Object Oriented Programming with Java

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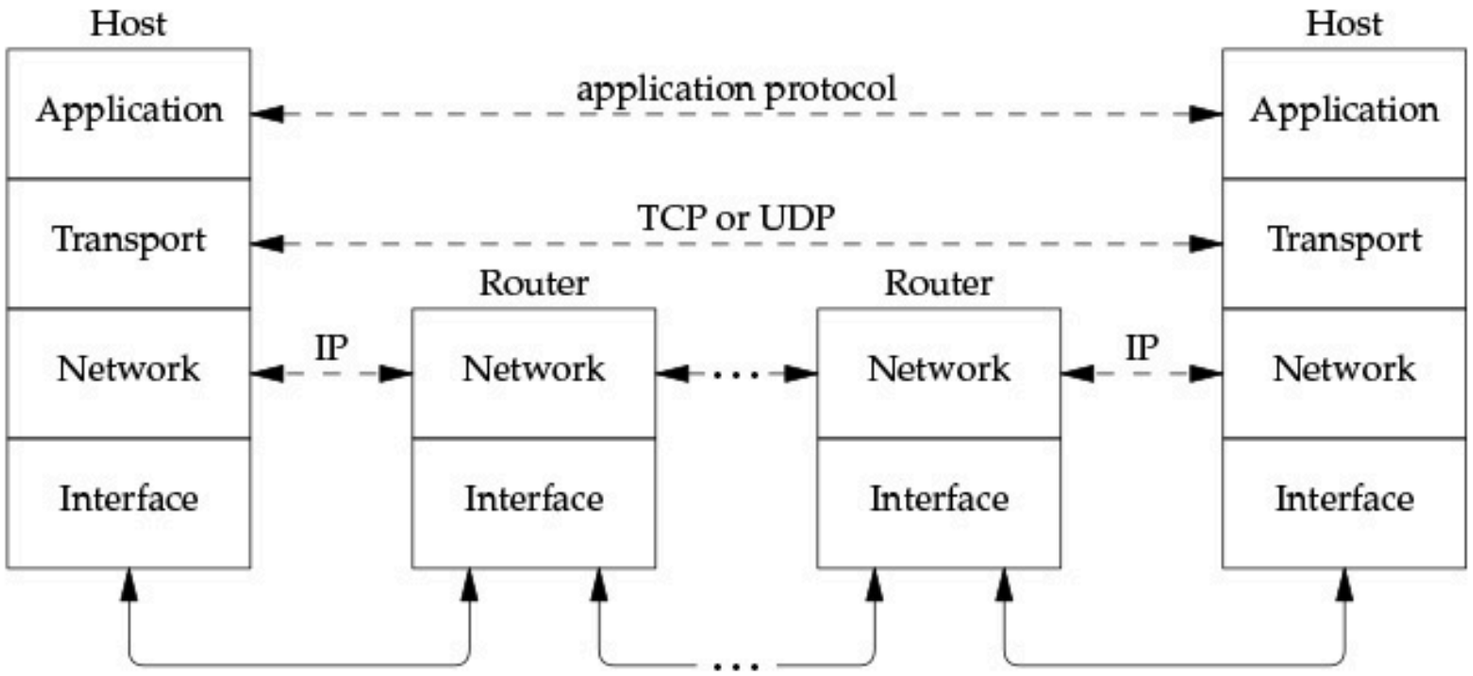
Networking

1. Networking Basics
2. HTTP and URL
3. Socket Programming
4. Datagram Programming

Networking Basics

- Computers running on the Internet communicate to each other using either the Transmission Control Protocol (TCP) or the User Datagram Protocol (UDP).

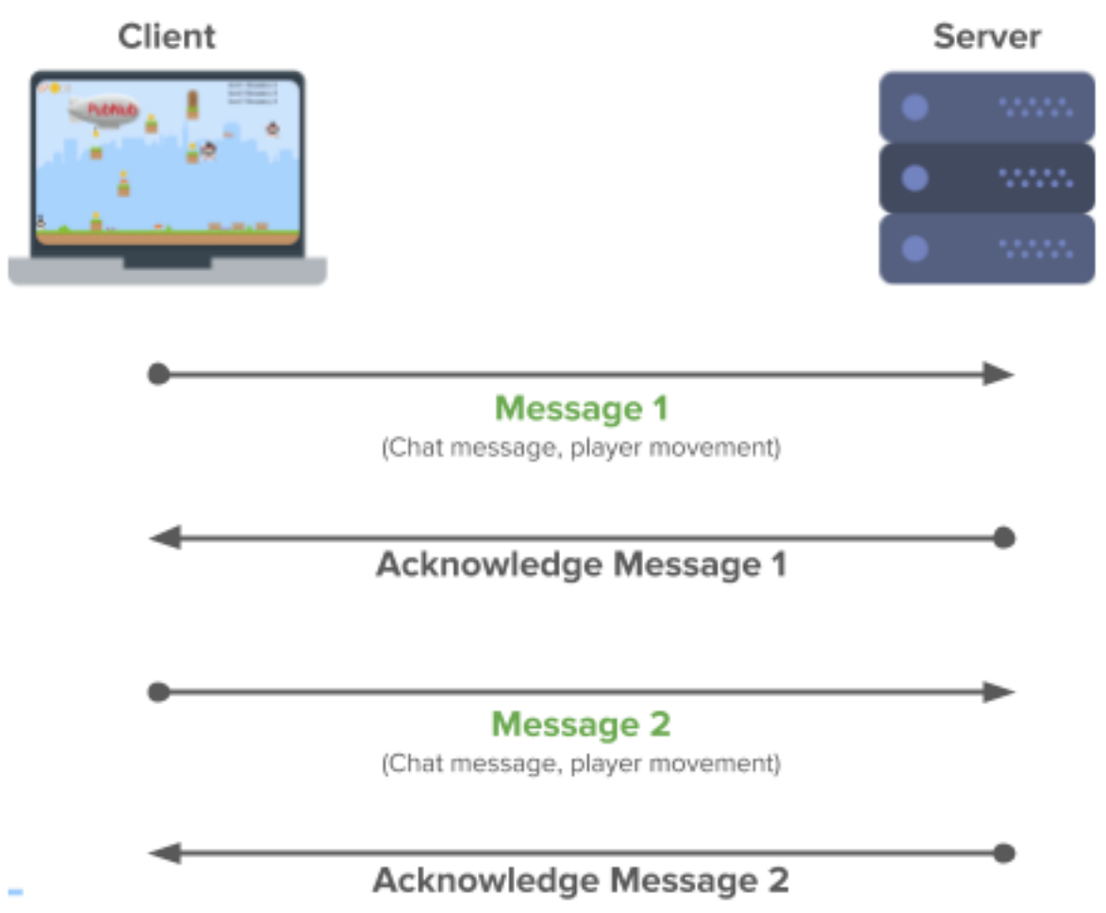


- When you write Java programs that communicate over the network, you are programming at the application layer.

- You need to decide which Transport Protocol your programs should use.

Transmission Control Protocol (TCP)

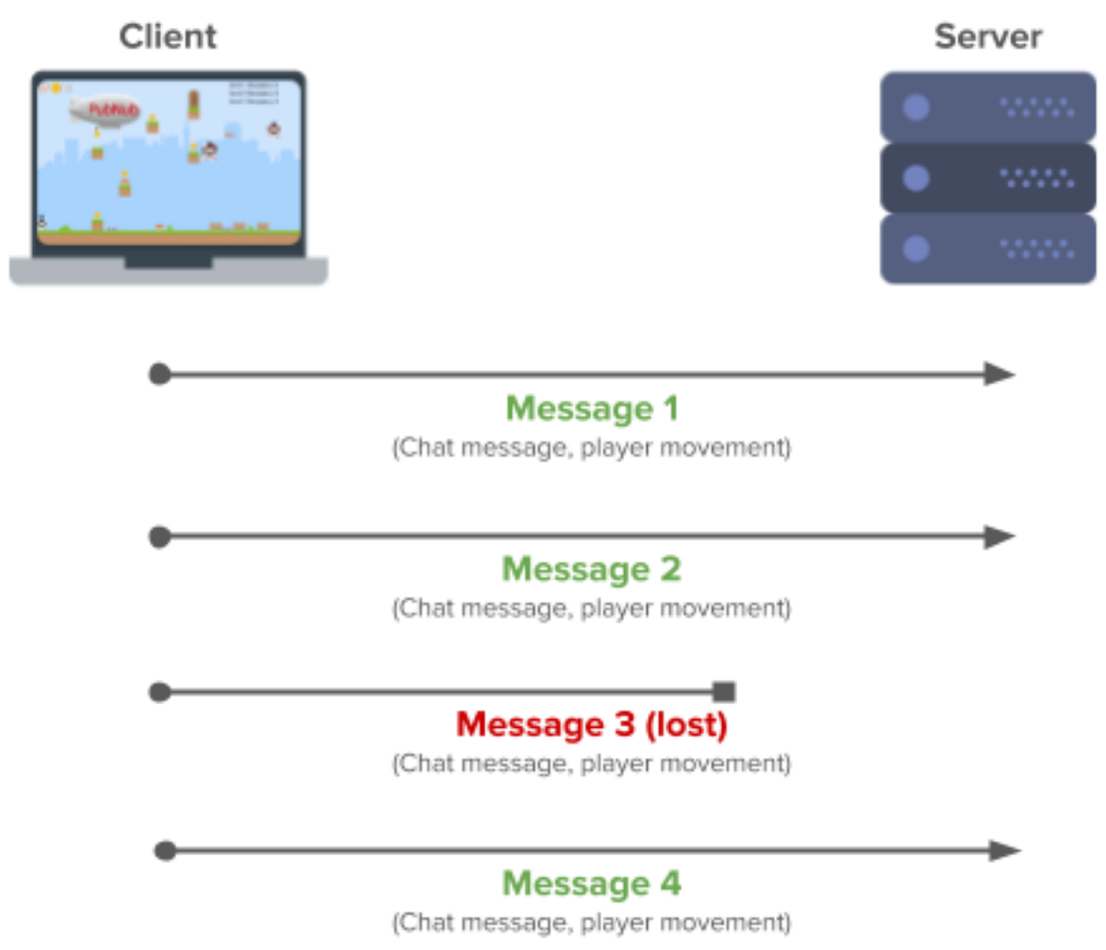
- TCP (Transmission Control Protocol) is a connection-based protocol that provides a reliable flow of data between two computers.
- TCP is typically used over the Internet Protocol, which is referred to as TCP/IP.



User Datagram Protocol (UDP)

- UDP (User Datagram Protocol) is a protocol that sends independent packets of data, called datagrams, from one computer to another with no guarantees about arrival.

- UDP is not connection -based like TCP.



Port

- In computer networking, a **port** is a communication endpoint.

- Ports are identified for each protocol and address combination by 16-bit unsigned numbers, commonly known as the **port number,** ranging from **0 to 65535.**

- A port number is always associated with an IP address of a host and the protocol type of the communication.

IP address

- An Internet Protocol address (IP address) is a numerical label assigned to each device connected to a computer network that uses the Internet Protocol for communication.

- Internet Protocol version 4 (IPv4) defines an IP address as a **32-bit number**.

- IP addresses are written and displayed in human-readable notations, such as 192.168.0.1

Domain Name and DNS

- A domain name is an identification string that defines a realm of administrative autonomy, authority or control within the Internet.

- Domain names are formed by the rules and procedures of the Domain Name System (DNS).

```
www.baidu.com -> 182.61.200.7
```

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URL

- A Uniform Resource Locator (URL), colloquially termed a web address, is a reference to a web resource that specifies its location on a computer network and a mechanism for retrieving it.

- A typical URL could have the form:

http://www.example.com/index.html
Or
http://www.example.com/xxx.jpeg

Accessing resource over network

1. Use URL to indicate the resource
2. Establish a connection
3. Get the InputStream
4. Read bytes

Example: accessing resource over network

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

public class DownloadWebpageExample {

    public static void main(String[] args) throws Exception {
        URL url = new URL("https://www.baidu.com/index.html");
        HttpURLConnection con =
                (HttpURLConnection) url.openConnection();
        InputStream in = con.getInputStream();
        BufferedReader reader =
                new BufferedReader(new InputStreamReader(in));
        String nextLine = "";
        while ((nextLine = reader.readLine()) != null) {
            System.out.println(nextLine);
        }
    }

}
```

TestAlgorithm - Apache NetBeans IDE 12.3

<default conf...

246.3/334.0MB

Search (⌘+I)

Start Page | DownloadWebpageExample.java

Source | History

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

public class DownloadWebpageExample {
    public static void main(String[] args) throws Exception {
        URL url = new URL("https://www.baidu.com/index.html");
        HttpURLConnection con = (HttpURLConnection) url.openConnection();
        InputStream in = con.getInputStream();
        BufferedReader reader = new BufferedReader(new InputStreamReader(in));
        String nextLine = "";
        while ((nextLine = reader.readLine()) != null) {
            System.out.println(nextLine);
        }
    }
}
```

Output – TestAlgorithm (run)

```
run:
<!DOCTYPE html>
<!--STATUS OK--><html> <head><meta http-equiv=content-type content=text/html;charset=utf-8><meta http-equiv=X-UA-Compatible content
=IE=Edge><meta content=always name=referrer><link rel=stylesheet type=text/css href=https://ss1.bdstatic.com/5eN1bjq8AAUYm2zgoY3K/r
/www/cache/bdorz/baidu.min.css><title>百度一下，你就知道</title></head> <body link=#0000cc> <div id=wrapper> <div id=head> <div class=he
rapper> <div class=s_form> <div class=s_form_wrapper> <div id=lg> <img hidefocus=true src=//www.baidu.com/img/bd_logo1.png width=27
0 height=129> </div> <form id=form name=f action=//www.baidu.com/s class=fm> <input type=hidden name=bdorz_come value=1> <input typ
e=hidden name=ie value=utf-8> <input type=hidden name=f value=8> <input type=hidden name=rsv_bp value=1> <input type=hidden name=rs
v_idx value=1> <input type=hidden name=tn value=baidu><span class="bg s_ipt_wr"><input id=kw name=wd class=s_ipt value maxlength=25
5 autocomplete=off autofocus=autofocus></span><span class="bg s_btn_wr"><input type=submit id=su value=百度一下 class="bg s_btn" autofo
cus></span> </form> </div> </div> <div id=u1> <a href=http://news.baidu.com name=tj_trnews class=mnav>新闻</a> <a href=https://www.ha
o123.com name=tj_trhao123 class=mnav>hao123</a> <a href=http://map.baidu.com name=tj_trmap class=mnav>地图</a> <a href=http://v.baidu
.com name=tj_trvideo class=mnav>视频</a> <a href=http://tieba.baidu.com name=tj_trtieba class=mnav>贴吧</a> <noscript> <a href=http://w
ww.baidu.com/bdorz/login.gif?login&amp;tpl=mn&amp;u=http%3A%2F%2Fwww.baidu.com%2f%3fbdorz_come%3d1 name=tj_login class=lb>登录</a> </
noscript> <script>document.write('<a href="http://www.baidu.com/bdorz/login.gif?login&tpl=mn&u='+ encodeURIComponent(window.locatio
n.href+ (window.location.search === "" ? "?" : "&")+ "bdorz_come=1")+ '" name="tj_login" class="lb">登录</a>');
                </script> <a href=//www.baidu.com/more/ name=tj_briicon class=bri style="display: block;">更多产品</a> </div> </div> </
div> <div id=ftCon> <div id=ftConw> <p id=lh> <a href=http://home.baidu.com>关于百度</a> <a href=http://ir.baidu.com>About Baidu</a> </
p> <p id=cp>&copy;2017 Baidu <a href=http://www.baidu.com/duty/>使用百度前必读</a>  <a href=http://jianyi.baidu.com/ clas
cp-feedback>意见反馈</a> 京ICP证030173号  <img src=//www.baidu.com/img/gs.gif> </p> </div> </div> </div> </body> </html>
BUILD SUCCESSFUL (total time: 6 seconds)
```

9:79 INS Unix (LF)

HTML

- HTML stands for Hyper Text Markup Language
- HTML describes the structure of a Web page
- HTML consists of a series of elements
- HTML elements tell the browser how to display the content
- HTML elements are represented by tags
- HTML tags label pieces of content such as "heading", "paragraph", "table", and so on
- Browsers do not display the HTML tags, but use them to render the content of the page

```
<!DOCTYPE html>
<html>
    <head>
        <title>
            Here is the Title
        </title>
    </head>
    <body>
        <h1>
            Here is a Heading
        </h1>
        <p>
            Here is a paragraph.
        </p>
    </body>
</html>
```

HTTP - HyperText Transfer Protocol

- Hypertext Transfer Protocol (HTTP) is an application-layer protocol for transmitting hypermedia documents, such as HTML.

- HTTP follows a classical client-server model, with a client opening a connection to make a request, then waiting until it receives a response.

- In most case, the client in HTTP is a browser, so it also known as **browser-server model**.

Important HTTP requests

- **GET** -- The GET method is used to retrieve information from the given server using a given URI. Requests using GET should only retrieve data and should have no other effect on the data.

- **POST** -- A POST request is used to send data to the server, for example, customer information, file upload, etc. using HTML forms.

- **PUT** -- Replaces all the current representations of the target resource with the uploaded content.

- **DELETE** -- Removes all the current representations of the target resource given by URI.

Send HTTP requests in Java

1. Defining the request URL
2. Adding Request Parameters
3. Setting Request Headers ***
4. Configuring Timeouts ***
5. Handling Cookies ***
6. Reading the Response

Send HTTP requests

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

public class HttpGetExample {
    public static void main(String[] args) throws Exception {
        String url = "https://www.bing.com/search";
        Map<String, String> params = new HashMap<>();
params.put("q", "UESTC");
String getUrl = url + "?";
for (String key : params.keySet()) {
    getUrl += key + "=" + params.get(key) + "&";
}
URL realUrl = new URL(getUrl);
//打开和URL之间的连接
URLConnection conn = realUrl.openConnection();

//Continued on next page…
```

```
            //设置通用的请求属性
            conn.setRequestProperty("accept", "*/*");
            conn.setRequestProperty("connection", “Keep-Alive");
            conn.setRequestProperty("user-agent",
                    "Mozilla/4.0 (compatible; MSIE 6.0;"
                    + " Windows NT 5.1;SV1)”);
            //建立实际的连接
            conn.connect();
            //获取所有的响应头字段
            Map<String, List<String>> map = conn.getHeaderFields();
            //遍历所有的响应头字段
            for (String key : map.keySet()) {
                System.out.println(key + "-->" + map.get(key));
            }
            // 定义 BufferedReader输入流来读取URL的响应
            BufferedReader in = new BufferedReader(
                    new InputStreamReader(conn.getInputStream()));
            String line;
            while ((line = in.readLine()) != null) {
                System.out.println(line);
            }
        }
    }
```

Handling HTTP requests

```
import com.sun.net.httpserver.*;
import java.io.*;
import java.net.InetSocketAddress;

public class BasicHttpServerExample {

    static String htmlPage =  "<!DOCTYPE html> <html> ... </html>";

    public static void main(String[] args) throws Exception {
        HttpServer server = HttpServer.create(new InetSocketAddress(80), 0);
        HttpContext context = server.createContext("/");
        context.setHandler(new HttpHandler() {
           public void handle(HttpExchange exchange) throws IOException {
                String response = htmlPage;
                exchange.sendResponseHeaders(200, response.getBytes().length);
                OutputStream os = exchange.getResponseBody();
                os.write(response.getBytes());
                os.close();
            }
        });
        server.start();
    }
}
```

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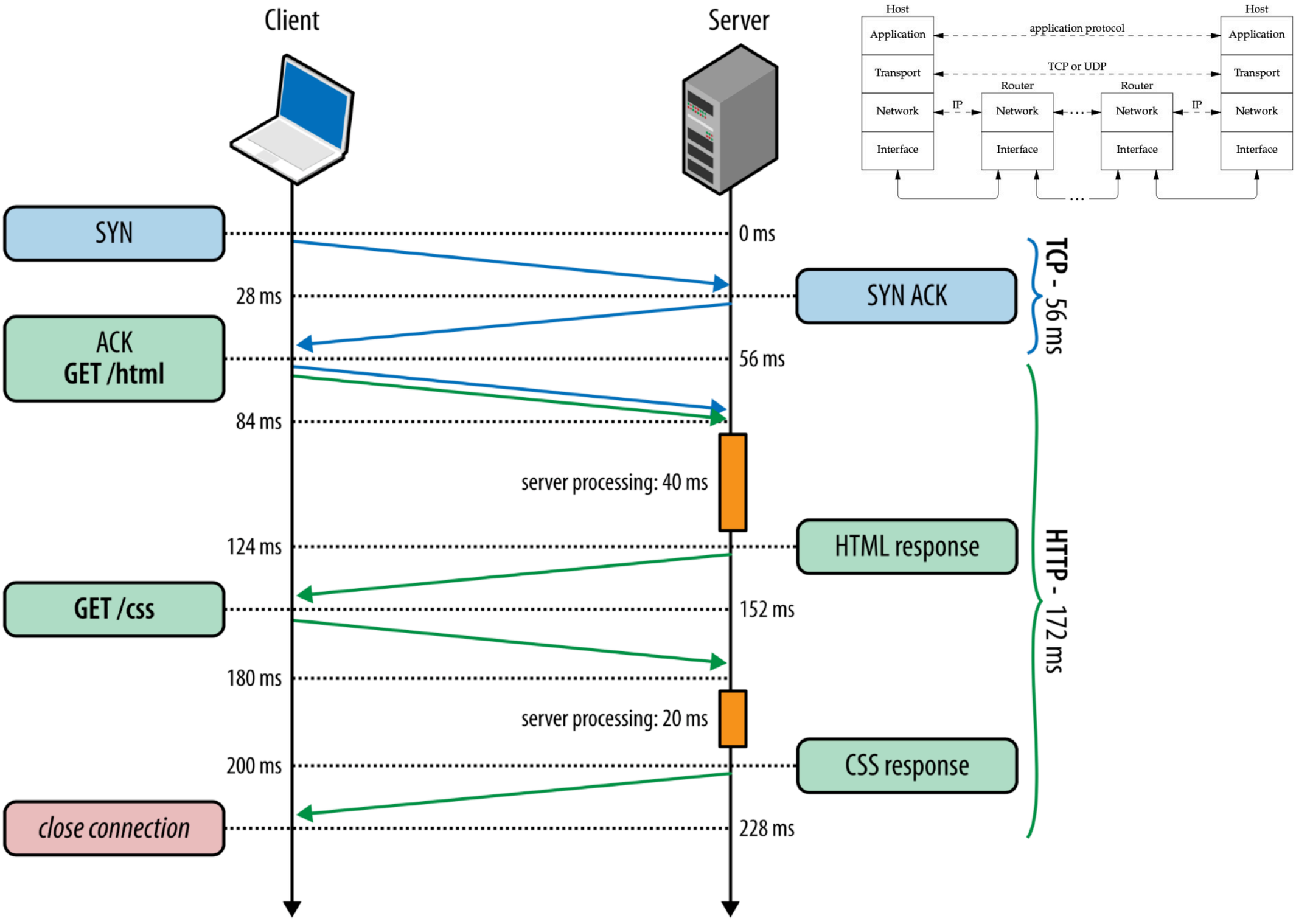
Http request over TCP connection



Socket Programming

- Java Socket programming is used for communication between the applications running on the network.

- A socket is one end-point of a two-way communication link.

- Socket classes are used to represent the connection between a client program and a server program.

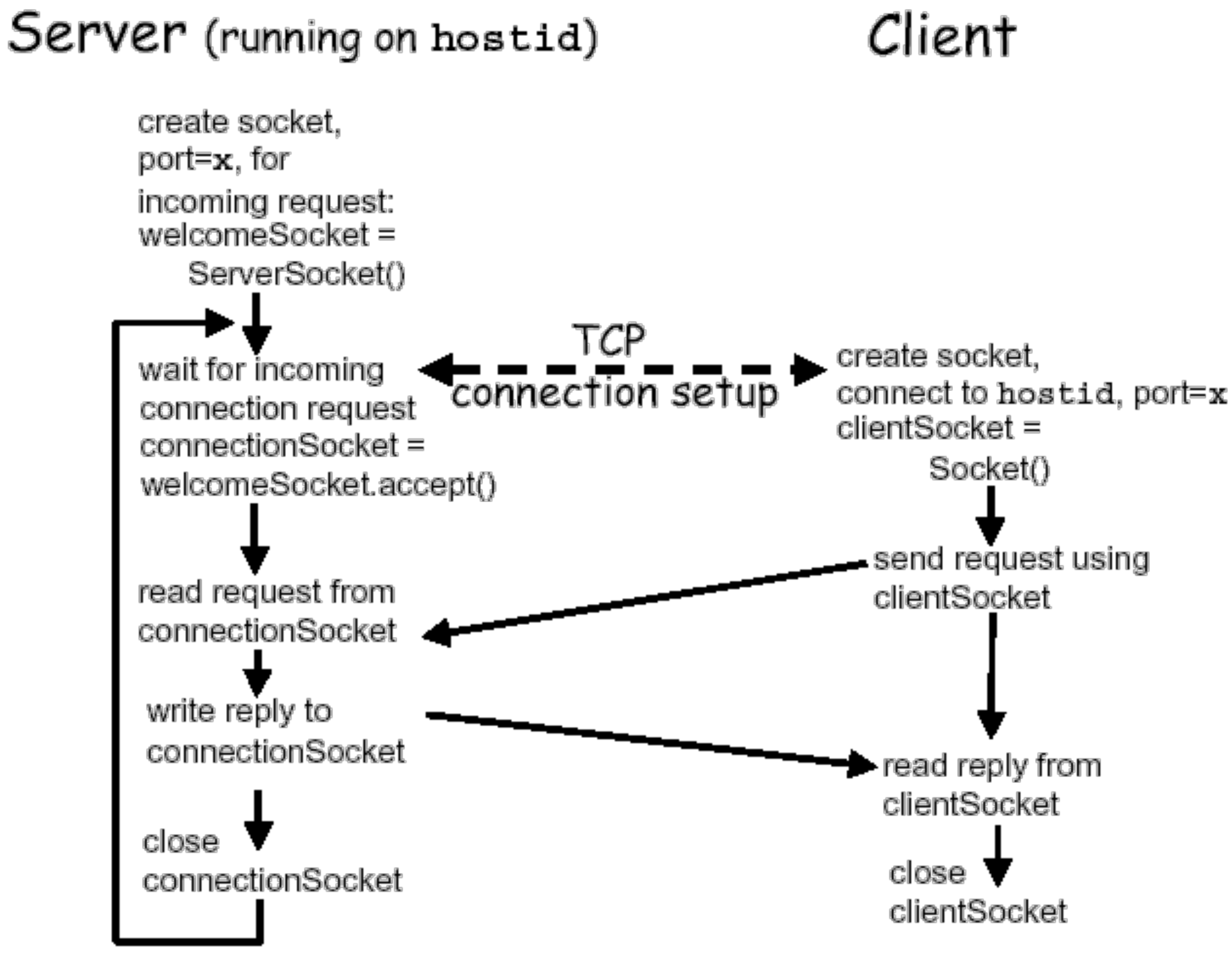
- The java.net package provides two classes--**Socket** and **ServerSocket**--that implement the client side of the connection and the server side of the connection, respectively.

ServerSocket Class Methods

Method	Description
public ServerSocket(int port)	attempts to create a server socket bound to the specified port.
public Socket accept()	returns the socket and establish a connection between server and client.
public synchronized void close()	closes the server socket.

Socket Class Methods

Method	Description
public Socket(String host, int port)	attempts to connect to the specified server at the specified port.
public InputStream getInputStream()	returns the InputStream attached with this socket.
public OutputStream getOutputStream()	returns the OutputStream attached with this socket.
public synchronized void close()	closes this socket


Server (running on hostid)
Client
create socket,
port=x, for
incoming request:
welcomeSocket =
ServerSocket()
wait for incoming
connection request
connectionSocket =
welcomeSocket.accept()
read request from
connectionSocket
write reply to
connectionSocket
close
connectionSocket
TCP
connection setup
create socket,
connect to hostid, port=x
clientSocket =
Socket()
send request using
clientSocket
read reply from
clientSocket
close
clientSocket

Example — Server

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

public class MyServer {
    public static void main(String[] args) {
        try {
            ServerSocket ss = new ServerSocket(6666);
            Socket s = ss.accept(); //establishes a connection
            DataInputStream dis = new DataInputStream(
                        s.getInputStream());
            String str = (String) dis.readUTF();
            System.out.println("message= " + str);
            ss.close();
        } catch (Exception e) {
            System.out.println(e);
        }
    }
}
```

Example — Client

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

public class MyClient {
    public static void main(String[] args) {
        try {
            Socket s = new Socket("localhost", 6666);
            DataOutputStream dout = new DataOutputStream(
                        s.getOutputStream());
            dout.writeUTF("Hello Server");
            dout.flush();
            dout.close();
            s.close();
        } catch (Exception e) {
            System.out.println(e);
        }
    }
}
```

How about two-way communication?

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

public class Client {

     static String ServerIP = "localhost";
     static int ServerPort = 1234;

     public static void main(String[] args) throws Exception {
          Scanner scn = new Scanner(System.in);
          Socket s = new Socket(ServerIP, ServerPort);
          DataInputStream dis = new DataInputStream(s.getInputStream());
          DataOutputStream dos = new DataOutputStream(s.getOutputStream());
          new Thread(() -> {
               try {
                    while (true) {
                         String msg = scn.nextLine();// read the message to deliver.
                         dos.writeUTF(msg);// write on the output stream
                    }
               } catch (IOException e) {
                    e.printStackTrace();
               }
          }, "发送信息的线程").start();
          new Thread(() -> {
               try {
                    while (true) {
                         // read the message sent to this client
                         String msg = dis.readUTF();
                         System.out.println(msg);
                    }
               } catch (IOException e) {
                    e.printStackTrace();
               }
          }, "接收信息的线程").start();
     }
}
```

Multi_threaded Client

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

public class Server {

    static int Port = 1234;
    static List<ClientHandler> ar = new ArrayList<>();
    static int i = 0;

    public static void main(String[] args) throws IOException {
        ServerSocket ss = new ServerSocket(Port);
        Socket s;
        // looping for getting client request
        while (true) {
            // Accept the incoming request
            s = ss.accept();
            System.out.println("New client request received : " + s);

            // obtain input and output streams
            DataInputStream dis = new DataInputStream(s.getInputStream());
            DataOutputStream dos = new DataOutputStream(s.getOutputStream());

            // Create a new handler object for handling this request.
            System.out.println("Creating a new handler for this client...");
            ClientHandler mtch = new ClientHandler(s, "client " + i++, dis, dos);

            // add this client to active clients list
            System.out.println("Adding this client to active client list");
            ar.add(mtch);

            // Start a new Thread with this object.
            new Thread(mtch).start();
        }
    }
}
```

Multi_threaded Server

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

class ClientHandler implements Runnable {

    Scanner scn = new Scanner(System.in);
    private String name;
    final DataInputStream dis;
    final DataOutputStream dos;
    Socket s;
    boolean isloggedin;

    // constructor
    public ClientHandler(Socket s, String name, DataInputStream dis, DataOutputStream dos) {
        this.dis = dis;
        this.dos = dos;
        this.name = name;
        this.s = s;
        this.isloggedin = true;
    }

    public void run() {
        try {
            String received;
            while (true) {
                // receive the string
                received = dis.readUTF();
                System.out.println(received);
                if (received.equals("logout")) {
                    this.isloggedin = false;
                    this.s.close();
                    break;
                }
                // send to all other clients
                for (ClientHandler mc : Server.ar) {
                    if (!mc.name.equals(name)) {
                        mc.dos.writeUTF(this.name + ": " + received);
                    }
                }
            }
            // closing resources
            this.dis.close();
            this.dos.close();
        } catch (IOException e) {
            e.printStackTrace();
        }
    }
}
```

Server ClientHandler

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Datagram

- **UDP (User Datagram Protocol)** is an alternative communications protocol to Transmission Control Protocol (TCP) used primarily for establishing low-latency and loss-tolerating connections between applications on the internet.

- A datagram is basically an information but there is no guarantee of its content, arrival or arrival time.

- Java **DatagramSocket** class represents a connection-less socket for sending and receiving datagram packets.

DatagramSocket class

- **DatagramSocket**(int port) — Creates a datagram socket, bound to the specified local address.

- void **receive**(DatagramPacket p) — Receives a datagram packet from this socket.

- void **send**(DatagramPacket p) — Sends a datagram packet from this socket.

- void **close**() — Closes this datagram socket.

DatagramPacket class

- **DatagramPacket**(byte[] barr, int length): it creates a datagram packet. This constructor is used to receive the packets.

- **DatagramPacket**(byte[] barr, int length, InetAddress address, int port): it creates a datagram packet. This constructor is used to send the packets.

Example — sending

```
import java.net.*;

public class DSender {
    public static void main(String[] args) throws Exception {
        DatagramSocket ds = new DatagramSocket();
        String str = "Welcome java";
        InetAddress ip = InetAddress.getByName("127.0.0.1");
        DatagramPacket dp = new DatagramPacket(
                  str.getBytes(), str.length(), ip, 3000);
        ds.send(dp);
        ds.close();
    }
}
```

Example — receiving

```
import java.net.*;

public class DReceiver {
    public static void main(String[] args) throws Exception {
        DatagramSocket ds = new DatagramSocket(3000);
        byte[] buf = new byte[1024];
        DatagramPacket dp = new DatagramPacket(buf, 1024);
        ds.receive(dp);
        String str = new String(dp.getData(), 0, dp.getLength());
        System.out.println(str);
        ds.close();
    }
}
```

Homework

Build your own chatting room.