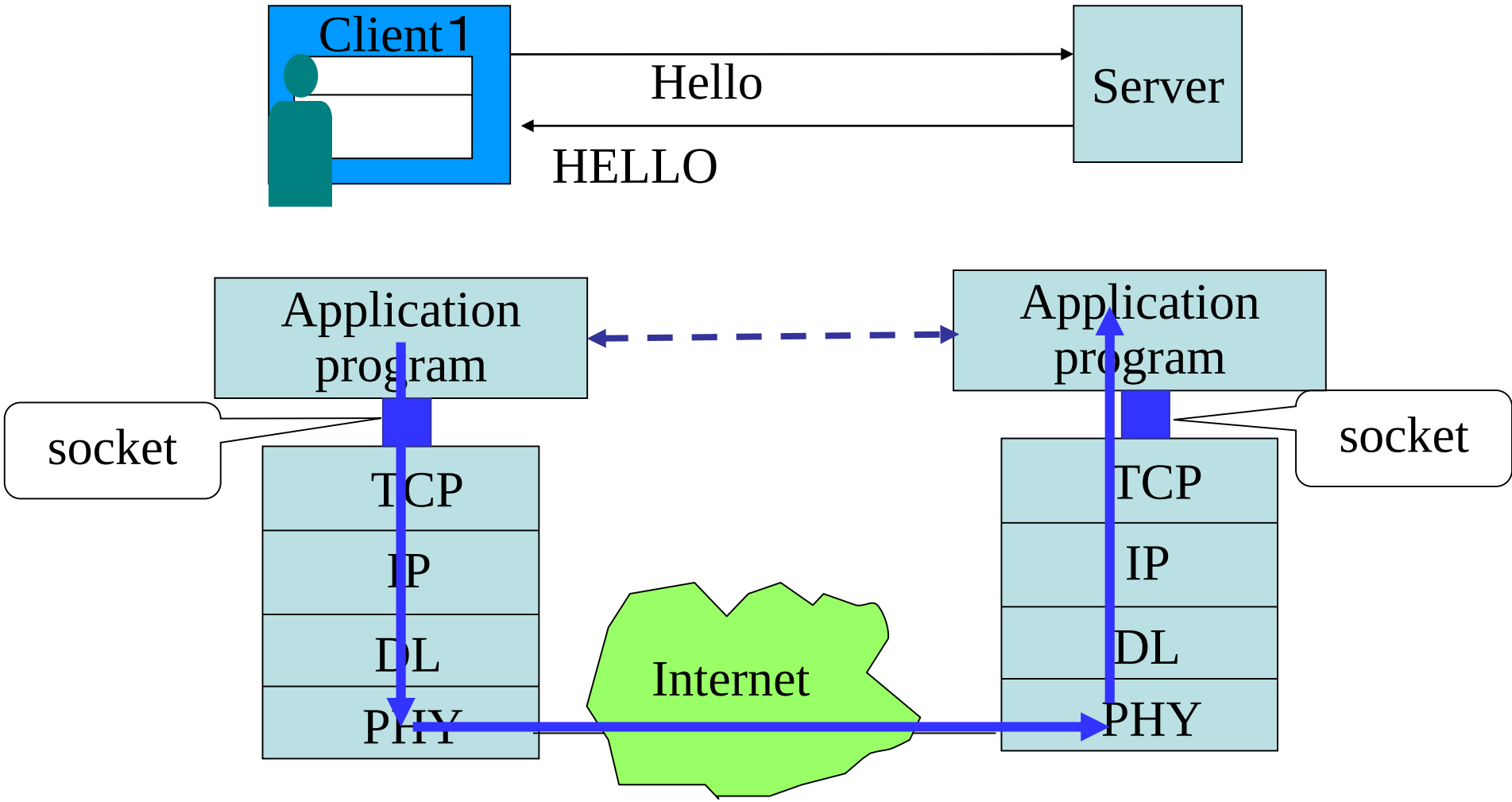
Java Network
(Socket)

Contents

- What is Socket
- Server Sockets and Sockets
- Datagram Sockets and Packets
- MulticastSockets

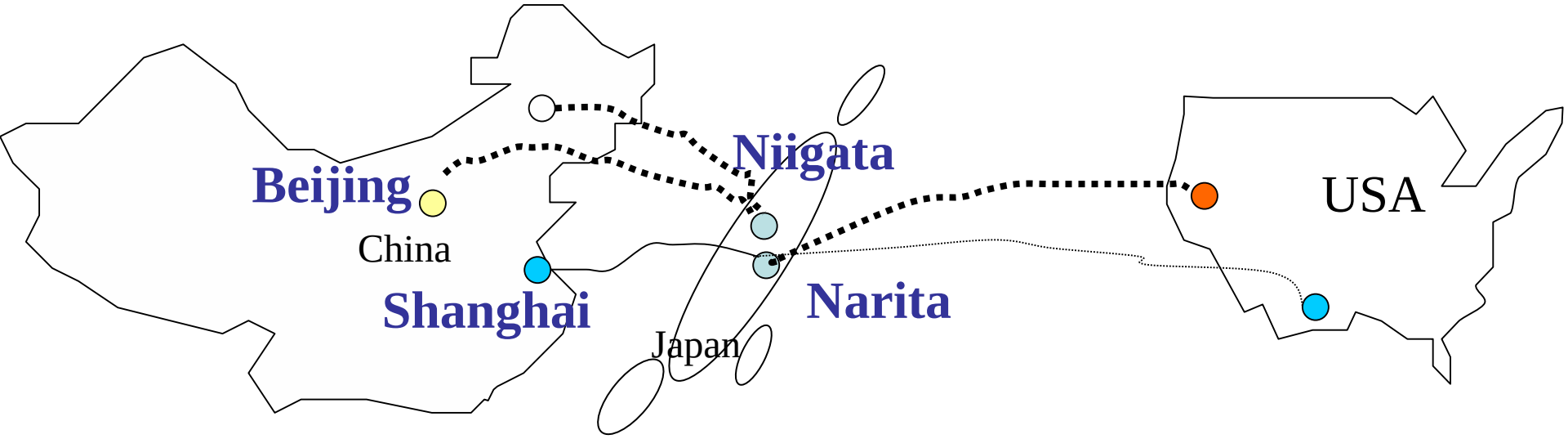
Socket : Interface for Application Layer

Echo Program

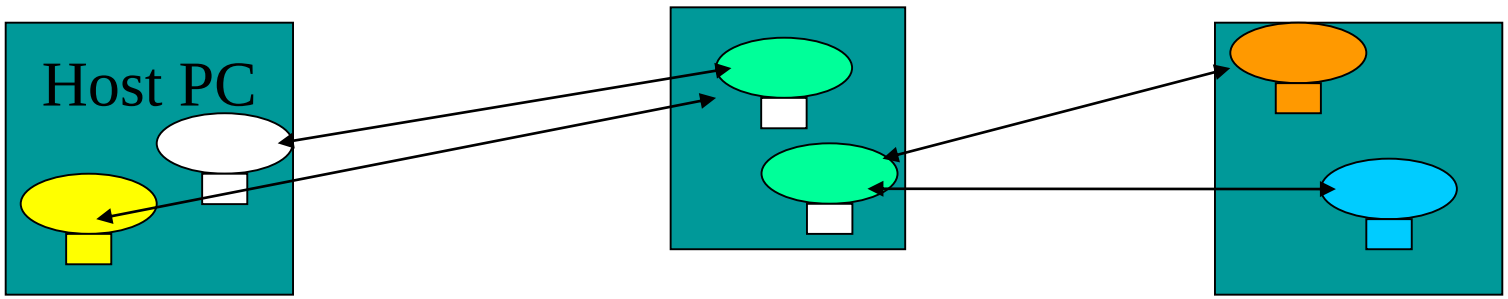


Socket Address：IP and Port

For example: Country and Airport
Air lines：country A airport Q to
country B airport R



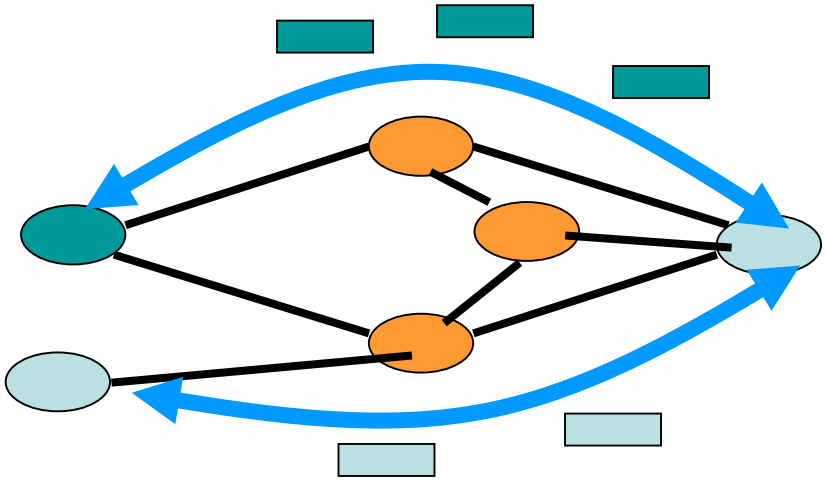
communication : A host Q port to B host R port **1 port : N ports**

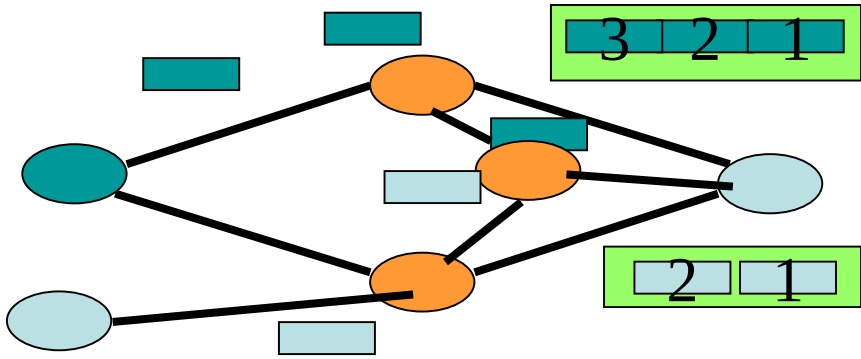


Two types of Data Transportation Services

1. Connection oriented

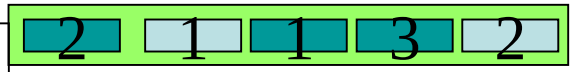
- Transmission Control Protocol (TCP) : To obtain reliable, sequenced data exchange.

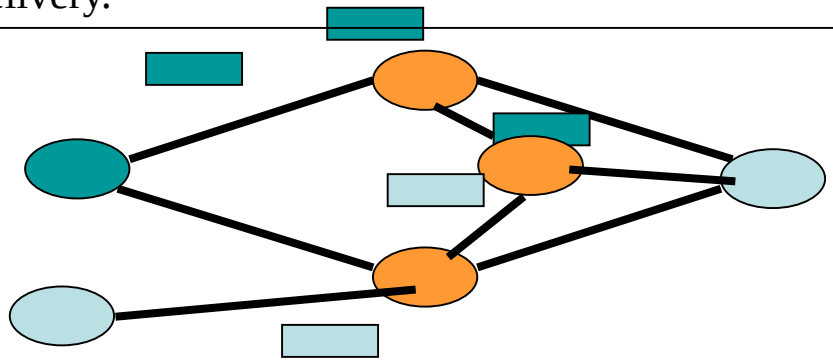


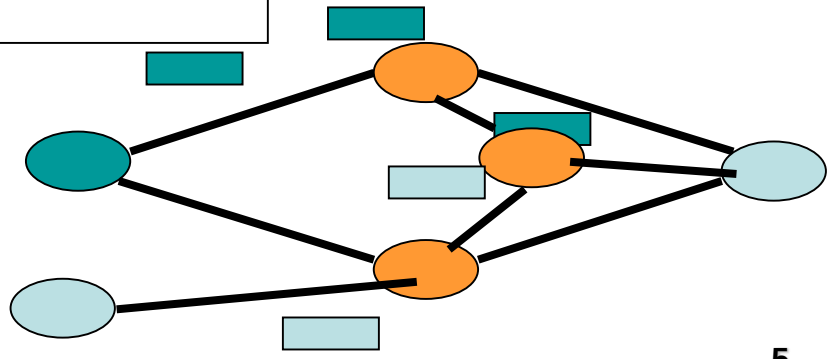


2. Connectionless

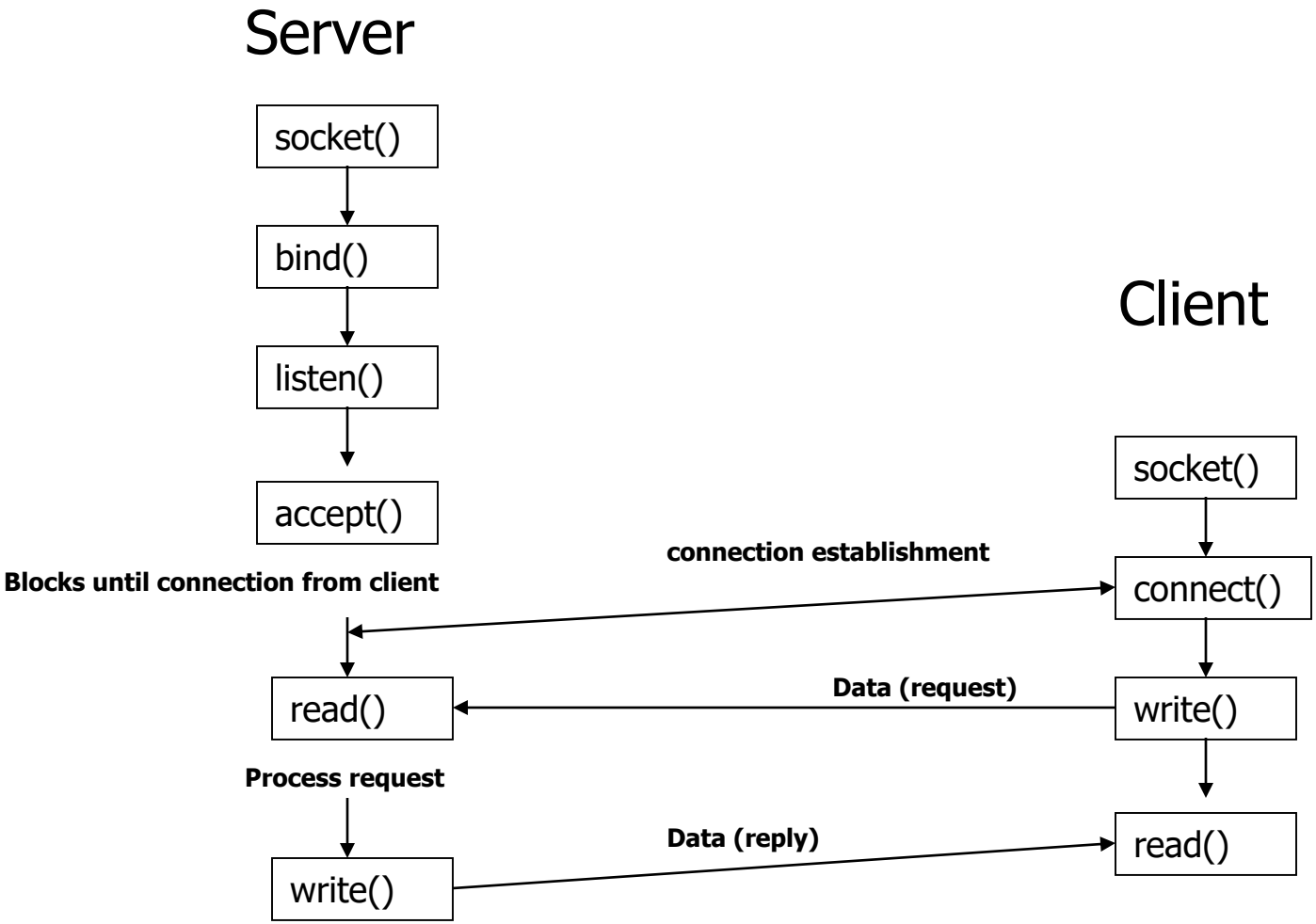
- User Datagram Protocol (UDP) : To obtain a more efficient, best-effort delivery.







Socket Call for Connection-Oriented Protocol



Server Sockets and Sockets

ServerSocket Constructor

This class implements server sockets. A server sock et waits for requests to come in over the network. It performs some operation based on that request, an d then possibly returns a result to the requester.

ServerSocket(int port) throws IOException

- Creates a server socket, bound to the specified port.

```
ServerSocket ss = new ServerSocket(port);
```

accept() Method

Socket accept() throws IOException
- Listens for a connection to be made to this socket and accepts it.

```
Socket s = ss.accept();
```

close() Method

void close() throws IOException
- Closes this socket.

```
s.close();
```

Socket Class

This class implements client sockets (also called j ust "sockets"). A socket is an endpoint for commu nication between two machines.

Socket(String hostName, int port) throws UnknownHostException, IOException
- Creates a stream socket and connects it to the specified port number at the specified IP address.

```
Socket s = new Socket(server, port);
```

getInputStream(), getOutputStream Method

InputStream getInputStream() throws IOException
-Returns an input stream for this socket.
OutputStream getOutputStream() throws IOException
- Returns an output stream for this socket.

```
OutputStream os = s.getOutputStream();
```

close()

void close() throws IOException
- Closes this socket.

http://docs.oracle.com/javase/8/docs/api/java/net/ServerSocket.html

http://docs.oracle.com/javase/8/docs/api/java/net/Socket.html

Example 1: Server Sockets and Sockets

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

class ServerSocketDemo {
  public static void main(String args[]) {
    try {

      // Get Port
      int port = Integer.parseInt(args[0]);
      Random random = new Random();
      //Create Server Socket
      ServerSocket ss = new ServerSocket(port);
      //Create Infinite Loop
      while(true) {
        //Accept Incoming Requests
        Socket s = ss.accept();

        //Write Result to Client
        OutputStream os = s.getOutputStream();
       DataOutputStream dos = new
DataOutputStream(os);
        dos.writeInt(random.nextInt());

        //Close socket
        s.close();
      }
    }
    catch (Exception e) {
      System.out.println("Exception: " + e);    }
  }
}
```

```
class SocketDemo {
  public static void main(String args[]) {
    try {
      //Get Server and Port
      String server = args[0];
      int port = Integer.parseInt(args[1]);
      //Create socket
      Socket s = new Socket(server, port);
      //Read random number from server
      InputStream is = s.getInputStream();
     DataInputStream dis = new
DataInputStream(is);
      int i = dis.readInt();
      //Display Result
      System.out.println(i);
      //Close Socket
      s.close();
    }
    catch (Exception e) {
      System.out.println("Exception: " + e);    }
  }
}
```

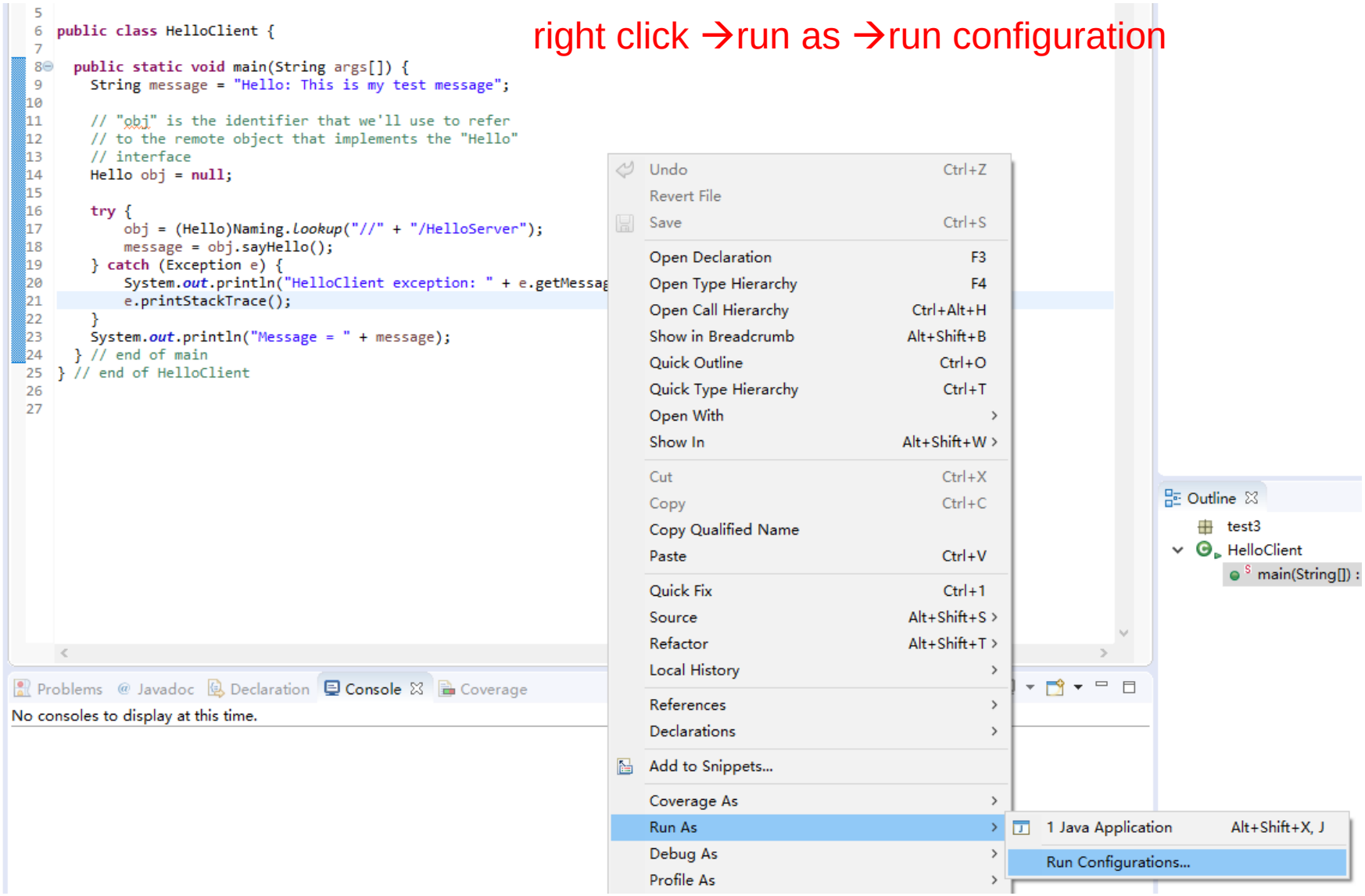
Running :

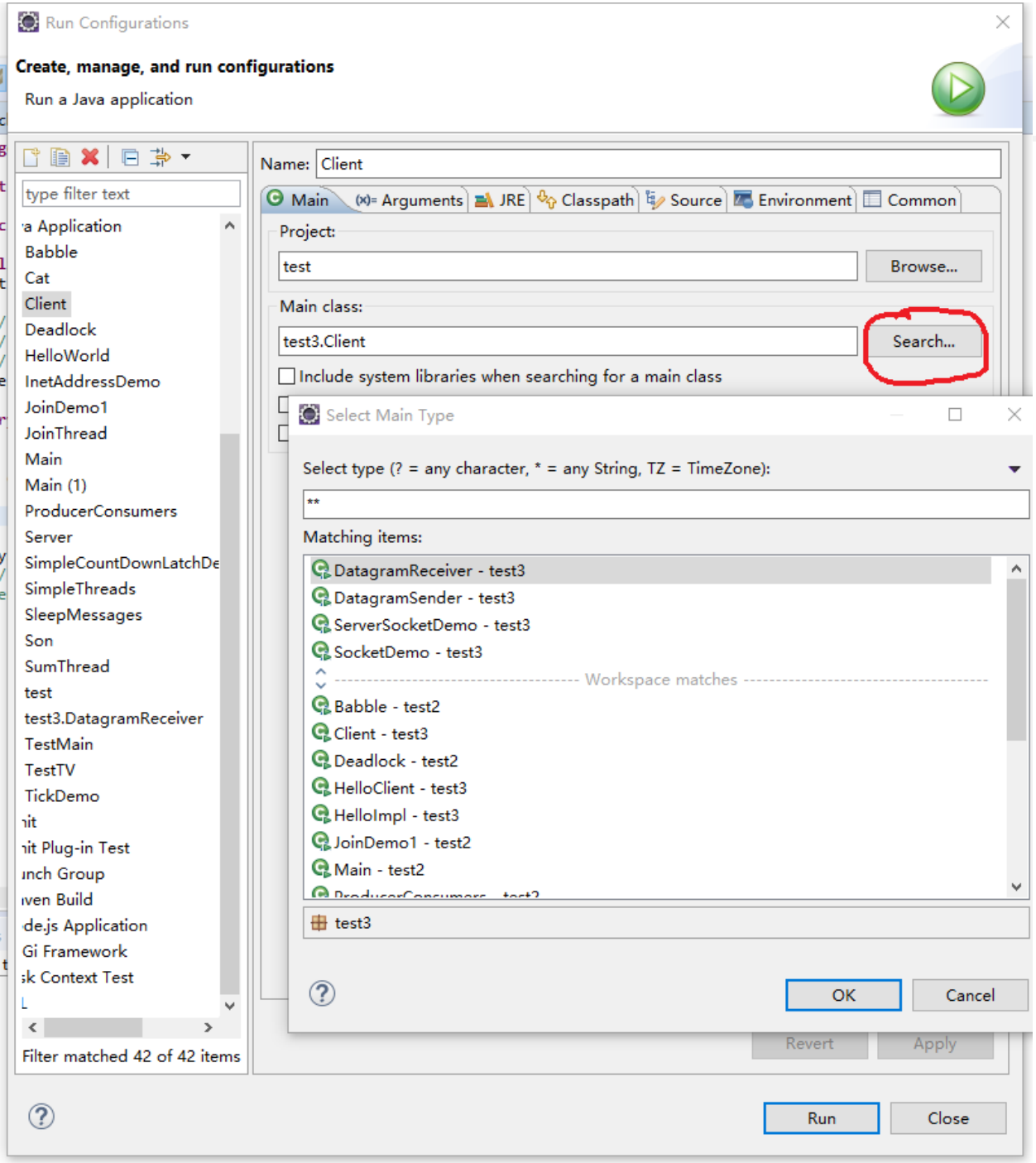
% java ServerSocketDemo 4321

% java SocketDemo 127.0.0.1 4321

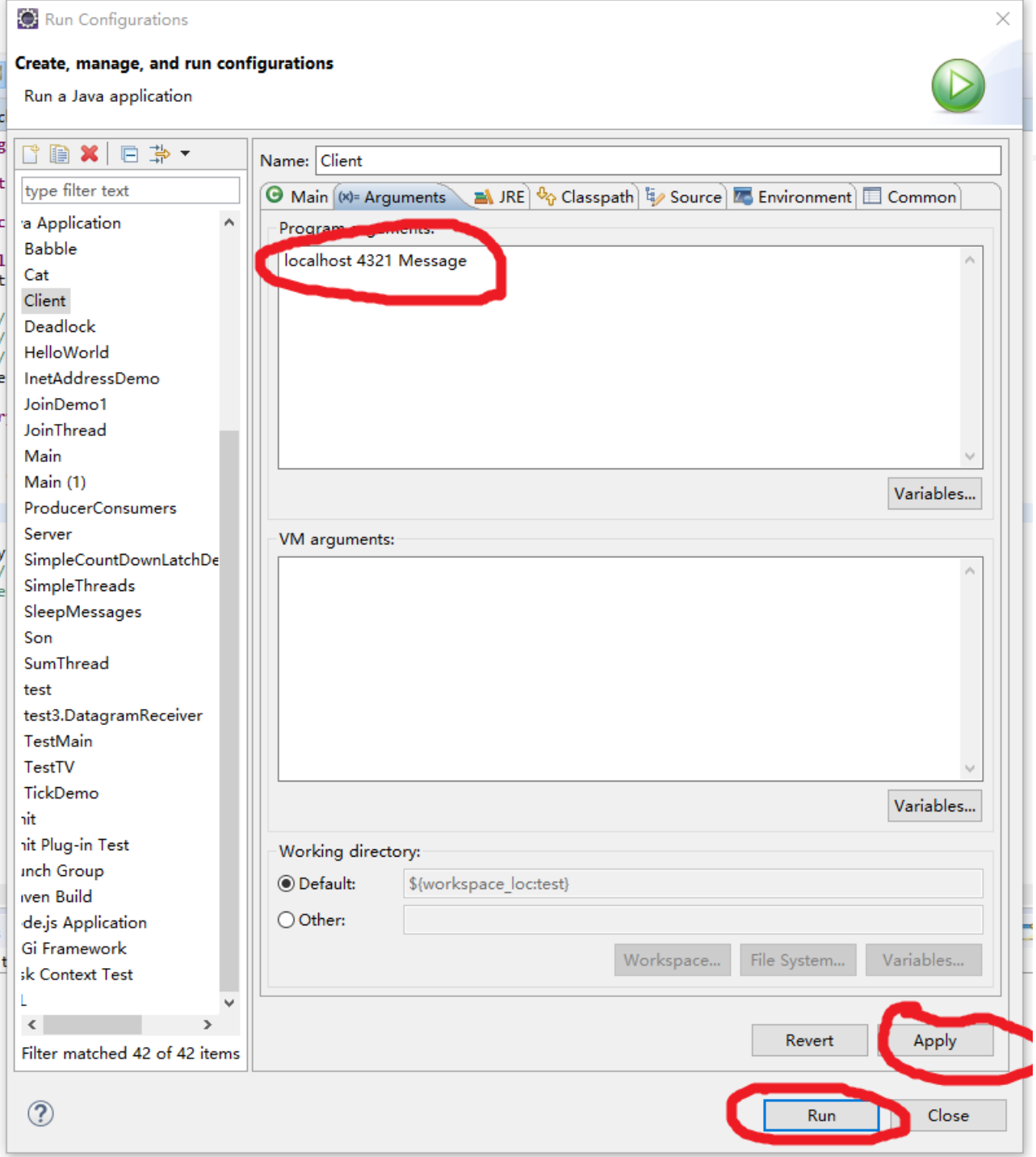
Run Configuration in Eclipse

right click →run as →run configuration





Search the program you want to run



Input parameters (space between parameters) →Apply →run

Switch Application

Example 2: Server and Client with TCP

```java
public class SocketServerExample {
 //static ServerSocket variable
 private static ServerSocket server;
 //socket server port on which it will listen
 private static int port = 9876;
 public static void main(String args[])
         throws IOException, ClassNotFoundException{
  //create the socket server object
  server = new ServerSocket(port);
  //keep listens indefinitely until receives 'exit' call or program terminates
  while(true){
   System.out.println("Waiting for the client request");
   //creating socket and waiting for client connection
   Socket socket = server.accept();
   //read from socket to ObjectInputStream object
   ObjectInputStream ois = new ObjectInputStream(socket.getInputStream());
   //convert ObjectInputStream object to String
   String message = (String) ois.readObject();
   System.out.println("Message Received: " + message);
   //create ObjectOutputStream object
   ObjectOutputStream oos = new ObjectOutputStream(socket.getOutputStream());
   //write object to Socket
   oos.writeObject("Hi Client "+message);
   //close resources
   ois.close();
   oos.close();
   socket.close();
   //terminate the server if client sends exit request
   if(message.equalsIgnoreCase("exit")) break;
  }
  System.out.println("Shutting down Socket server!!");
  //close the ServerSocket object
  server.close();
 }
}
```

```java
public class SocketClientExample {
 public static void main(String[] args)
         throws UnknownHostException,IOException,
         ClassNotFoundException, InterruptedException{
  /*get the localhost IP address, if server
   is running on some other IP, you need to use that*/
  InetAddress host = InetAddress.getLocalHost();
  Socket socket = null;
  ObjectOutputStream oos = null;
  ObjectInputStream ois = null;
  for(int i=0; i<5;i++){
  //establish socket connection to server
  socket = new Socket(host.getHostName(), 9876);
  //write to socket using ObjectOutputStream
  oos = new ObjectOutputStream(socket.getOutputStream());
  System.out.println("Sending request to Socket Server");
  if(i==4)oos.writeObject("exit");
  else oos.writeObject(""+i);
  //read the server response message
  ois = new ObjectInputStream(socket.getInputStream());
  String message = (String) ois.readObject();
  System.out.println("Message: " + message);
  //close resources
  ois.close();
  oos.close();
  Thread.sleep(100);
  }
 }
}
```

Example 3: Client and Server Application

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

public class Server
{
  public ServerSocket svrSocket = null;
  public Socket socket = null;
  public InputStream inputStream = null;
  public OutputStream outputStream = null;
  public DataInputStream dataStream = null;
  public PrintStream printStream = null;
  public DataOutputStream dataoutputStream = null;
  public String message;
  public BufferedReader charStream = new
BufferedReader(new InputStreamReader(System.in));

  public Server() {
    try {
      svrSocket = new ServerSocket(1056);
      System.out.println("\nInitializint Port...");
      System.out.println("\nListen...");
      socket = svrSocket.accept();
      System.out.println("\nConnect to Client!\n");
      inputStream = socket.getInputStream();
      dataStream = new DataInputStream(inputStream);
      outputStream = socket.getOutputStream();
      dataoutputStream = new
DataOutputStream(outputStream);

      message = dataStream.readUTF();
      System.out.println(message + "\n");
    }  catch( UnknownHostException e) {
       System.out.println("Error : Cannot find server." + e);
    }
    catch( IOException e ) {
      System.out.println("Error : I/O Error." + e);
    }
  }
```

```
public void readSocket(){
    try {
      message = dataStream.readUTF();
      System.out.println(message + "\n");
      if(message.equals("Exit")){
        System.exit(0);
                                                  }
    }
    catch( UnknownHostException e) {
      System.out.println("Error : Cannot find server." + e);
    }
    catch( IOException e ) {
      System.out.println("Error : I/O Error." + e);
    }
  }

  public void writeSocket(){
    try {
      String initmsg_r = new String("Enter your message: ");
      dataoutputStream.writeUTF(initmsg_r);
      System.out.print("Enter please for ready... ");
      message = charStream.readLine();
      if  (! Message.equals("Exit")) return;
      else {dataoutputStream.writeUTF("Exit");
              System.exit(0); }
    }
    catch( UnknownHostException e) {
      System.out.println("Error : Cannot find server." + e);
    }
    catch( IOException e ) {
      System.out.println("Error : I/O Error." + e);
    }
  }
```

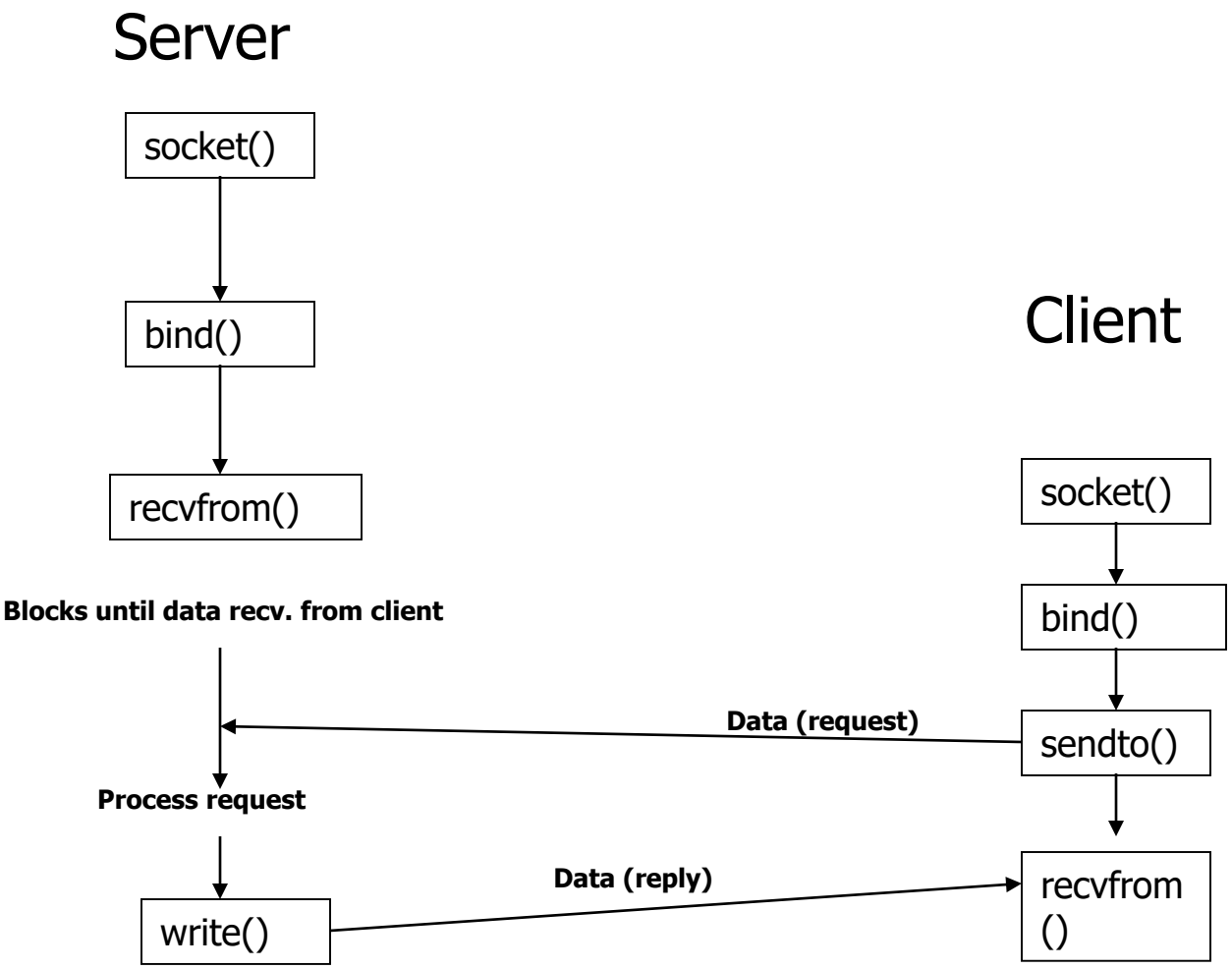
Example 3: Client and Server Application

```
  public static void main(String args[]) {
    Server svr = new Server();
    for(;;){
      svr.writeSocket();
      svr.readSocket();
    }
  }
}
// End of Server
```

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

public class Client {

  public static void main(String args[]) {
  // Initialize the stream
  OutputStream outputStream = null;
  DataOutputStream dataoutputStream = null;
  InputStream inputStream = null;
  DataInputStream dataStream = null;
  BufferedReader charStream = null;

  // Initialize Socket
  Socket socket = null;
  String message;

  try {
      charStream = new BufferedReader(new
InputStreamReader(System.in));
 message = new String("Hi! I am a client");
      socket = new Socket("127.0.0.1", 1056);
```

```
dataStream = new DataInputStream(inputStream);
      outputStream = socket.getOutputStream();
      dataoutputStream = new
DataOutputStream(outputStream);
      dataoutputStream.writeUTF(message);
   } catch(UnknownHostException e) {
       System.out.println("Error : Cannot find server." + e);
     }
     catch(IOException e) {
       System.out.println("Error : I/O Error." + e);
     }

 while(true) {
   try {
      inputStream = socket.getInputStream();
      dataStream = new DataInputStream(inputStream);
      message = dataStream.readUTF();
      System.out.print(message);
      if(message.equals("Exit")){ System.exit(0); }
        message = charStream.readLine();
        dataoutputStream.writeUTF(message);
    } catch(UnknownHostException e) {
        System.out.println("Error : Cannot find server." + e);
      }
      catch(IOException e) {
        System.out.println("Error : I/O Error." + e);
      }
  } // end of while
 } // end of main method
} // end of Client Constructor
```

Socket Call for Connectionless Protocol



Datagram Sockets and Packets

◆ **UDP does not guarantee reliable, sequenced data exchange, and therefore requires much less overhead**.

◆ DatagramSocket() Method

DatagramSocket() throws SocketException
DatagramSocket(int port) throws SocketException

```
DatagramSocket ds = new DatagramSocket(port);
```

◆ DatagramPacket Constructor

DatagramPacket(byte buffer[], int size)

DatagramPacket(byte buffer[], int size, InetAddress ia, int port)

```
DatagramPacket dp = new DatagramPacket(buffer, buffer.length);
DatagramPacket dp = new DatagramPacket(buffer, buffer.length, ia, port);
```

◆ receive() Method

void receive(DatagramPacket dp) throws IOException

```
ds.receive(dp);
```

◆send() Method

void send(DatagramPacket dp) throws IOException

```
ds.send(dp);
```

◆ close() Method

void close()

http://docs.oracle.com/javase/8/docs/api/java/net/DatagramPacket.html

Datagram Sockets and Packets

```
class DatagramReceiver {
  private final static int BUFSIZE = 20;
  public static void main(String args[]) {
    try {
      //Obtain port
      int port = Integer.parseInt(args[0]);

      //Create a DatagramSocket object for the port
      DatagramSocket ds = new DatagramSocket(port);

      //Create a buffer to hold incoming data
      byte buffer[] = new byte[BUFSIZE];

      //Create infinite loop
      while(true) {
        //Create a datagram packet
        DatagramPacket dp =
          new DatagramPacket(buffer, buffer.length);

        //Receive data
        ds.receive(dp);

        //Get data from the datagram packet
        String str = new String(dp.getData());

        // Display the data
        System.out.println(str);
      }
    }
    catch (Exception e) {
      e.printStackTrace();
    }
  }
}
```

```
class DatagramSender {
  public static void main(String args[]) {
    try  {
      // Create destination Internet address
      InetAddress ia =
        InetAddress.getByName(args[0]);
      // Obtain destination port
      int port = Integer.parseInt(args[1]);

      // Create a datagram socket
      DatagramSocket ds = new DatagramSocket();

      //Create a datagram packet
      byte buffer[] = args[2].getBytes();
      DatagramPacket dp =
        new DatagramPacket(buffer, buffer.length,
          ia, port);
      // Send the datagram packet
      ds.send(dp);
    }
    catch (Exception e) {
      e.printStackTrace();
    }
  }
}
```

Running :

% java DatagramReceiver 4321

% java DatagramSender localhost 4321 Message

Example : Quote Client and Server

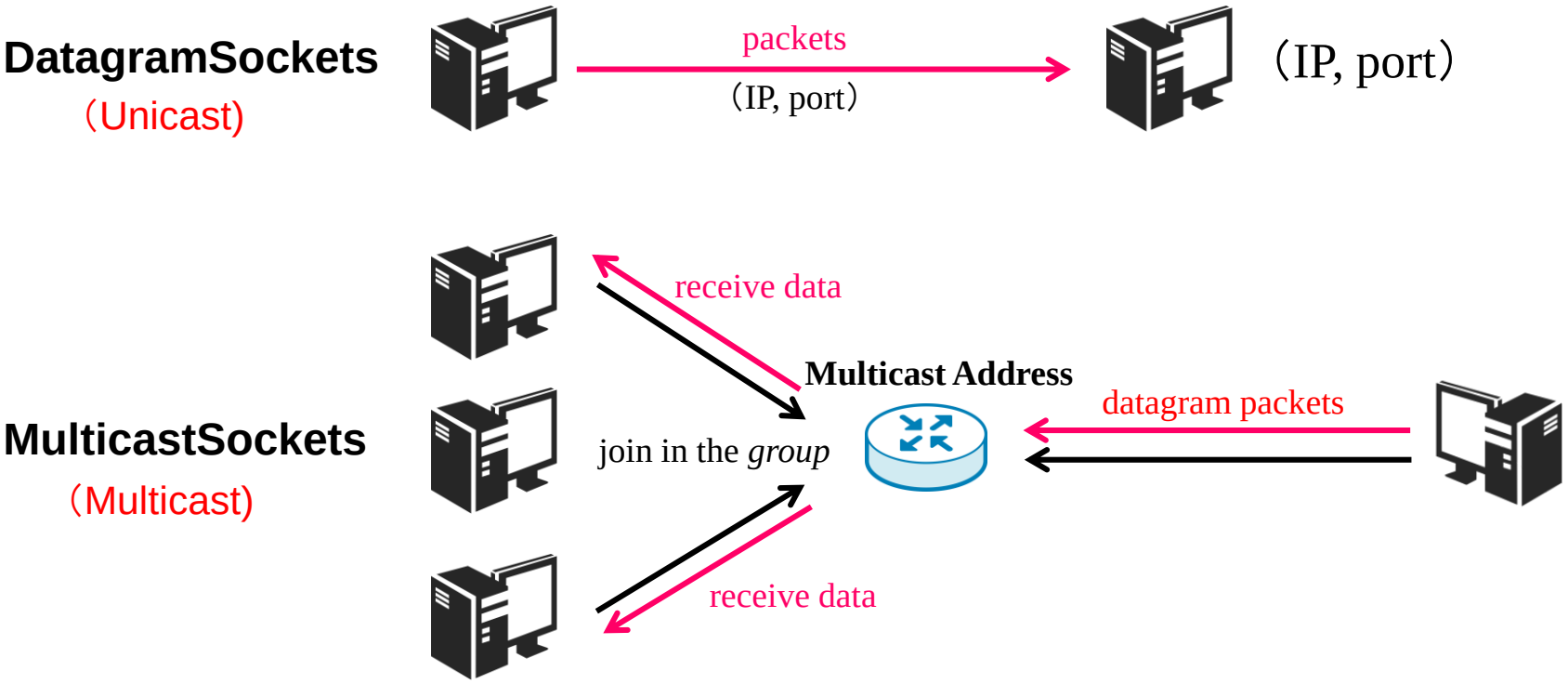
```
public class QuoteServerThread extends Thread {
 protected DatagramSocket socket = null;
 protected BufferedReader in = null;
 protected boolean moreQuotes = true;

 public QuoteServerThread() throws IOException {
  this("QuoteServerThread");
 }

 public QuoteServerThread(String name) throws IOException {
  super(name);
  socket = new DatagramSocket(4445);

  try {
   in = new BufferedReader(new FileReader("one-liners.txt"));
  } catch (FileNotFoundException e) {
   System.err.println("Could not open file. Serving time instead.");
  }
 }
public void run() {
  while (moreQuotes) {
   try {
    byte[] buf = new byte[256];
    // receive request
    DatagramPacket packet = new DatagramPacket(buf, buf.length);
    socket.receive(packet);
    // figure out response
    String dString = null;
    if (in == null)
     dString = new Date().toString();
    else
     dString = getNextQuote();

    buf = dString.getBytes();
    // send the response to the client at "address" and "port"
    buf = dString.getBytes();
    // send the response to the client at "address" and "port"
    InetAddress address = packet.getAddress();
    int port = packet.getPort();
    packet = new DatagramPacket(buf, buf.length, address, port);
    socket.send(packet);
   } catch (IOException e) {
    e.printStackTr ace();
    moreQuotes = false;
   }
  }
  socket.close();
 }

    protected String getNextQuote() {
        String returnValue = null;
        try {
            if ((returnValue = in.readLine()) == null) {
                in.close();
                moreQuotes = false;
                returnValue = "No more quotes. Goodbye.";
            }
        } catch (IOException e) {
            returnValue = "IOException occurred in server.";
        }
        return returnValue;
    }

    public static void main(String[] args) throws IOException {
        new QuoteServerThread().start();
    }
}
```

Example : Quote Client and Server

```
public class QuoteClient {
  public static void main(String[] args) throws IOException {
    if (args.length != 1) {
      System.out.println("Usage: java QuoteClient <hostname>");
      return;
    }
    // get a datagram socket
    DatagramSocket socket = new DatagramSocket();
    // send request
    byte[] buf = new byte[256];
    InetAddress address = InetAddress.getByName(args[0]);
    DatagramPacket packet = new DatagramPacket(buf, buf.length, address, 4445);
    socket.send(packet);
    // get response
    packet = new DatagramPacket(buf, buf.length);
    socket.receive(packet);
    // display response
    String received = new String(packet.getData(), 0, packet.getLength());
    System.out.println("Quote of the Moment: " + received);
    socket.close();
  }
}
```

Multicast

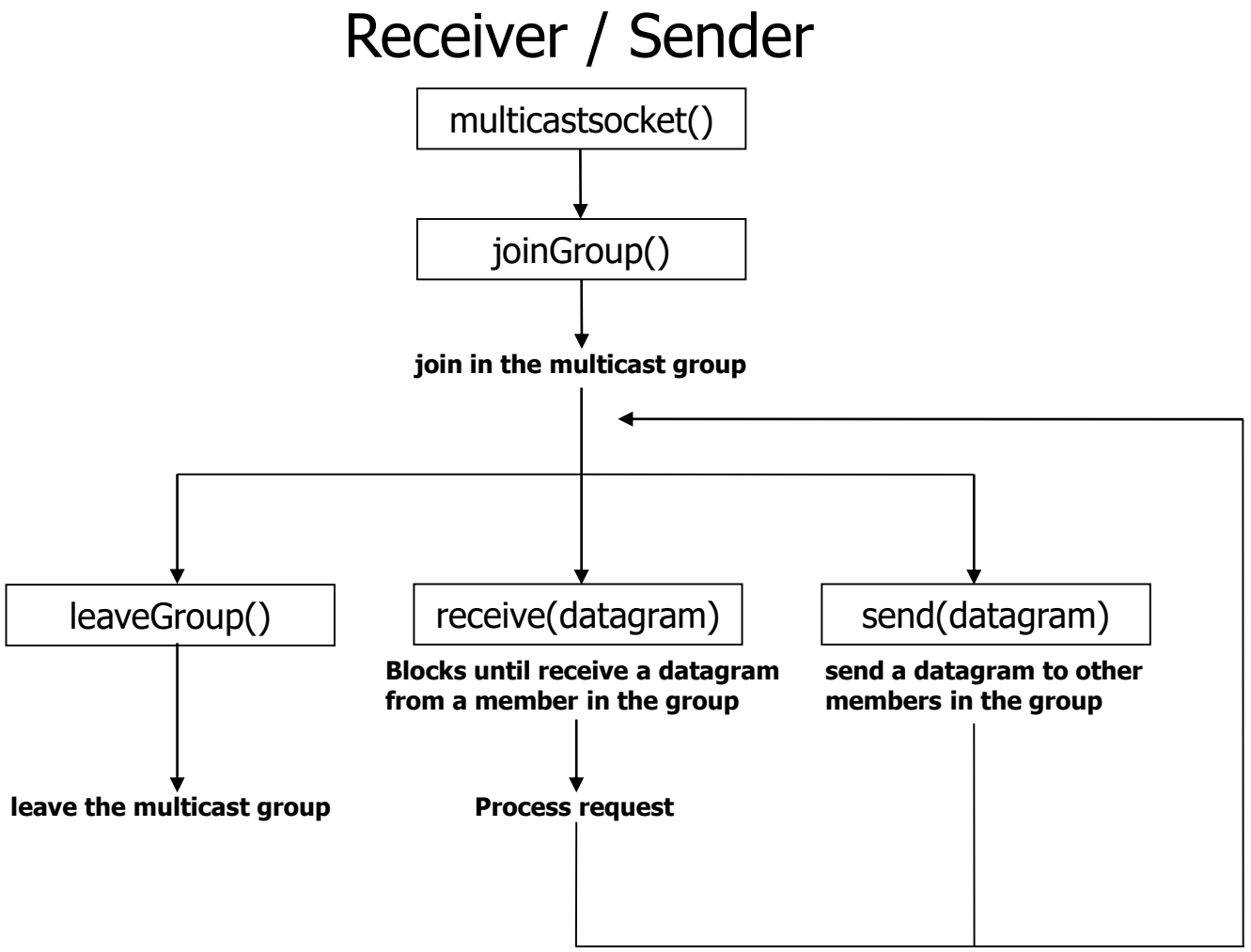
◆ **MulticastSockets is another socket based on Connectionless Protocol, representing multicast protocol. Comparing with DatagramSockets, it can send packets to a *group* of users that join in the *multicast group* .**



https://www.sciencedirect.com/topics/computer-science/multicast-group

Socket Call for Multicast Protocol

◆ **Everyone can either receive the datagram packets from a member of group, or send datagram packets to other members of group.**



Multicast Sockets and InetAddress

A multicast group is specified by a class D IP address and by a standard UDP port number. Class D IP addresses are in the range 224.0.0.0 to 239.255.255.255, inclusive. The address 224.0.0.0 is reserved and should not be used.

MulticastSocket() Constructor

MulticastSocket() throws SocketException
MulticastSocket(int port) throws IOException
MulticastSocket(SocketAddress bindaddr) throws IOException

```
MulticastSocket ms = new MulticastSocket(port);
```

InetAddress::getByName() Method

static InetAddress getByName(String host) throws UnknownHostException

```
InetAddress ia=InetAddress.getByName(host);
```

joinGroup() method

void joinGroup(InetAddress mcastaddr)
void joinGroup(SocketAddress mcastaddr, NetworkInterface netIf)

```
ms.joinGroup(ia);
```

send() Method

void send(DatagramPacket dp) throws IOException

```
ms.send(dp);
```

receive() Method

void receive(DatagramPacket dp) throws IOException

```
ms.receive(dp);
```

leaveGroup() method

void leaveGroup(InetAddress mcastaddr)
void leaveGroup(SocketAddress mcastaddr, NetworkInterface netIf)

```
ms.leaveGroup(ia);
```

http://docs.oracle.com/javase/8/docs/api/java/net/MulticastPacket.html

Multicast Sockets and InetAddress

```java
package multicast;

import java.net.DatagramPacket;
import java.net.InetAddress;
import java.net.MulticastSocket;

public class MulticastListener {
    private int port;
    private String host;

    public MulticastListener(String host, int port) {
        this.host = host;
        this.port = port;
    }

    public void listen() {
        byte[] data = new byte[256];
        try {
            InetAddress ip = InetAddress.getByName(this.host);
            MulticastSocket ms = new MulticastSocket(this.port);
            ms.joinGroup(ip);
            DatagramPacket packet = new DatagramPacket(data, data.length);
            // receive()是阻塞方法，会等待客户端发送过来的信息
            ms.receive(packet);
            String message = new String(packet.getData(), 0, packet.getLength());
            System.out.println(message);
            ms.close();
        } catch (Exception e) {
            e.printStackTrace();
        }
    }

    public static void main(String[] args) {
        int port = 1234;
        String host = "230.0.0.0";
        MulticastListener ml = new MulticastListener(host, port);
        while(true)
          ml.listen();
    }
}
```

```java
package multicast;

import java.net.DatagramPacket;

public class MulticastSender {
    private int port;
    private String host;
    private String data;

    public MulticastSender(String data, String host, int port) {
        this.data = data;
        this.host = host;
        this.port = port;
    }

    public void send() {
        try {
            InetAddress ip = InetAddress.getByName(this.host);
            DatagramPacket packet = new DatagramPacket(this.data.getBytes(),
                    this.data.length(), ip, this.port);
            MulticastSocket ms = new MulticastSocket();
            ms.joinGroup(ip);
            ms.send(packet);
            ms.close();
        } catch (Exception e) {
            e.printStackTrace();
        }
    }

    public static void main(String[] args) {
        int port = 1234;
        String host = "230.0.0.0";
        String data = "hello world.";
        MulticastSender ms = new MulticastSender(data, host, port);
        while(true) {
            ms.send();
            System.out.println(data);
            try {
                Thread.sleep(4000);
            } catch (InterruptedException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            }
        }
    }
}
```

Multicast Sockets and InetAddress

```
public class MulticastThread extends Thread {
    private String groupIP;
    private int port;
    private int id;

    public MulticastThread(int id){
        this.groupIP = " 230.0.0.0 ";
        this.port = 4321;
        this.id = id;
    }

    public void run() {
        try {
            // create InetAddress
            InetAddress group =
                    InetAddress.getByName(this.groupIP);
            // create MulticastSocket
            MulticastSocket ms = new MulticastSocket(port);
            ms.joinGroup(group);
            // the package it send will loop back to itself
            ms.setLoopbackMode(false);
            // wait for other members
            Thread.sleep(3000);

            // send a package to other members
            String message = "Hello, I am User " +
                        String.valueOf(this.id) + ".";
            byte[] buffer = message.getBytes();
            DatagramPacket dp = new DatagramPacket(buffer,
                        buffer.length,group,port);
            ms.send(dp);

            // receive packages from other members
            buffer = new byte[8192];
            dp = new DatagramPacket(buffer, buffer.length);
            ms.receive(dp);
            String s = new String(dp.getData(),0,dp.getLength());
            System.out.println("User " +
                    String.valueOf(this.id) + " receive :" + s);

            buffer = new byte[8192];
            dp = new DatagramPacket(buffer, buffer.length);
            ms.receive(dp);
            s = new String(dp.getData(),0,dp.getLength());
            System.out.println("User " +
                    String.valueOf(this.id) + " receive :" + s);

            buffer = new byte[8192];
            dp = new DatagramPacket(buffer, buffer.length);
            ms.receive(dp);
            s = new String(dp.getData(),0,dp.getLength());
            System.out.println("User " +
                    String.valueOf(this.id) + " receive :" + s);

            // leave group and close the socket
            ms.leaveGroup(group);
            ms.close();
        }
        catch (Exception e) {
            e.printStackTrace();
        }
    }
}
```

Multicast Sockets and InetAddress

◆ **Every member of the multicast group will receive their own datagram packages and other members' datagram packages.**

```
public class MulticastMain {
    public static void main(String[] args){
        MulticastThread t1 = new MulticastThread(1);
        MulticastThread t2 = new MulticastThread(2);
        MulticastThread t3 = new MulticastThread(3);

        t1.start();
        t2.start();
        t3.start();
    }
}
```

MulticastMain.java

```
User 1 receive :Hello, I am User 2.
User 3 receive :Hello, I am User 2.
User 2 receive :Hello, I am User 2.
User 3 receive :Hello, I am User 3.
User 1 receive :Hello, I am User 3.
User 2 receive :Hello, I am User 3.
User 3 receive :Hello, I am User 1.
User 1 receive :Hello, I am User 1.
User 2 receive :Hello, I am User 1.

Process finished with exit code 0
```

Result

Exercise : Echo Program

Echo program using socket:

1) client reads line from standard input (**`inFromUser`** stream) , and sends to server via socket (**`outToServer`** stream)
2) server reads line from socket
3) server converts line to uppercase, sends back to client
4) client readsfrom socket (**`inFromServer`** stream) , and show the modified line through (**outToUser** stream)