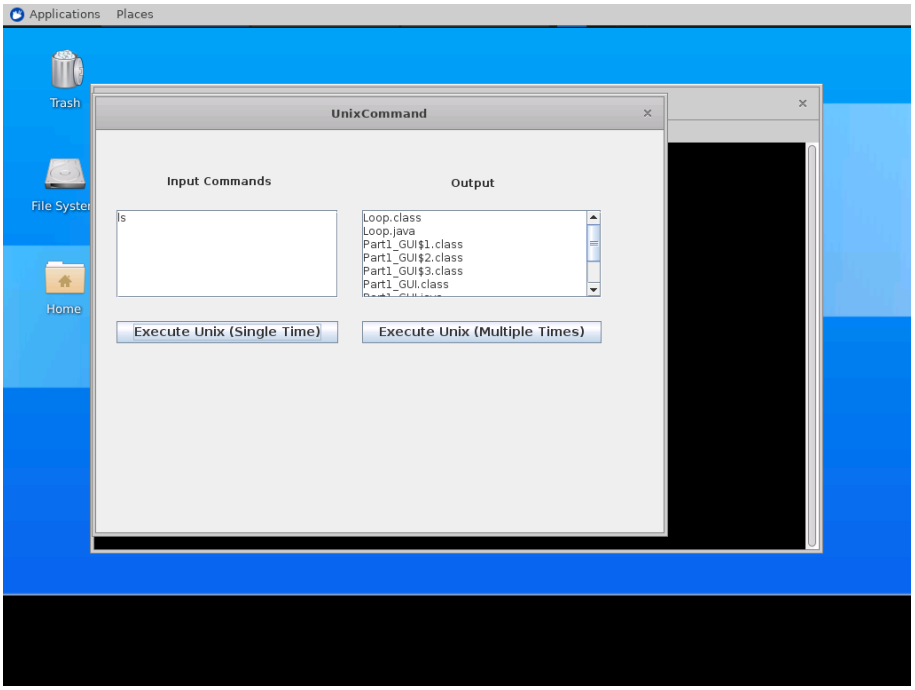
- ls, pwd, uptime, cat file.txt, who, ps, grep, ifconfig
- It has to be possible to pipeline command. For example this command
  - $cd /home/ && pwd | ls –all

  should return a detailed list of files and directories under /home/ folder.

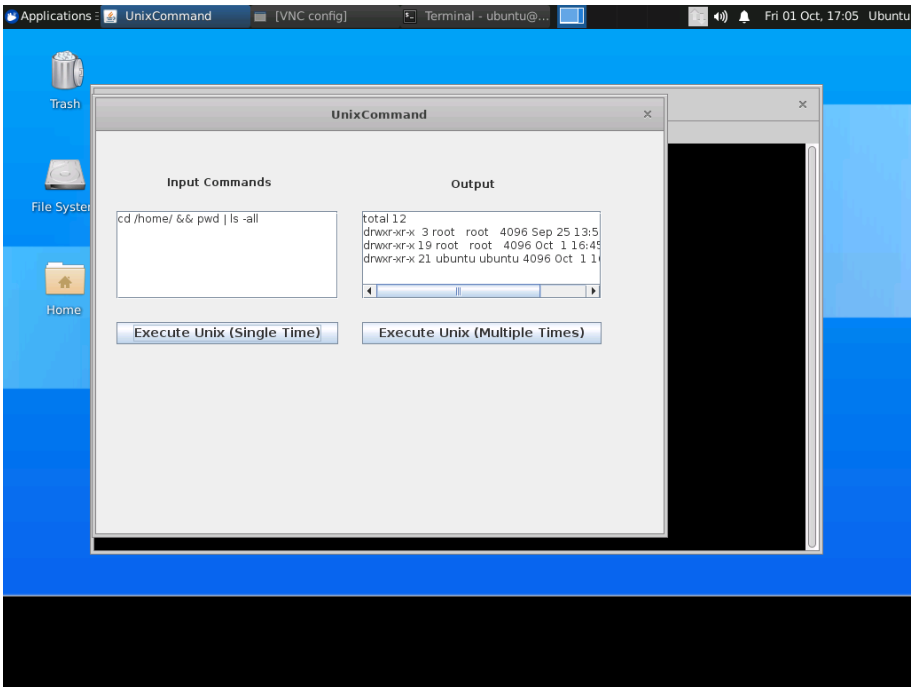
The task has been performed on an AWS instance. A simple java GUI (Part1_GUI.java) has been implemented with two fields and one button, where first field is used to input command and the second one is to display output, as shown below.



The application is capable of executing the Unix commands mentioned in the question. For example, if a user wants to see the list of files in the current working directory, he can write the command “ls" in the input field and click on the “Execute Unix (Single Time)" button. Then the GUI will show the output as shown below.

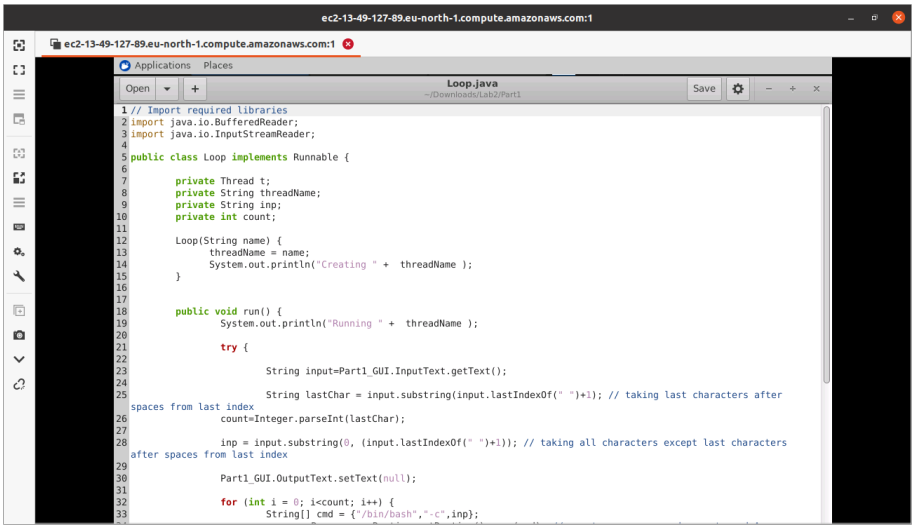


It is possible to pipeline command. For example, the command ***$cd /home/ && pwd | ls –all*** will return a detailed list of files and directories under /home/ folder as shown below.

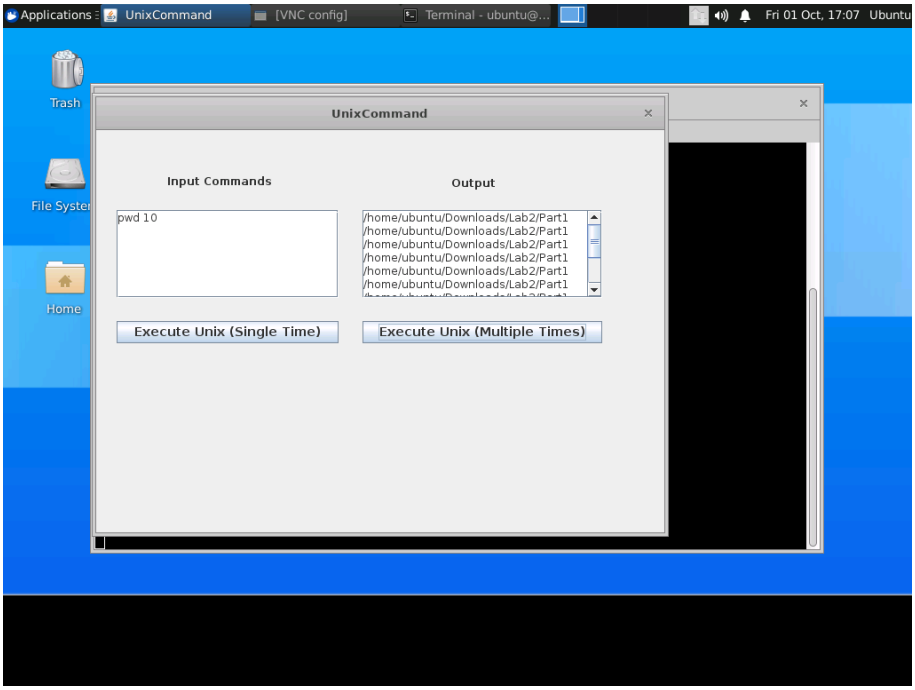


Now write another Java class, which will executes an empty loop. The program should take the number of loop iterations as a parameter, print this in the output field, launch the loop. Launch this program from the GUI!

Another Java class (Loop.java) has been created as shown below.



In the GUI, a user can specify how many times he wants to see the output. For example, if a user wants to see the name of the current working directory 10 times, he can write the command “pwd 10" in the input field and click on the “Execute Unix (Multiple Times)" button. Then the GUI will show the output 10 times, as shown below.



The GUI and the command executions are implemented in separate classes. Threads have been utilized to implement the command execution.

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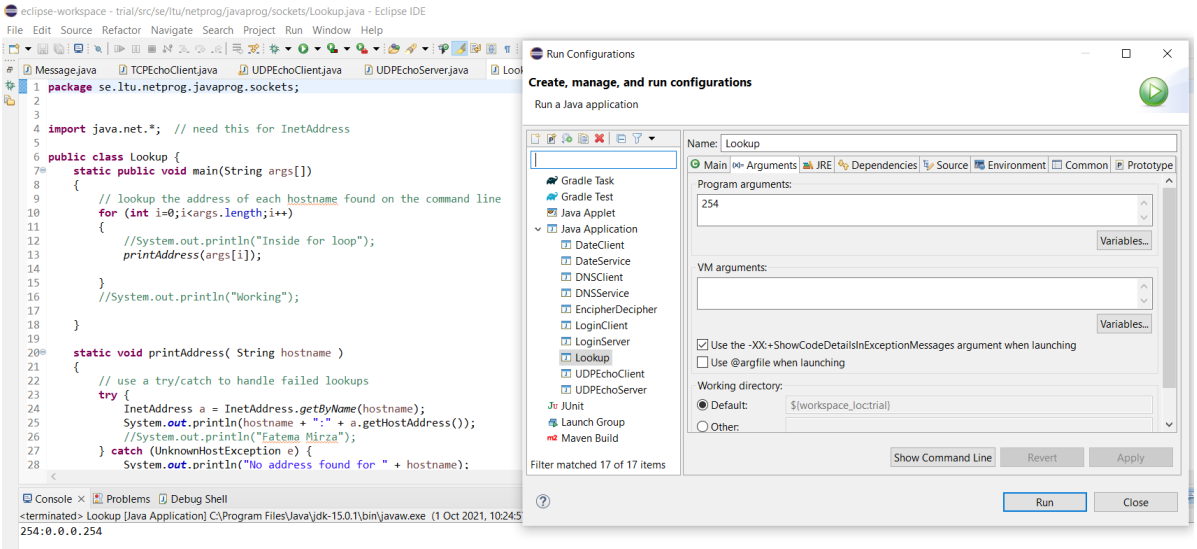
Part II –Java netprog patterns –sockets & threads

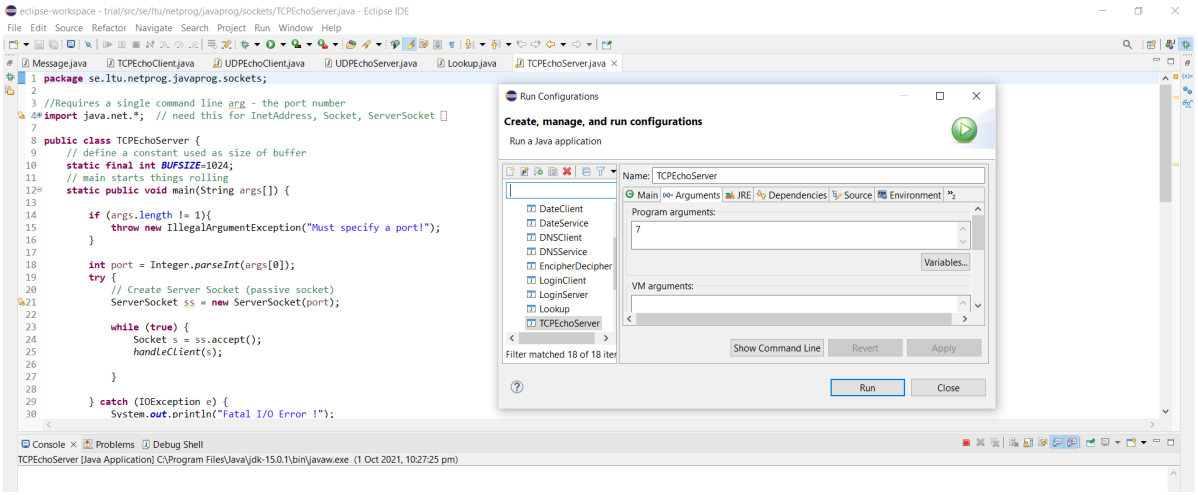
Copy CodeExamples_JavaProgrammingModule.zip file from Fronter to your home directory either on your local computer or on your AWS instance.Import the source files into your favorite IDE, for example Eclipse.

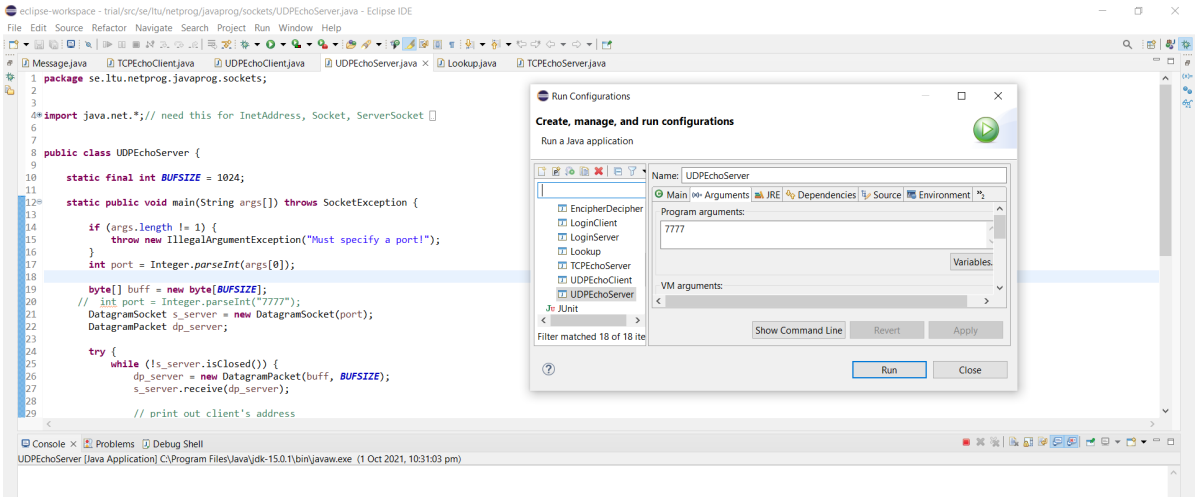
2.1. Compile and debug the Lookup, TCPEchoServer and UDPEchoServer classes.

It can be observed that the Lookup classes displays the IP address of a host given at execution time.

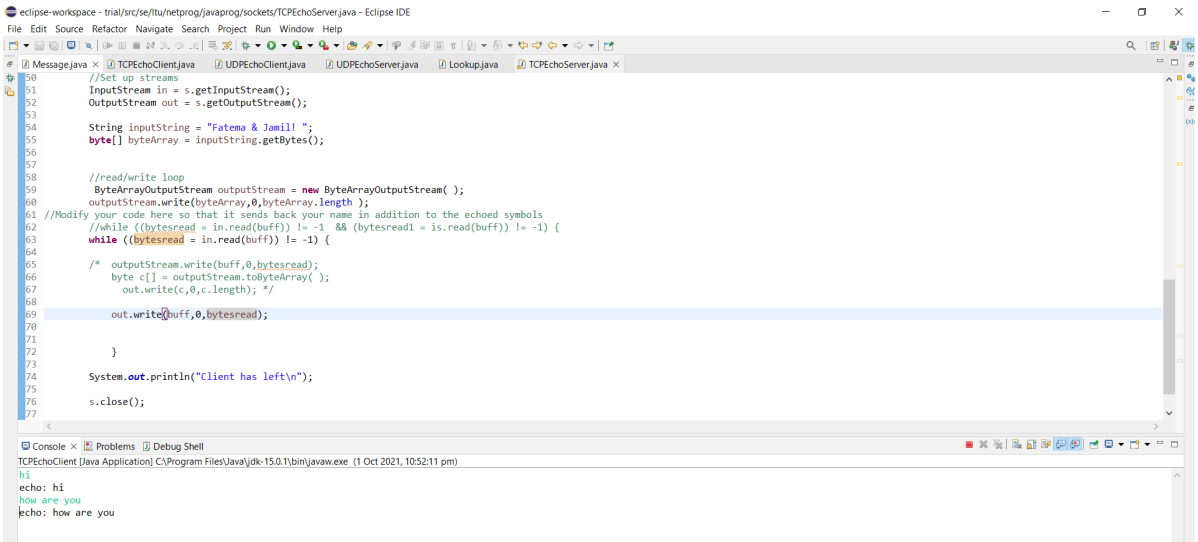


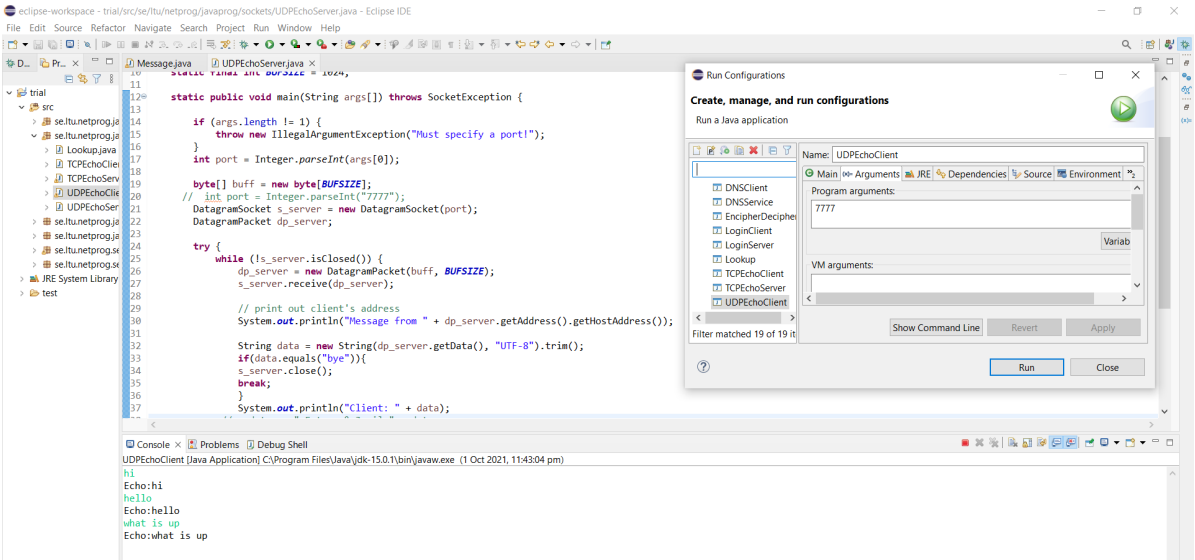
It can be observed that while both the TCPEchoServer and UDPEchoServer classes are working perfectly, that is not showing any error, it is not being able to echo anything as of yet.





This is because TCPEchoServer and UDPEchoServer does not have its corresponding TCPEchoClient and UDPEchoClient classes. After the client classes are written, the following can be observed:



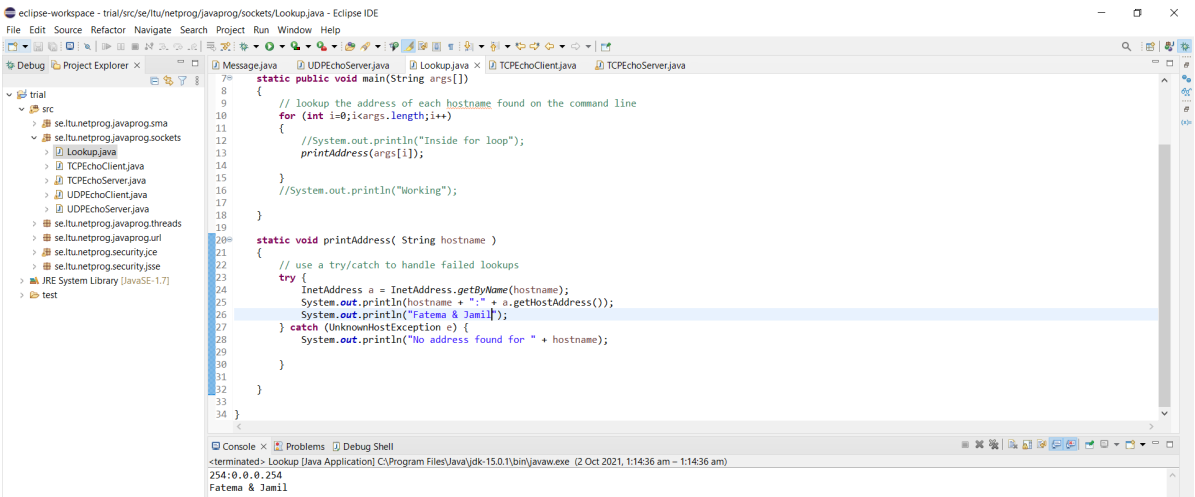


2.2. Be able to describe the details of the implementation of each class (to be tested during individual assessment by Evgeny).

Source code has been provided.

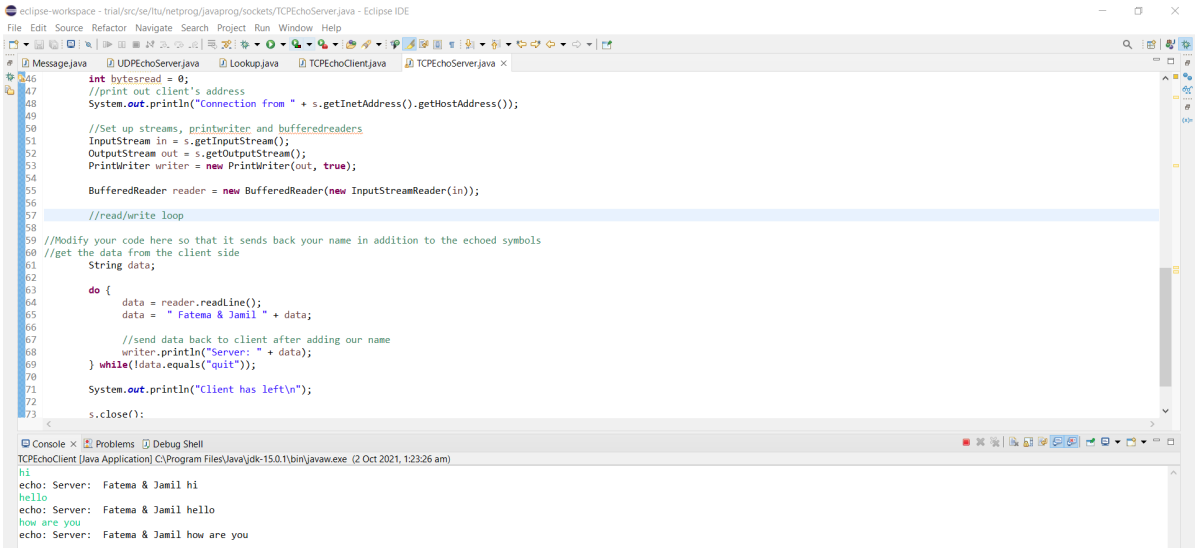
2.3. Modify the Lookup class so, that it outputs your name in addition to the input parameters that you supply at runtime

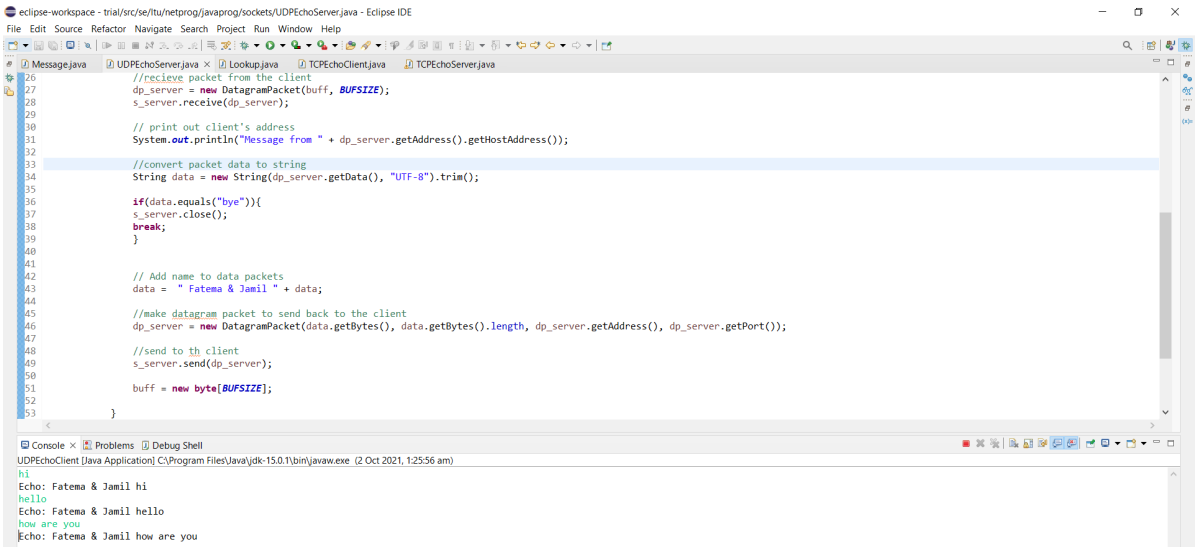
The edited part of the code as well as the output has been displayed below.



2.4. Modify both the TCPEchoServer and UDPEchoServer classes so that in addition to echoed input symbols the server would send back your name.

The edited part of the code as well as the output has been displayed below.





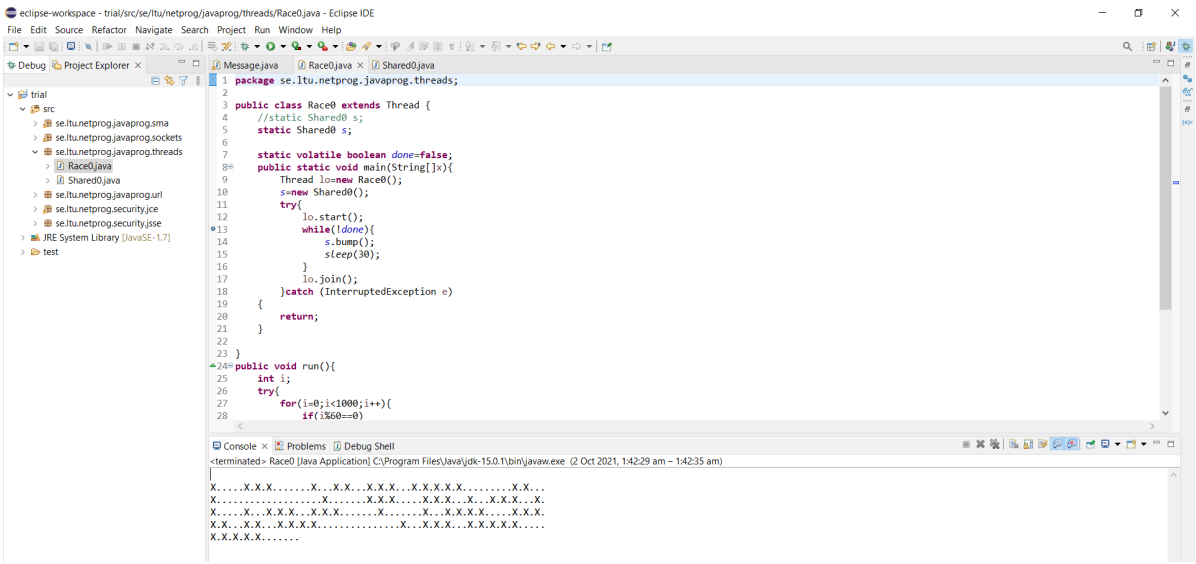
2.5. Compile the class Race0 in the threads part of the project.

1. What kind of behavior do you observe?

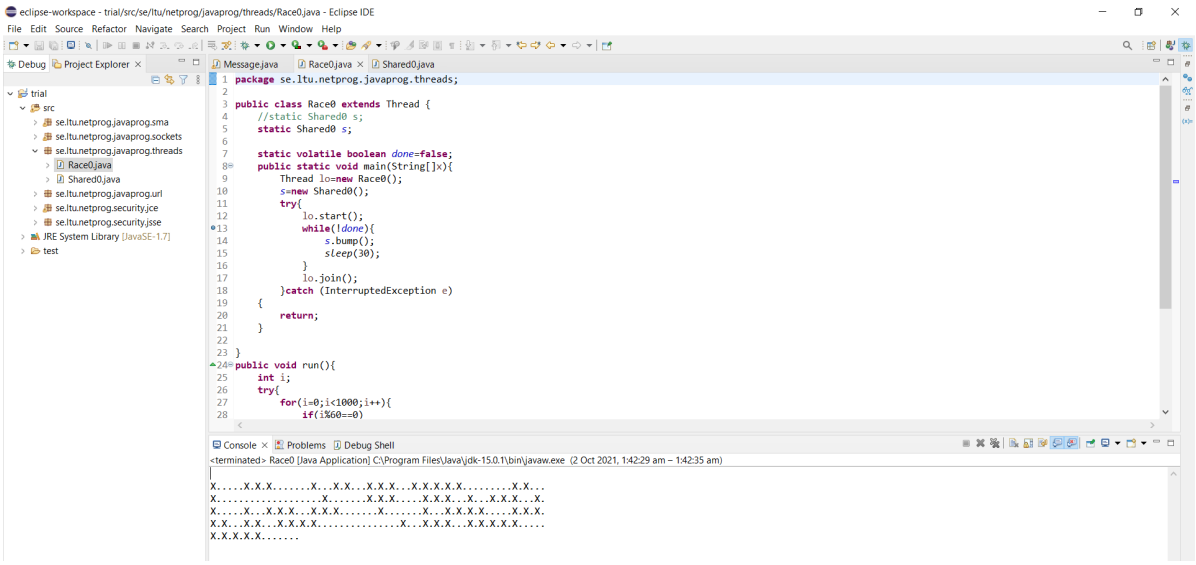
2. Make now both dif() and bump() methods synchronized. Compile the classes and run.

3. How the behavior is changed now?

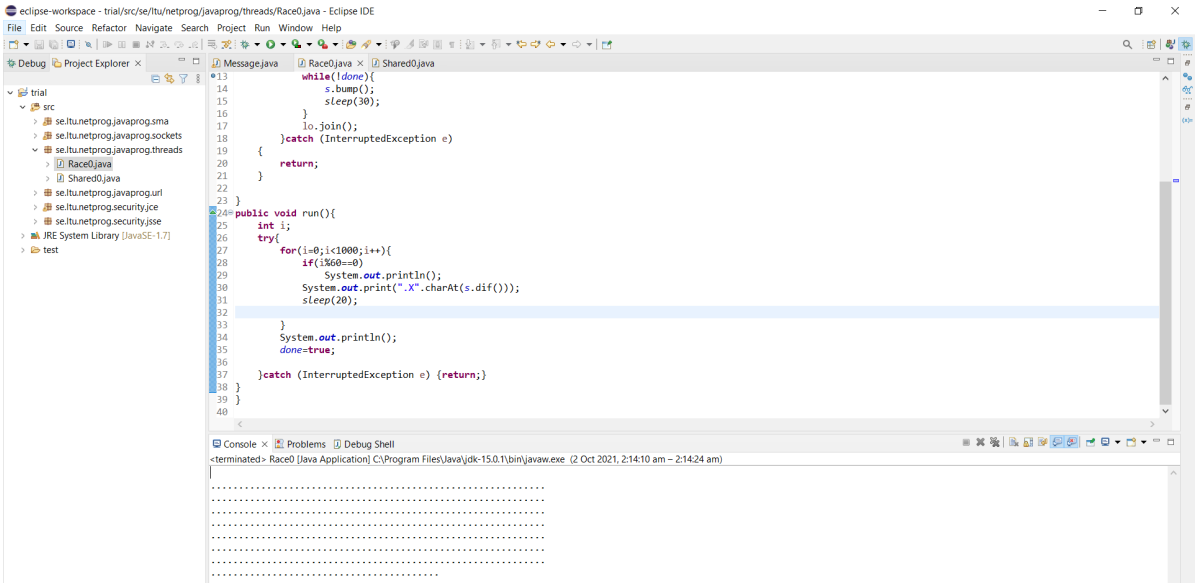
1. The behaviour that is displayed is called **Race Condition** - a condition that arises when two or more threads attempt to access a shared resources simultaneously. There the shared resources, in this instance the integer values of x and y fall under race conditions. There is a change for x or y to be read by the thread calling dif() while executing the bump() call leading at times to a value of 1 (prints an X) and rest of the times 0 (prints an .).



2. The following output is observed:



3. The Race Condition has been eliminated with use of the keyword synchronized. The shared resources are now locked when the methods bump() or dif() is executed which means that they will not be able to use the shared resources at the same time or until one method has stopped executing. This leads to the value of x and y being same at all times, and the method dif() always returning a 0 and hence always printing a . .


eclipse-workspace - trial/src/se/ltu/netprog/javaprog/threads/Race0.java - Eclipse IDE
File Edit Source Refactor Navigate Search Project Run Window Help
Debug
Project Explorer
trial
src
se.ltu.netprog.javaprog.sma
se.ltu.netprog.javaprog.sockets
se.ltu.netprog.javaprog.threads
Race0.java
Shared0.java
se.ltu.netprog.javaprog.url
se.ltu.netprog.security.jce
se.ltu.netprog.security.jsse
JRE System Library [JavaSE-1.7]
test
Message.java
Race0.java
Shared0.java
13 while(!done){
14 s.bump();
15 sleep(30);
16 }
17 lo.join();
18 }catch (InterruptedException e)
19 {
20 return;
21 }
22
23 }
24 public void run(){
25 int i;
26 try{
27 for(i=0;i<1000;i++){
28 if(i%60==0)
29 System.out.println();
30 System.out.print(".X".charAt(s.dif()));
31 sleep(20);
32
33 }
34 System.out.println();
35 done=true;
36
37 }catch (InterruptedException e) {return;}
38 }
39 }
40
Console
Problems
Debug Shell
<terminated> Race0 [Java Application] C:\Program Files\Java\jdk-15.0.1\bin\javaw.exe (2 Oct 2021, 2:14:10 am – 2:14:24 am)

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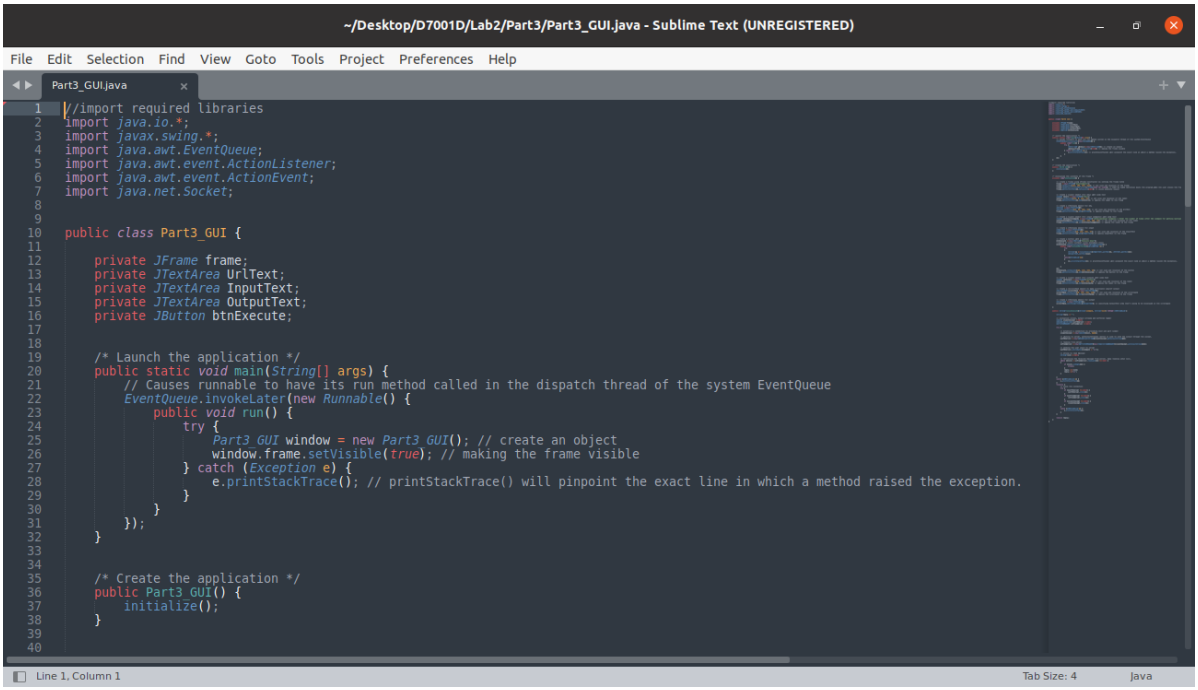
Part III: Client-server application

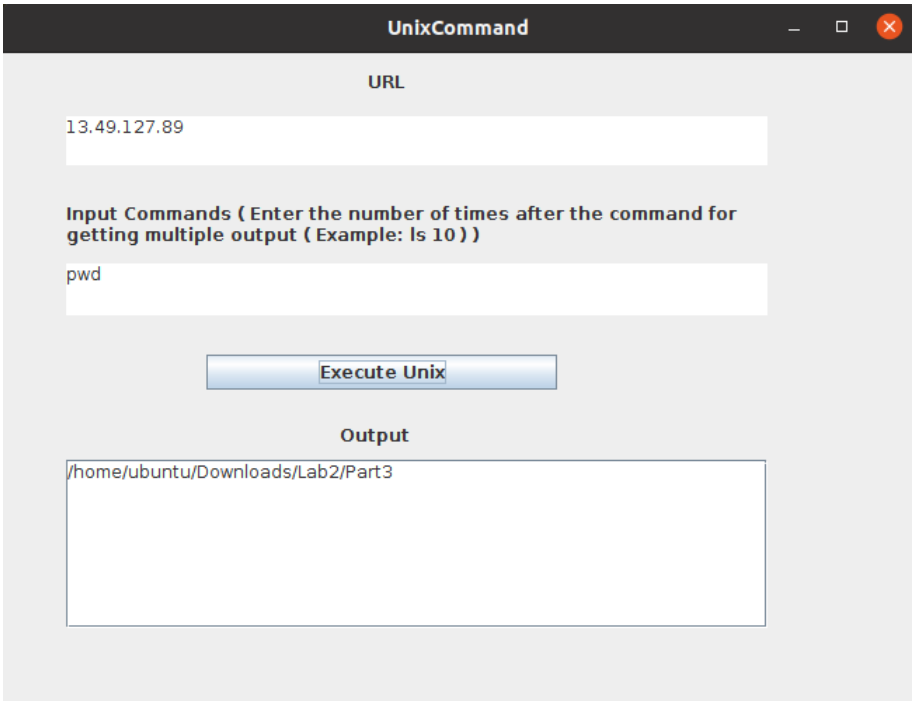
Modify Part I of this Lab 2 so that:

3.1. The GUI runs as a client-side application. Add an additional field to your GUI where the user can enter the URL of the server-side application

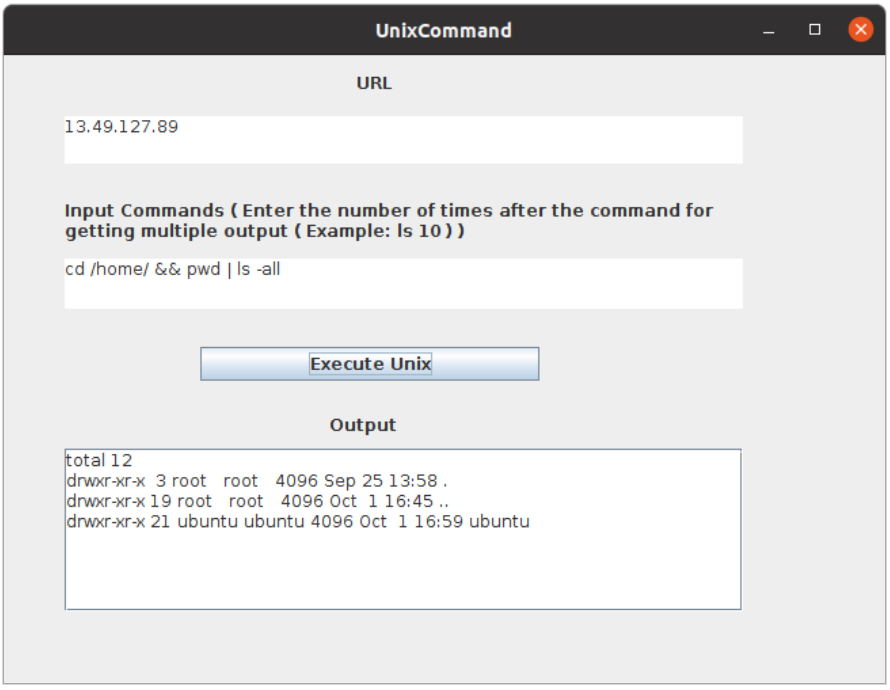
A GUI (Part3_GUI.java) has been implemented on a local machine that runs as a client-side application, which is shown below.



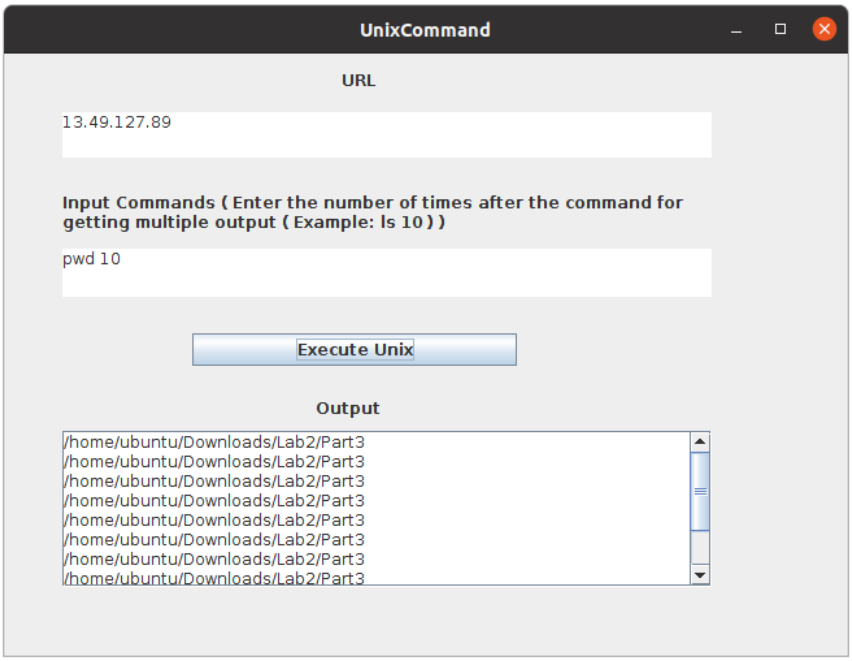
In the GUI, an additional field has been added where the user can enter the URL of the server-side applications. If a user wants to see the name of the current working directory, he can write the command “pwd" in the input field and click on the “Execute Unix" button. Then the GUI will show the output as shown below.



Likewise, the command ***$cd /home/ && pwd | ls –all*** will return a detailed list of files and directories under /home/ folder as shown below.



Finally, if a user wants to see the name of the current working directory 10 times, he can write the command “pwd 10" in the input field and click on the “Execute Unix (Multiple Times)" button. Then the GUI will show the output 10 times, as shown below.

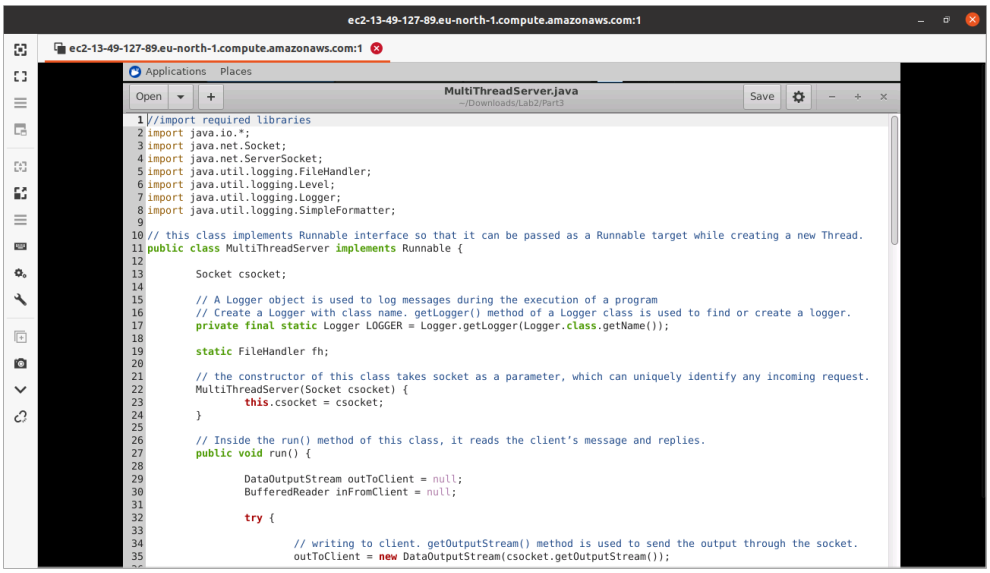


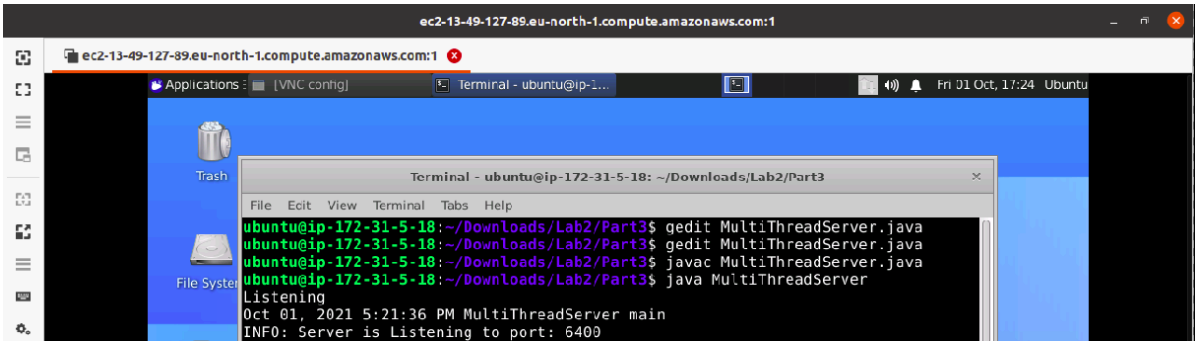
3.2. The entered commands should be executed and run as the server-side application. You can implement this assignments in either of the following two ways:

1. A CGI program running at the remote webserver 2 (you would get minimum points sufficient to pass this task, however).

2. Implement your own multi-threaded TCP server (higher points will be granted).

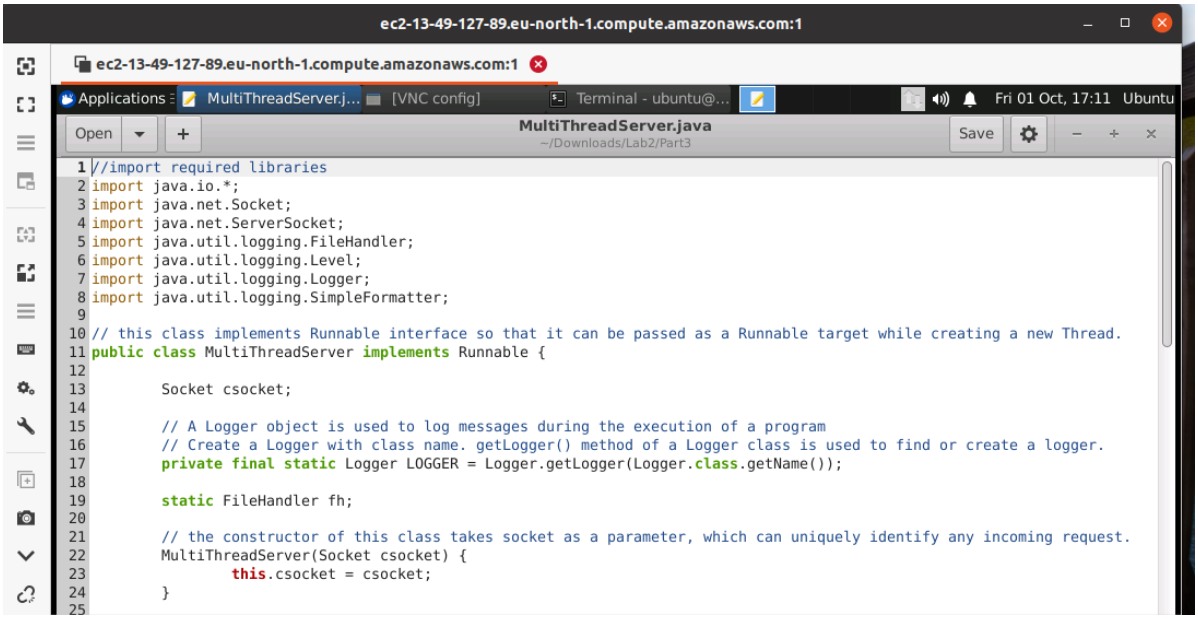
A **multi-threaded TCP server** (MultiThreadServer.java) has been implemented and placed on an AWS instance, which runs as a server-side application and executes the commands provided in the GUI by a client, as shown below.

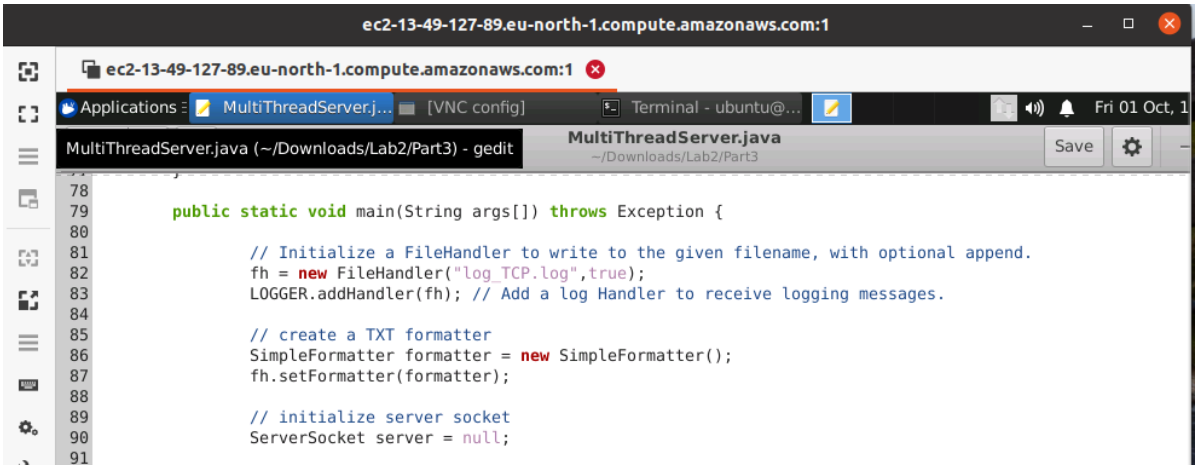


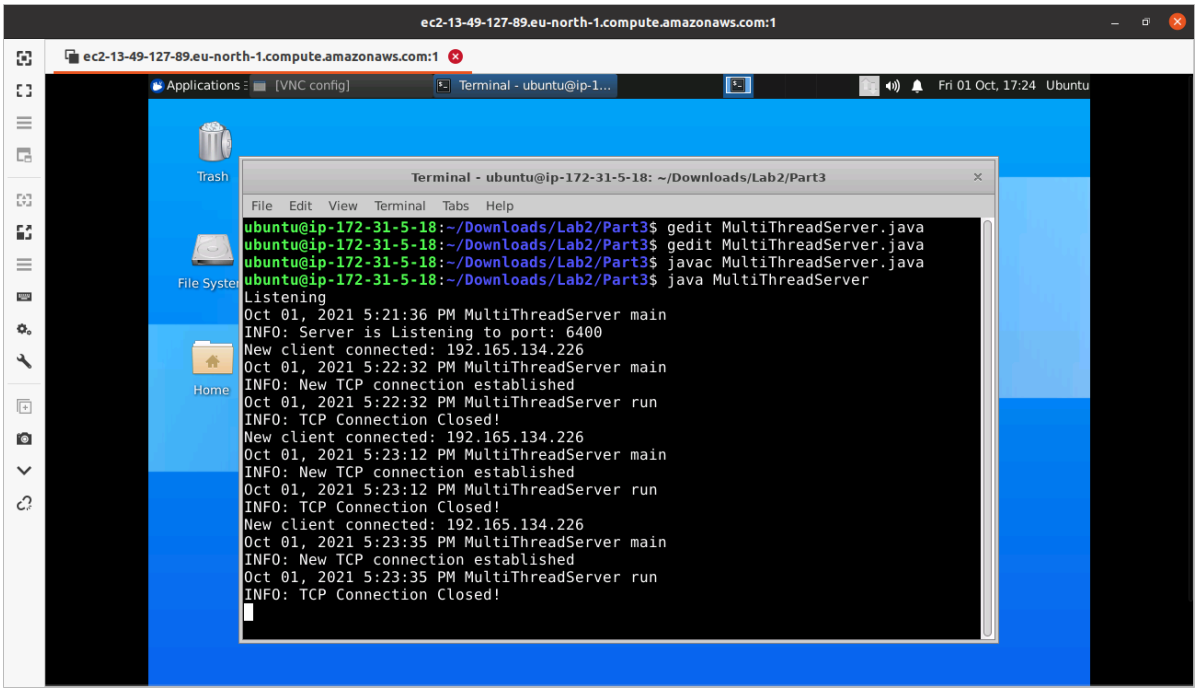


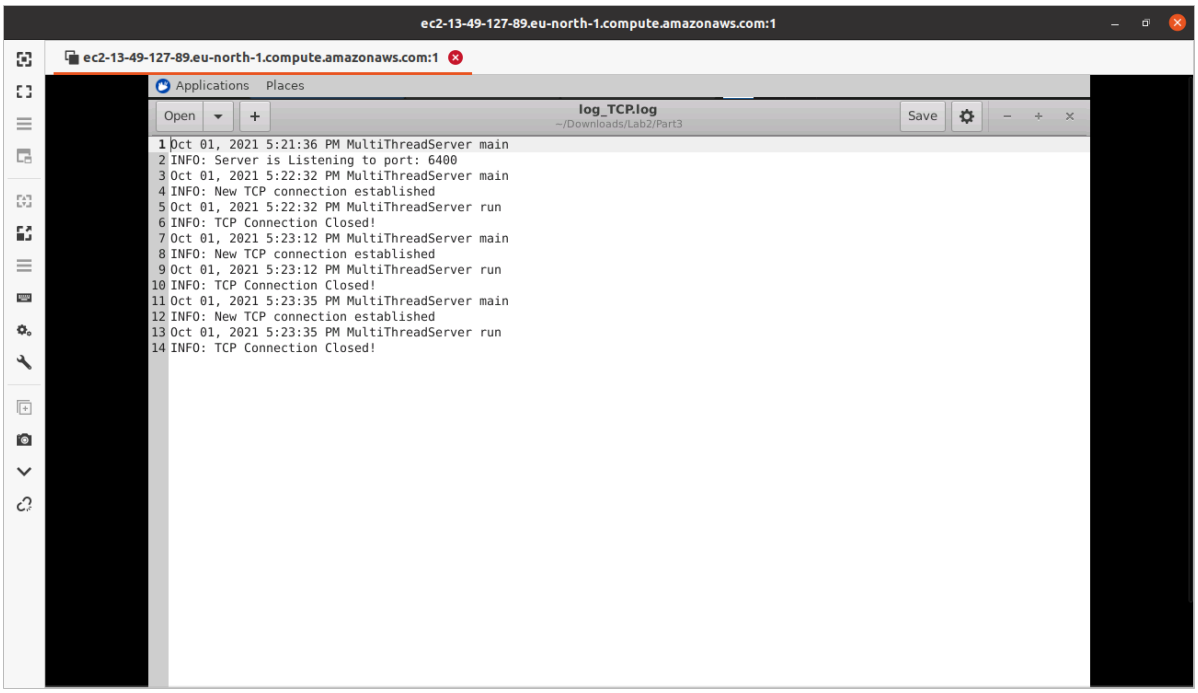
3.3. Add logging capability to the server-side application

Logging capability has been added to the server-side application as shown below.









3.4. The application should take an argument defining which level of debug should be logged (warning, info, error, debug)

In the server-side application, which level of debug should be logged is defined with the corresponding argument, as shown below.

Applications Places

Open + MultiThreadServer.java ~/Downloads/Lab2/Part3 Save

```java
                try {

            // server is listening on port 6400
            server = new ServerSocket(6400);
                System.out.println("Listening");

                // The log levels define the severity of a message.
                // The Level class is used to define which messages should be written to the log.
                // it sets the logger to the info level, which means all messages with severe, warning and info will be logged.
                LOGGER.setLevel(Level.INFO);

                // Call info method
                LOGGER.info("Server is Listening to port: 6400");

            // running infinite loop for getting client request
            while (true) {

                // socket object to receive incoming client requests
                Socket client = server.accept();

                // Displaying that new client is connected to server
                System.out.println("New client connected: " + client.getInetAddress().getHostAddress());

                LOGGER.setLevel(Level.INFO);
                        LOGGER.info("New TCP connection established");

                // the start() method is invoked on newly created thread object. This thread will handle the client separately
                        new Thread(new MultiThreadServer(client)).start();
                }
        }
        catch (IOException e) {
            e.printStackTrace();
        }
```

Applications Places

Open + MultiThreadServer.java ~/Downloads/Lab2/Part3 Save

```java
                try {

                        // writing to client. getOutputStream() method is used to send the output through the socket.
                        outToClient = new DataOutputStream(csocket.getOutputStream());

                        // takes input from the client socket (reading from client)
                        inFromClient = new BufferedReader(
                                        new InputStreamReader(csocket.getInputStream()));

                        String cmd = inFromClient.readLine(); // received message from client

                        Unix unix = new Unix();
                        String reply = unix.execute(cmd);


                        outToClient.writeBytes(reply + "\n");  // sending the response to client

                        // The log levels define the severity of a message.
                        // The Level class is used to define which messages should be written to the log.
                        // it sets the logger to the info level, which means all messages with severe, warning and info will be logged.
                        LOGGER.setLevel(Level.INFO);

                        // Call info method
                        LOGGER.info("TCP Connection Closed!");

                } catch (IOException e) {
                        e.printStackTrace();
                        LOGGER.setLevel(Level.SEVERE); // Severe occurs when some critical or terrible errors shown by the application. In such cases, the application is not able to continue further.
                        LOGGER.severe("IO Exception detected!");
                        LOGGER.warning("Exception occured!"); // warning occurs due to user mistake. If a user inputs the wrong credentials, the application shows a warning.
                }
                finally {
```

3.5. When adding different log levels to functions you have to explain why you add this level of logging to the specific function. Write this explanation as a comment in your source code

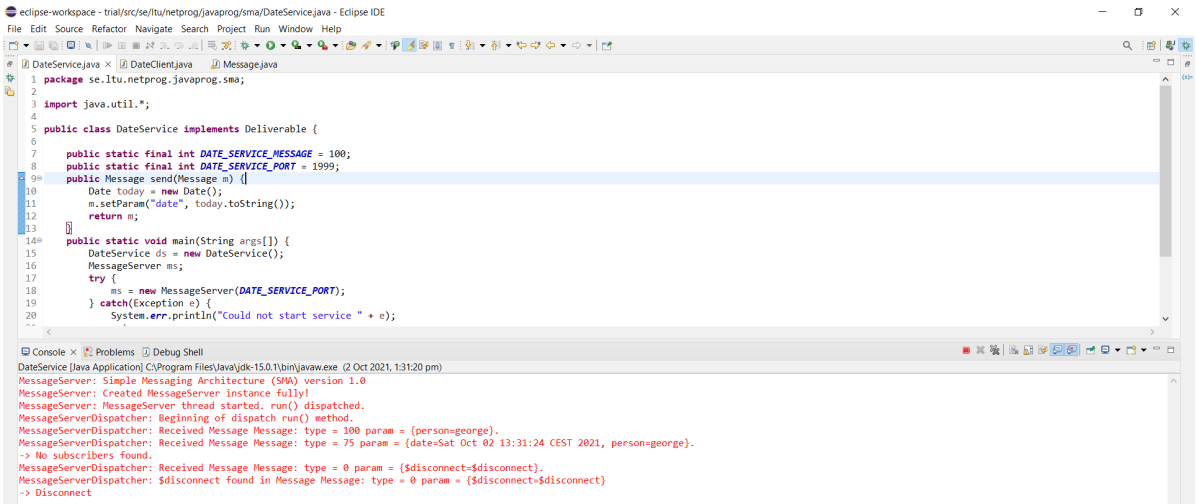
After adding different log levels, the explanation to add this level of logging is written as a comment in the source code, as illustrated in the above two Figures.

4

Part IV –Java netprog patterns –Simple Messaging Architecture

4.1. Compile and install the classes in the SMA module of the project.

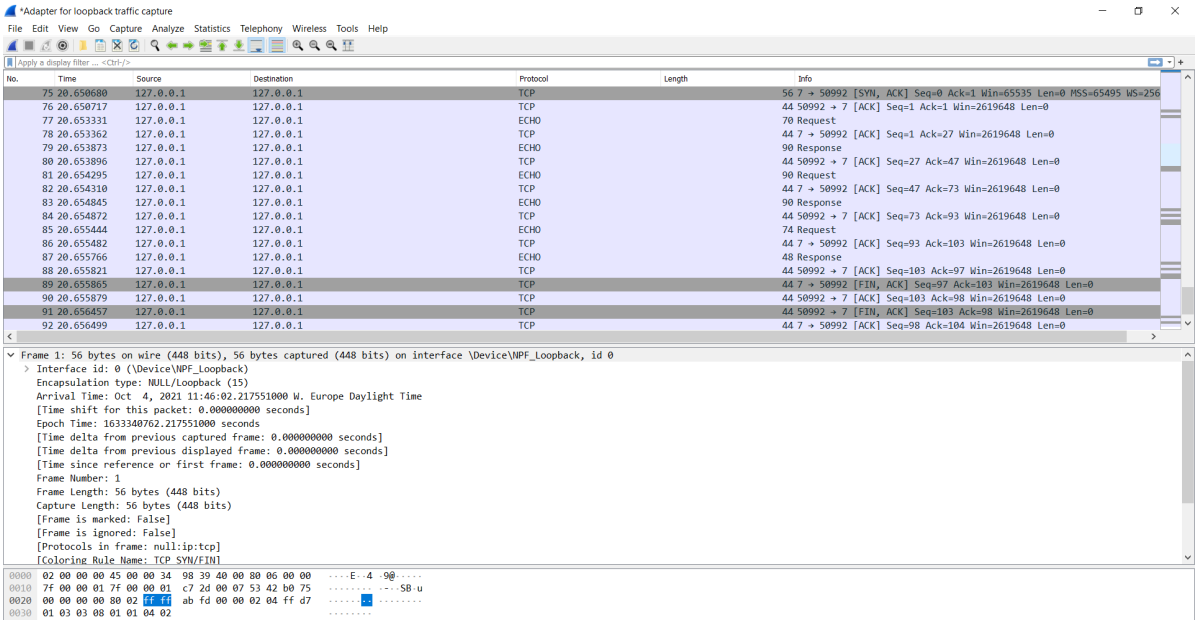
After compiling and installing the classes, the following output is achieved:



4.2. Demonstrate the functioning classes during the lab assessment. Use Wireshark to capture the traffic of the SMA session. You should be able to explain the details of the implementation during the individual assessment.

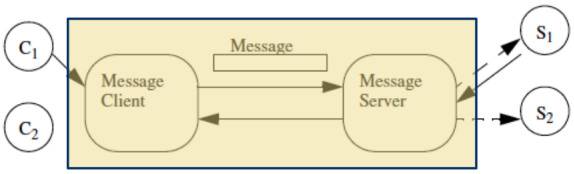
The source code is provided at:

A portion of the wireshark capture is provided below:

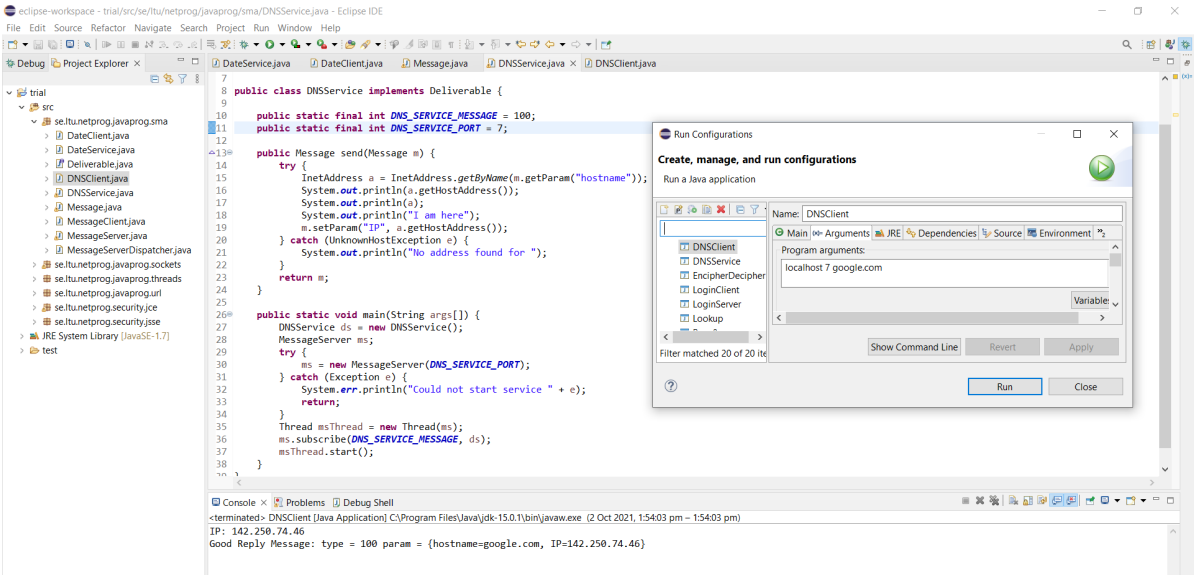


4.3. Extend the architecture adding a new kind of service of your choice!For example a simplified DNS service resolving an IP address for a given host number. (This is only a suggestion though)

DNS Service is implemented by adding a new service and client for that service.



Message represents the class used to represent a basic unit of communication (an abstraction that is built using a hash table, wherein the key and values are String instances). MessageServer denotes the the common functionality of a server. MessageClient denotes the common functionality of a client. DNSService is created to represent functionalities on top of the MessageServer whereas DNSClient is used to represent functionalities on top of the MessageClient.


eclipse-workspace - trial/src/se/ltu/netprog/javaprog/sma/DNSService.java - Eclipse IDE
File Edit Source Refactor Navigate Search Project Run Window Help
Debug
Project Explorer
trial
src
se.ltu.netprog.javaprog.sma
DateClient.java
DateService.java
Deliverable.java
DNSClient.java
DNSService.java
Message.java
MessageClient.java
MessageServer.java
MessageServerDispatcher.java
se.ltu.netprog.javaprog.sockets
se.ltu.netprog.javaprog.threads
se.ltu.netprog.javaprog.url
se.ltu.netprog.security.jce
se.ltu.netprog.security.jsse
JRE System Library [JavaSE-1.7]
test
DateService.java
DateClient.java
Message.java
DNSService.java
DNSClient.java
public class DNSService implements Deliverable {
public static final int DNS_SERVICE_MESSAGE = 100;
public static final int DNS_SERVICE_PORT = 7;
public Message send(Message m) {
try {
InetAddress a = InetAddress.getByName(m.getParam("hostname"));
System.out.println(a.getHostAddress());
System.out.println(a);
System.out.println("I am here");
m.setParam("IP", a.getHostAddress());
} catch (UnknownHostException e) {
System.out.println("No address found for ");
}
return m;
}
public static void main(String args[]) {
DNSService ds = new DNSService();
MessageServer ms;
try {
ms = new MessageServer(DNS_SERVICE_PORT);
} catch (Exception e) {
System.err.println("Could not start service " + e);
return;
}
Thread msThread = new Thread(ms);
ms.subscribe(DNS_SERVICE_MESSAGE, ds);
msThread.start();
}
Run Configurations
Create, manage, and run configurations
Run a Java application
DNSClient
DNSService
EncipherDecipher
LoginClient
LoginServer
Lookup
Filter matched 20 of 20 ite
Name: DNSClient
Main
Arguments
JRE
Dependencies
Source
Environment
Program arguments:
localhost 7 google.com
Variables
Show Command Line
Revert
Apply
Run
Close
Console
Problems
Debug Shell
<terminated> DNSClient [Java Application] C:\Program Files\Java\jdk-15.0.1\bin\javaw.exe (2 Oct 2021, 1:54:03 pm – 1:54:03 pm)
IP: 142.250.74.46
Good Reply Message: type = 100 param = {hostname=google.com, IP=142.250.74.46}

5

Part V: Java netprog patterns – security

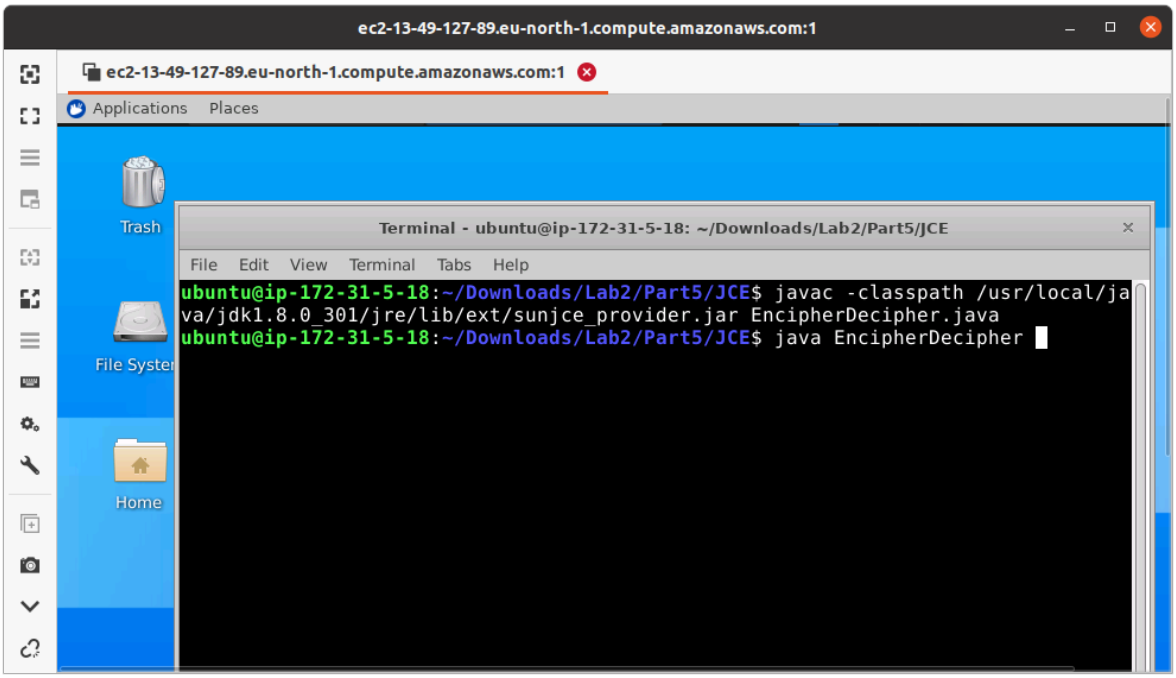
5.1. Compile and install (in the cloud) the classes in the security module of the project (JCE and JSSE)

5.1.1. JCE:

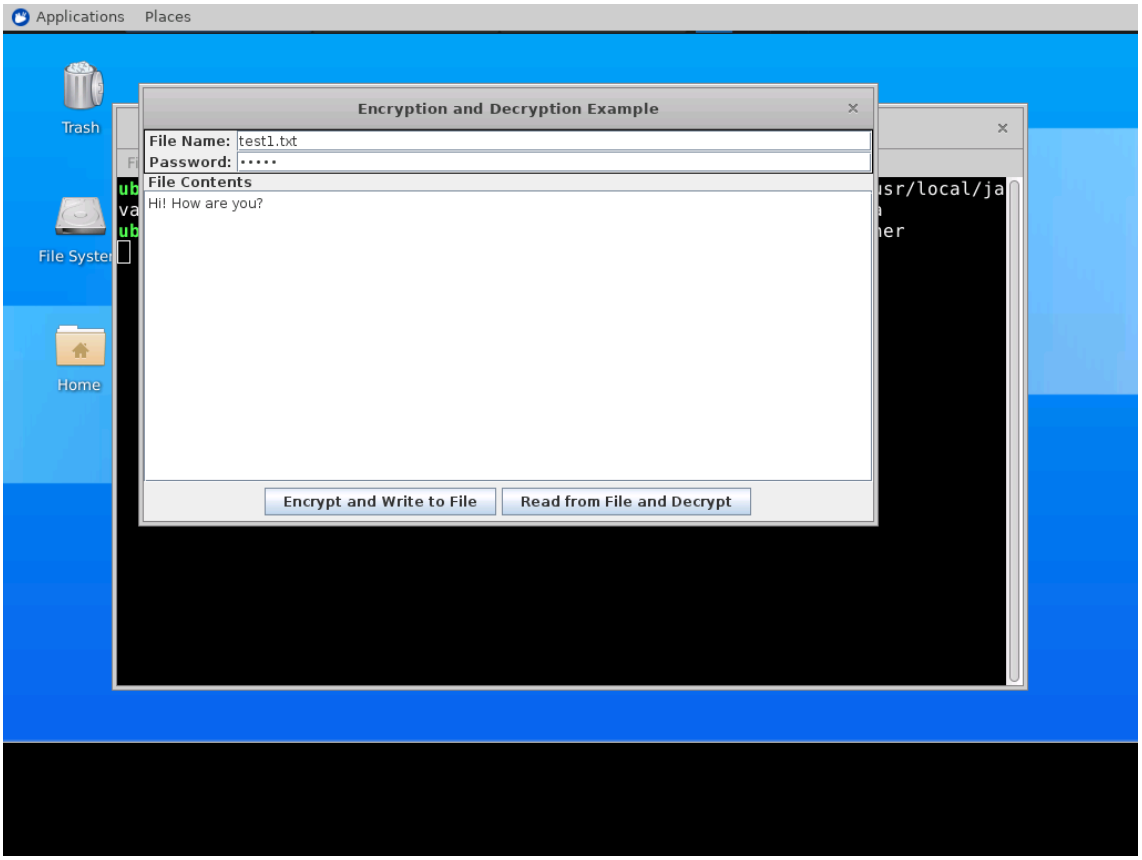
The Java Cryptography Extension (JCE) provides Java applications with several security facilities (Deitel et al., 2002). JCE supports secret-key encryption, such as 3DES, and public-key algorithms, such as Diffie-Hellman and RSA (Deitel et al., 2002).

In the JCE module of the project, Class EncipherDecipher uses JCE to demonstrate Password-Based Encryption (PBE). Class EncipherDecipher provides users with a graphical user interface that allows them to specify the file name of a file that the application will use to write to and read from, the contents of the file to encrypt/decrypt, and the password used to encrypt/decrypt the file (Deitel et al., 2002).

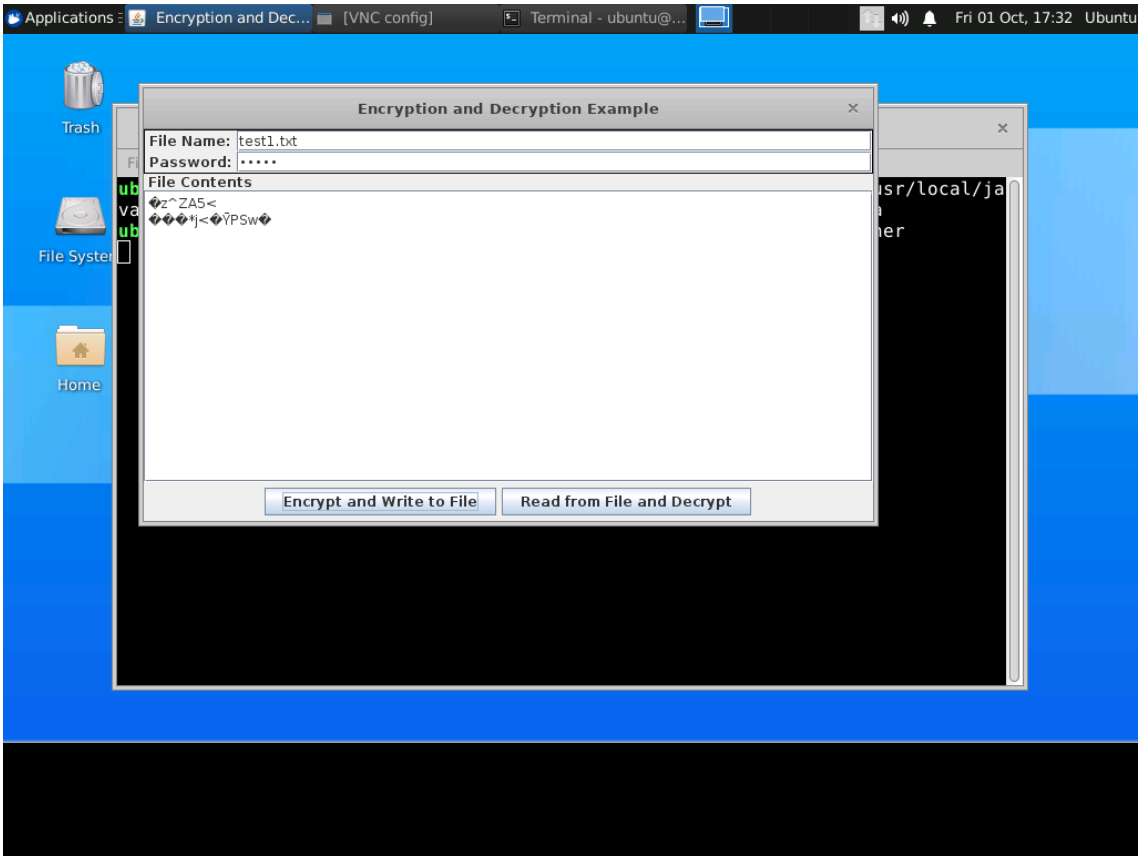
The task has been performed on an AWS instance. The following command is used to compile and run the class EncipherDecipher.



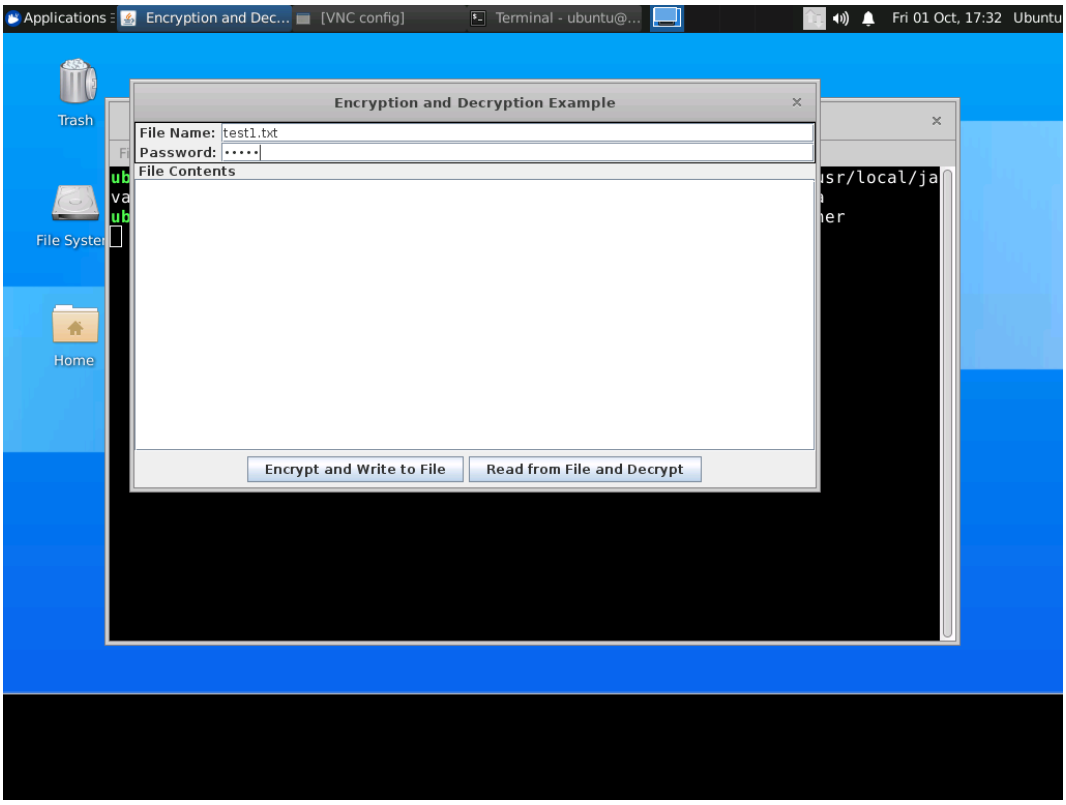
The following figure displays the contents that application EncipherDecipher will encrypt and write to file 'test1.txt' using password 'jamil'.



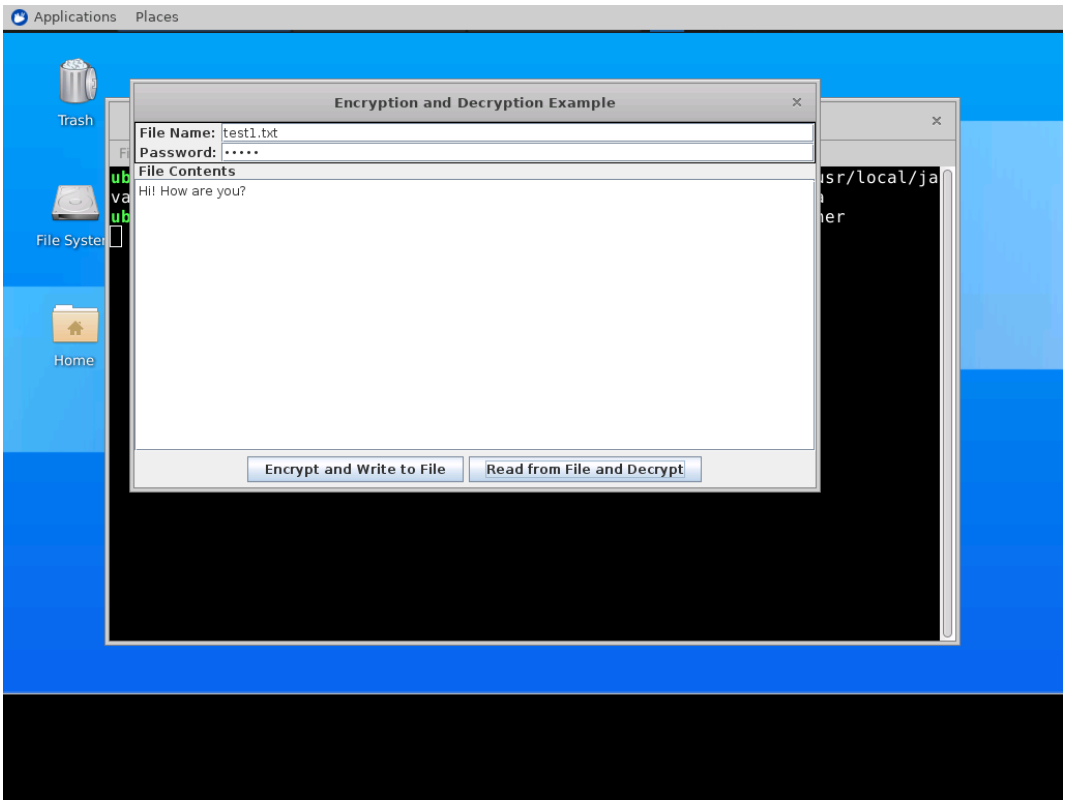
The following figure displays the contents of the file after pressing button ‘Encrypt and Write to File’.



The following figure displays the contents that application EncipherDecipher will read from file and decrypt ‘test1.txt’ using password ‘jamil’.



The following figure displays the contents of the file after pressing button ‘Read from File and Decrypt’.



5.1.2. JSSE:

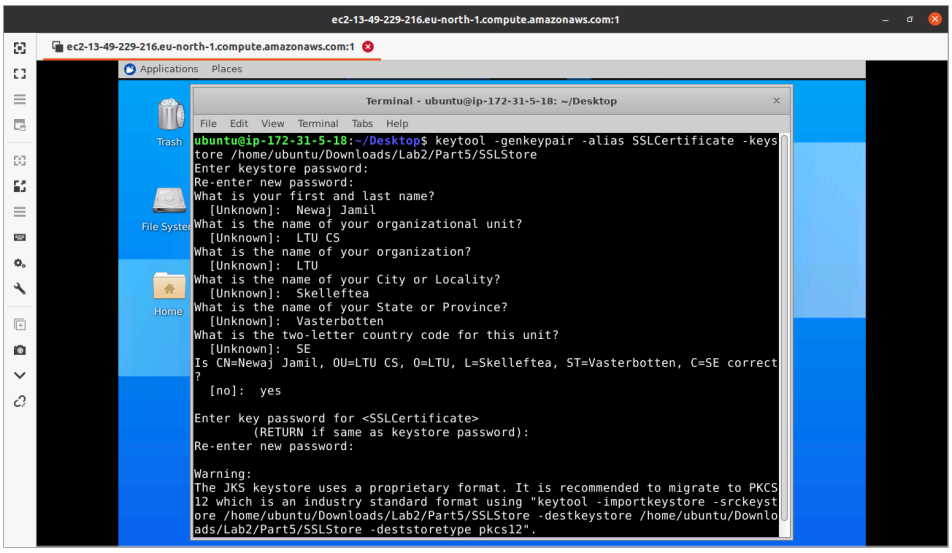
SSL encryption has been integrated into Java technology through the Java Secure Socket Extension (JSSE) (Llewellyn, 2006). JSSE uses keystores to secure storage of key pairs and certificates used in PKI (Public Key Infrastructure which integrates public-key cryptography with digital certificates and certificate authorities to authenticate parties in a transaction) (Llewellyn, 2006). A truststore is a keystore that contains keys and certificates used to validate the identities of servers and clients (Llewellyn, 2006).

In the JSSE module of the project, the classes involves a client application (LoginClient.java) that attempts to logon to a server (LoginServer.java) using SSL.

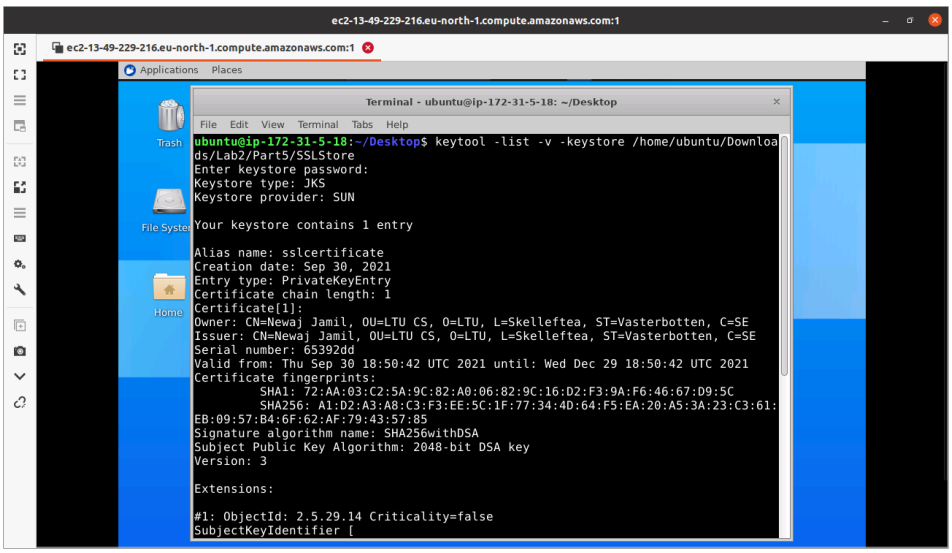
Before executing the LoginServer and LoginClient application using SSL, we have to create a keystore and certificate for the SSL to operate correctly. Utilizing the keytool (a key and certificate management tool) in Java, a keystore and a certificate for the server application can be generated.

The server (LoginServer.java) is placed on an AWS instance. First, we have created a self-signed certificate for the server (LoginServer.java) in the server's KeyStore. Then on a local machine (client machine), class InstallCert.java has to be run by providing the server's address along with port number and passphrase in order to add the server's certificate to the client's TrustStore with other trusted certificates. Finally, we can run the client application (LoginClient.java) in order to establish a secure connection with the server.

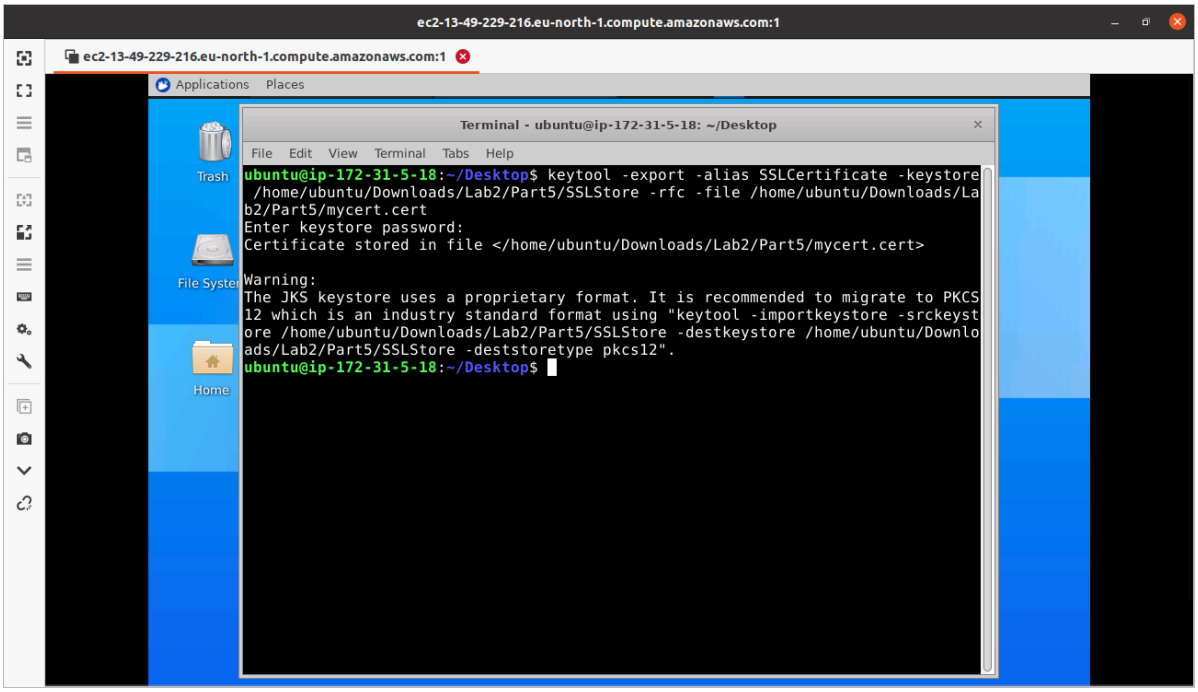
Creating a Self-Signed Certificate: Java keytool command is used to generate a self-signed certificate for the server and place it in the KeyStore.



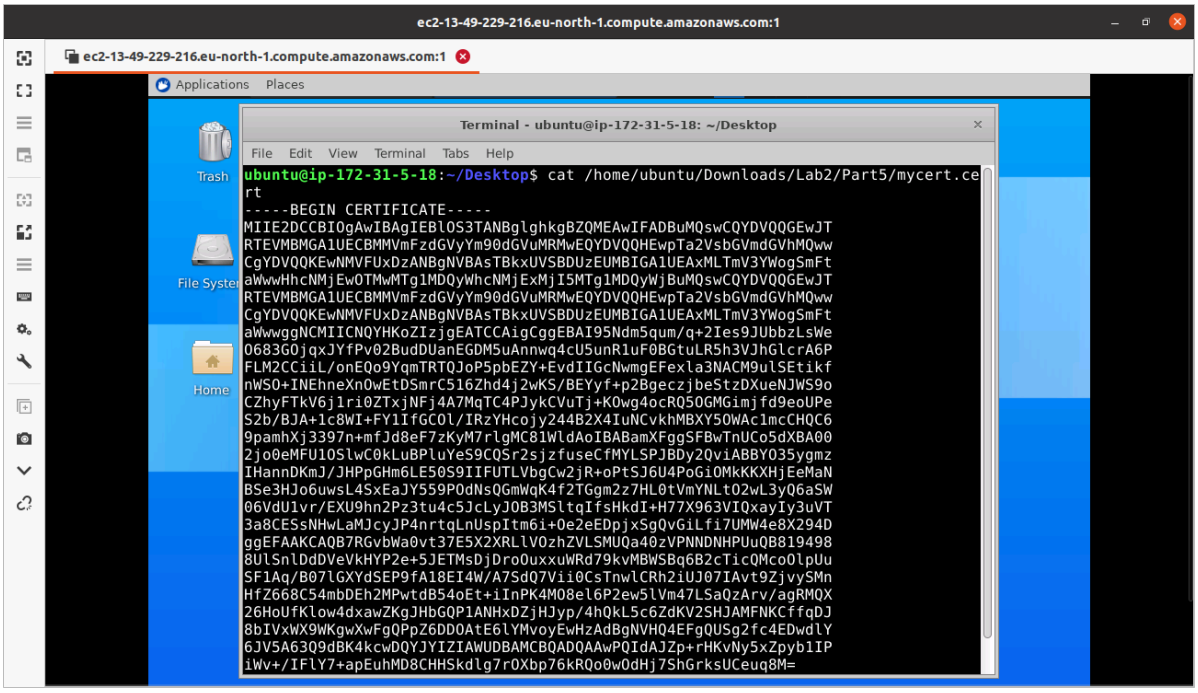
We can view the keystore contents after its creation using the following command:



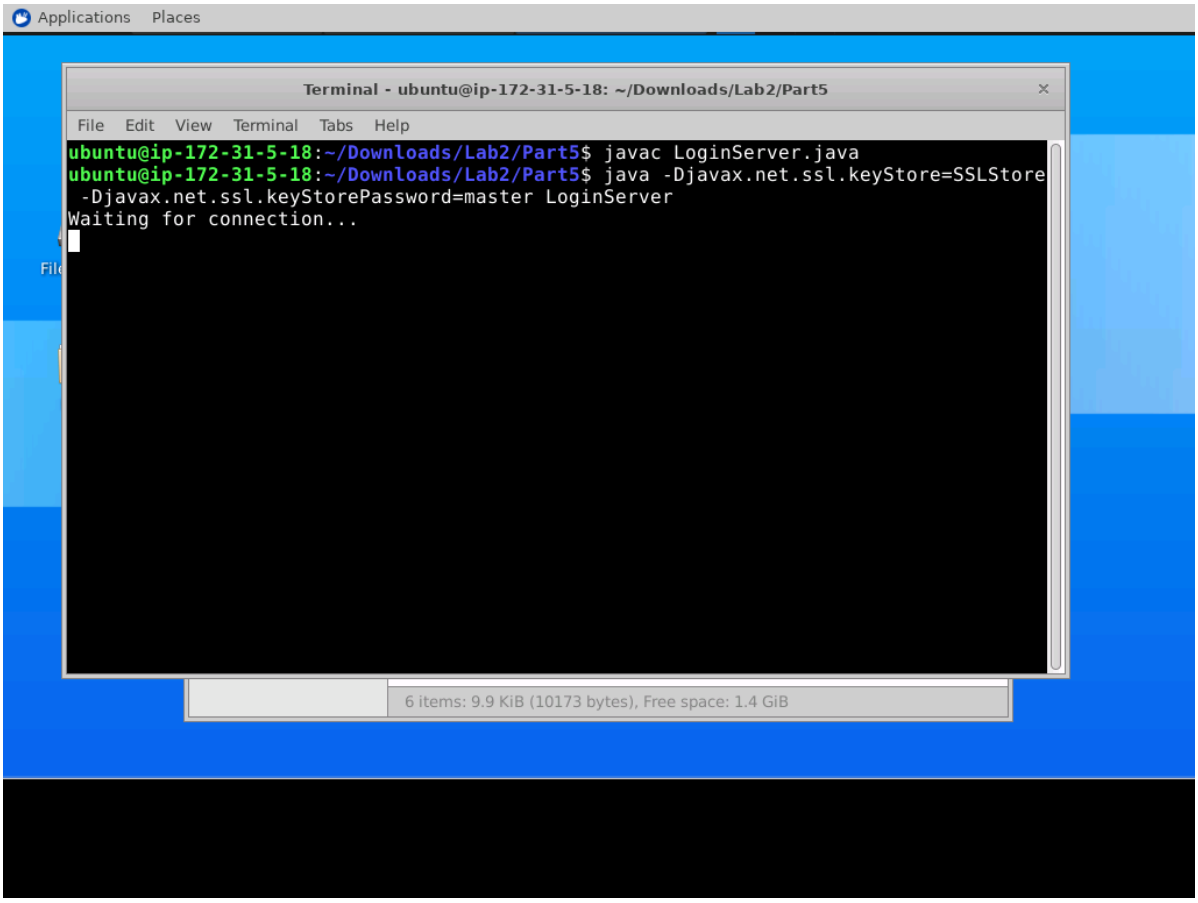
Then we have exported the certificate into a certificate file (mycert.cert).



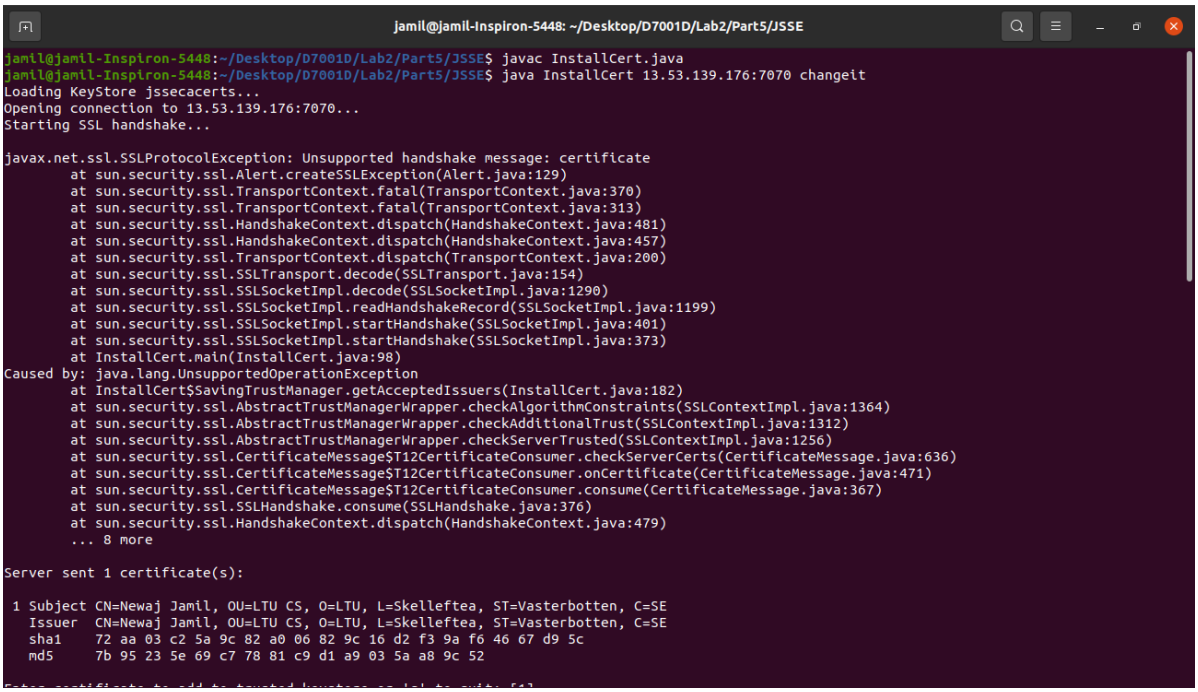
We can view the contents of the certificate using the following command:



Launching LoginServer.java: We can start the server from a terminal by specifying the keystore for the server. Once started, the server simply waits for a connection from a client. The following command is used to start the server.



Launching InstallCert.java: On a local machine (client machine), class InstallCert.java has to be run by providing the server's address along with port number and passphrase in order to add the server's certificate to the client's TrustStore with other trusted certificates.



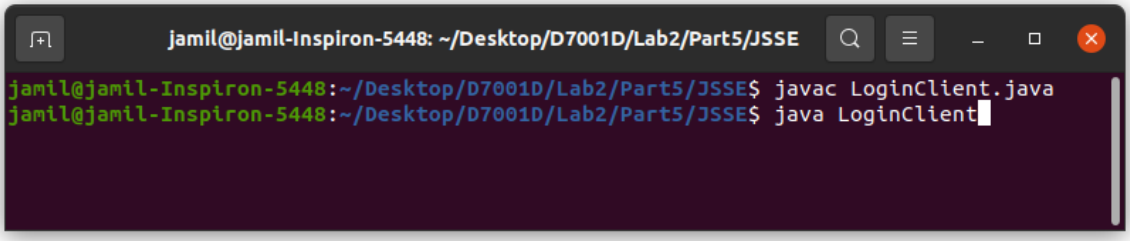
```
jamil@jamil-Inspiron-5448: ~/Desktop/D7001D/Lab2/Part5/JSSE
Enter certificate to add to trusted keystore or 'q' to quit: [1]


[
[
  Version: V3
  Subject: CN=Newaj Jamil, OU=LTU CS, O=LTU, L=Skelleftea, ST=Vasterbotten, C=SE
  Signature Algorithm: SHA256withDSA, OID = 2.16.840.1.101.3.4.3.2

  Key:  Sun DSA Public Key
    Parameters:DSA,
        p:     8f7935d9 b9aae9bf abed887a cf4951b6 f32ec59e 3baf3718 e8eac496 1f3efd36
    06e74351 a9c41833 39b809e7 c2ae1c53 9ba7475b 85d011ad b8b47987 75498469
    5cac0e8f 14b33608 28a22ffa 27110a3d 62a99345 3409a0fe 696c4658 f84bdd20
    819c3709 a01057b1 95adcd00 233dba54 84b6291f 9d648ef8 83448677 979cec04
    b434a6ac 2e75e998 5de23db0 292fc111 8c9ffa9d 8181e733 8db792b7 30d7b9e3
    49592f60 09987215 3915ea3d 6b8b4653 c633458f 803b32a4 c2e0f272 90256e4e
    3f8a3b08 38a1c450 e4e18c1a 29a37ddf 5ea143de 4b66ff04 903ed5cf 1623e158
    d487c608 e97f211c d81dca23 cb6e3807 65f822e3 42be484c 05763939 601cd667
        q:     baf696a6 8578f7df dee7fa67 c977c785 ef32b233 bae580c0 bcd5695d
        g:     16a65c58 20485070 4e7502a3 9757040d 34da3a34 78c154d4 e4a5c02d 242ee04f
    96e61e4b d0904abd ac8f37ee b1e09f31 82d23c90 43cb642f 88004160 edf9ca09
    b32076a7 9c32a627 f2473e91 879ba2c4 e744bd20 81544cb5 5b802c36 8d1fa83e
    d489e94e 0fa0688e 32428a5c 78c478c6 8d0527b7 1c9a3abb 0b0be12c 44689639
    e7d3ce74 db101a65 aa2b87f6 4c6826db 3ec72f4b 5599834b b4edb02f 7c90e9a4
    96d3a55d 535bebfc 45d4f619 f63f3ded bb873925 c2f224e0 7731296d a887ec1e
    4748f87e fb5fdeb7 5484316b 2232dee5 53ddaf02 112b0d1f 02da3097 3224fe27
    aeda8b9d 4b2922d9 ba8be39e d9e103a6 3c52810b c688b7e2 ed4316e1 ef17dbde

  y:
    7b446bdb 59ad2fb7 7ec4e57d 9744b955 3b385954 b48c5106 b8d3354f 34d0cd1c
    f52e401f 35f78f7c f149529e 50dd0d57 9590760f d9efb924 44ccb038 c3ae83ae
    c71b9645 defd92f3 0159206a e81d9c4e 271031ca 0e96952e 485d40ab f074ee51
    9761d484 3fd7c0d7 c108e16f c0ed2750 ed58a2d0 2b139f09 42461da2 509d3b20
    0bedf598 efc92327 1df67aeb c0b9e266 c3121d8c 3f0b5d07 9e2812df a22273ca
    e0c3bc7a 5e8fd9ec 399559b8 ecb49a43 302bbff6 a044c417 dba1e851 f2a5a30e
    1dc5ac19 2a02476c 640fd403 47c43663 1c9ca9ff 885090be 5ce9974a 57648724
    030534a0 9f7ea0c9 f1b215c5 65fd58a8 305f0160 40fa59e8 30ce02d1 3a95832f
```

```
jamil@jamil-Inspiron-5448: ~/Desktop/D7001D/Lab2/Part5/JSSE
    aeda8b9d 4b2922d9 ba8be39e d9e103a6 3c52810b c688b7e2 ed4316e1 ef17dbde

  y:
    7b446bdb 59ad2fb7 7ec4e57d 9744b955 3b385954 b48c5106 b8d3354f 34d0cd1c
    f52e401f 35f78f7c f149529e 50dd0d57 9590760f d9efb924 44ccb038 c3ae83ae
    c71b9645 defd92f3 0159206a e81d9c4e 271031ca 0e96952e 485d40ab f074ee51
    9761d484 3fd7c0d7 c108e16f c0ed2750 ed58a2d0 2b139f09 42461da2 509d3b20
    0bedf598 efc92327 1df67aeb c0b9e266 c3121d8c 3f0b5d07 9e2812df a22273ca
    e0c3bc7a 5e8fd9ec 399559b8 ecb49a43 302bbff6 a044c417 dba1e851 f2a5a30e
    1dc5ac19 2a02476c 640fd403 47c43663 1c9ca9ff 885090be 5ce9974a 57648724
    030534a0 9f7ea0c9 f1b215c5 65fd58a8 305f0160 40fa59e8 30ce02d1 3a95832f

  Validity: [From: Thu Sep 30 20:50:42 CEST 2021,
              To: Wed Dec 29 19:50:42 CET 2021]
  Issuer: CN=Newaj Jamil, OU=LTU CS, O=LTU, L=Skelleftea, ST=Vasterbotten, C=SE
  SerialNumber: [    065392dd]

Certificate Extensions: 1
[1]: ObjectId: 2.5.29.14 Criticality=false
SubjectKeyIdentifier [
KeyIdentifier [
0000: 4A 0D 9F 73 81 03 C1 D9   58 E8 95 79 03 AD D0 F5  J..s....X..y....
0010: D0 4A E2 47                                        .J.G
]
]

]
  Algorithm: [SHA256withDSA]
  Signature:
0000: 30 3D 02 1D 00 96 69 FA   B1 CA BC DC B9 C5 9A 72  0=....i.......r
0010: 6F 52 0F 89 6B FE FC 81   65 63 BF 9A A4 4B A1 30  oR..k...ec...K.0
0020: 3F 02 1C 74 A4 76 58 3B   AC E5 DB A7 BE A4 45 0A  ?..t.vX;......E.
0030: 34 C0 E7 47 8F B4 A1 1A   B9 2C 50 27 AE AB C3     4..G.....,P'...

]

Added certificate to keystore 'jssecacerts' using alias '13.53.139.176-1'
jamil@jamil-Inspiron-5448:~/Desktop/D7001D/Lab2/Part5/JSSE$
```

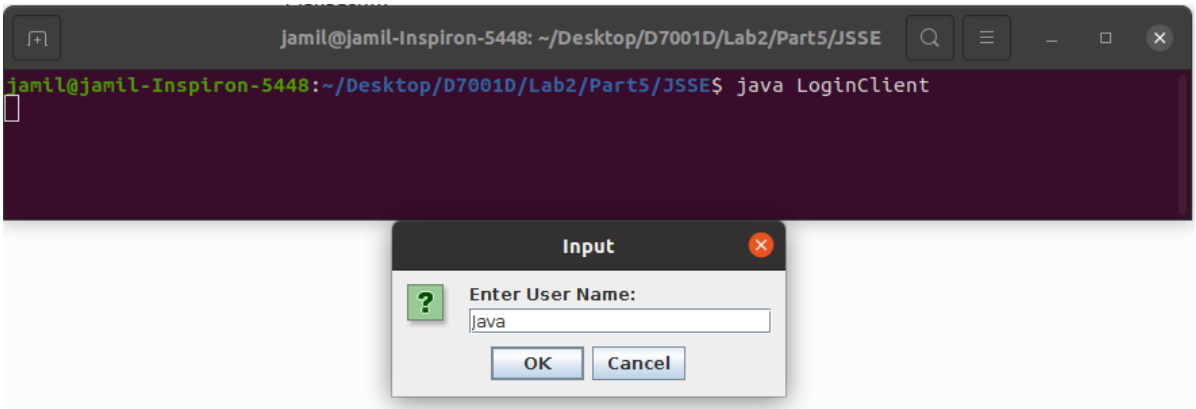
The certificate is added to keystore 'jssecacerts' in the current directory. We have to copy the file from the current directory to the security properties directory, 'java.home \lib \security \', where java.home is the runtime environment directory (the jre directory in the SDK). This will facilitate Java to use 'jssecacerts' to authenticate the servers.

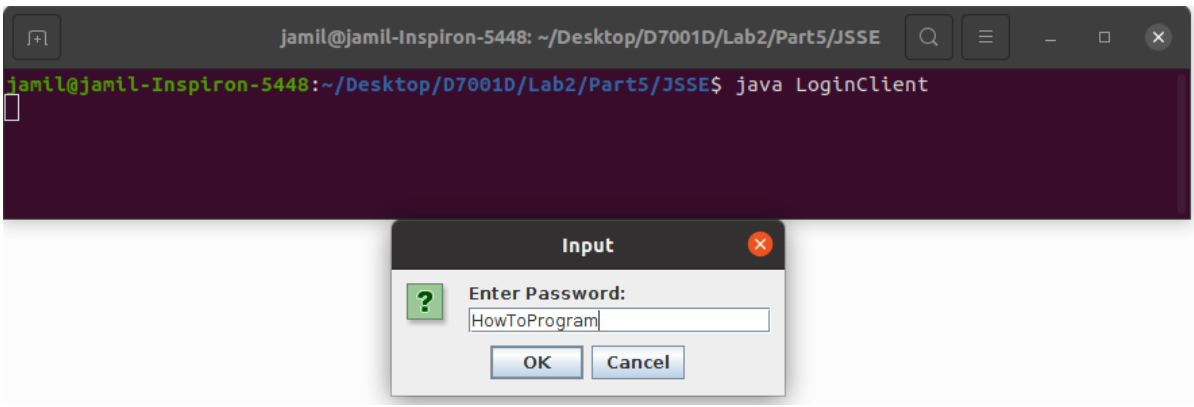
```
jamil@jamil-Inspiron-5448: ~/Desktop/D7001D/Lab2/Part5/JSSE
jamil@jamil-Inspiron-5448:~/Desktop/D7001D/Lab2/Part5/JSSE$ sudo cp jssecacerts /usr/local/java/
jdk1.8.0_301/jre/lib/security/
[sudo] password for jamil:
jamil@jamil-Inspiron-5448:~/Desktop/D7001D/Lab2/Part5/JSSE$
```

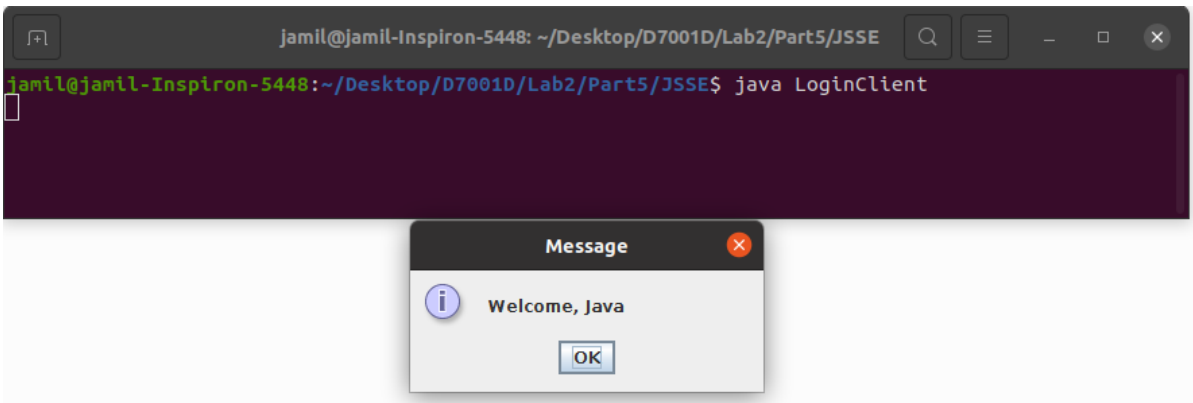
Launching LoginClient.java: Now we can start the client application to the client host from a terminal. Once the client establishes communication with the server, the authentication process begins. The following command is used to start the client application.



After that, the client has to enter the username and password which are sent to the server. If the authentication is successful, the client is logged on.







Bibliography

Deitel, H., Deitel, P., & Santry, S. (2002). *Advanced java 2 platform: How to program*. Prentice Hall. https://books.google.se/books?id=umtwQgAACAAJ

Llewellyn, M. (2006). *Cop 4610l: Java networking part 3*. Retrieved October 7, 2021, from http://www.cs.ucf.edu/courses/cop4610L/fall2005/javanet3.pdf