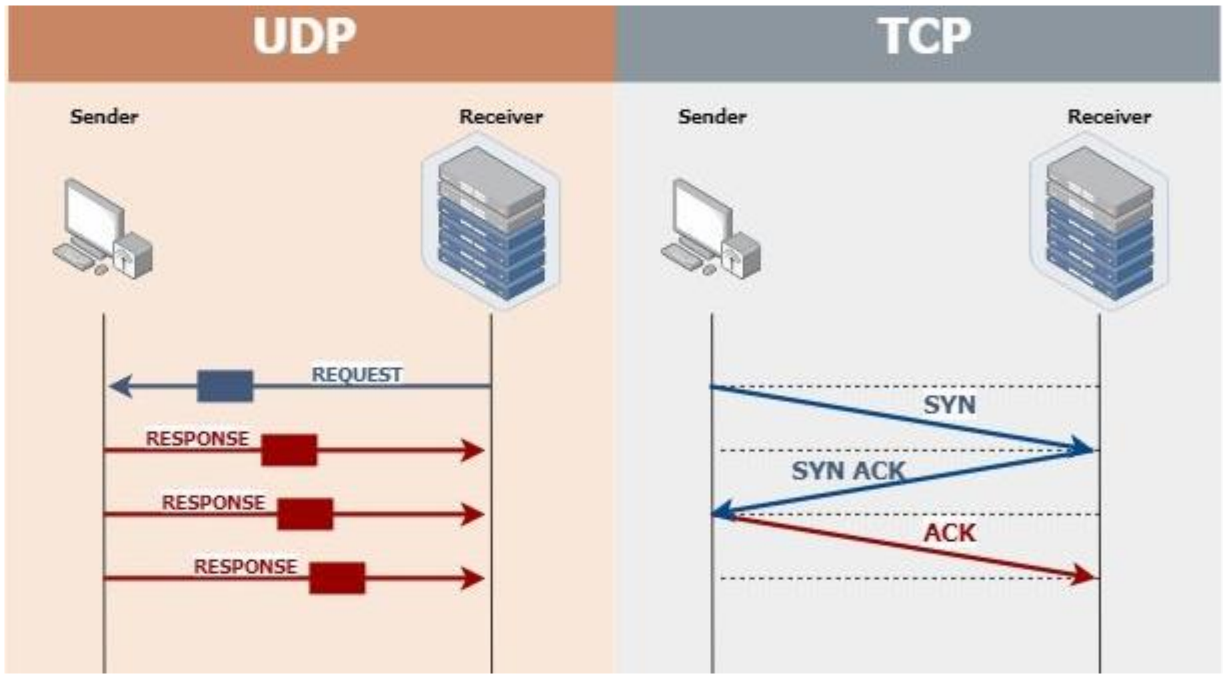
UDP

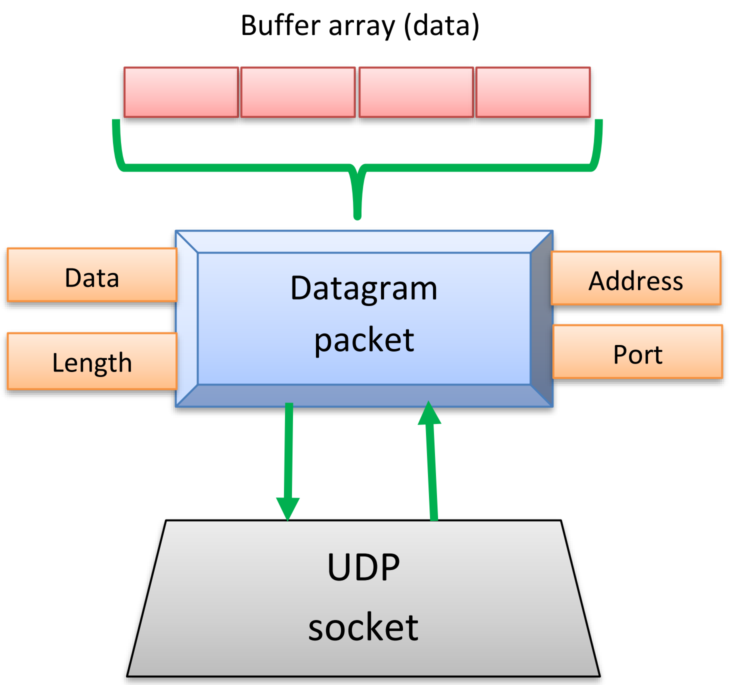
Contents

User Datagram Protocol

- UDP is used for time-sensitive communications.
    - Examples: Video playback, DNS lookup, Gaming, Streaming, Google QUIC.
- The TCP begins by establishing a connection via an automated process called a **handshake**.
    - Only once this handshake has been completed will one computer transfer data packets to the other.
- UDP is a **connectionless** communication model.
    - It sends packets directly to a target computer, without establishing a connection first, indicating the order of said packets, or checking whether they arrived as intended.
    - UDP packets are referred to as **datagrams**.
- TCP vs UDP



UDP Sockets



UDP server

Step	Code
1. Create a *DatagramSocket* object.	*DatagramSocket datagramSocket = new DatagramSocket*(1234);
2. Create a buffer for incoming datagrams.	*byte*[] *buffer* = *new byte*[256];
3. Create a DatagramPacket object for the incoming datagrams.	*DatagramPacket inPacket = new DatagramPacket*(*buffer* , *buffer*.*length*);
4. Accept an incoming datagram.	*datagramSocket*.*receive*(*inPacket*);
5. Accept the sender's address and port from the packet.	*InetAddress clientAddress* = *inPacket*.*getAddress*(); *int clientPort* = *inPacket*.*getPort*();
6. Retrieve the data from the buffer.	*String message* = *new String*(*inPacket*.*getData*(), 0, *inPacket*.*getLength*());
7. Create the response datagram.	*DatagramPacket outPacket = new DatagramPacket*(*response*. *getBytes*(), *response*.*length*(), *clientAddress*, *clientPort*);
8. Send the response datagram.	*datagramSocket*.*send*(*outPacket*);
9. Close the DatagramSocket.	*datagramSocket*.*close*();

- Example

UDPEchoServer

```
public class UDPEchoServer {
    private static final int PORT = 1234;
    private static DatagramSocket datagramSocket;
    private static DatagramPacket inPacket, outPacket;
    private static byte[] buffer;

    public static void main(String[] args) {
        System.out.println("Opening Port...");
        try { // STEP 1
            datagramSocket = new DatagramSocket(PORT);
            System.out.println("Port opened successfully\n");
        } catch (IOException ioException) {
            System.out.println("Failed to open the port");
            System.exit(1);
        }
        handleClient();
    }

    private static void handleClient() {
        try {
            String msgIn, msgOut;
            int numMsgs = 0;
            InetAddress clientAddress = null;
            int clientPort;

            do {
                buffer = new byte[256]; //STEP 2
                inPacket = new DatagramPacket(buffer, buffer.length); //STEP 3
                datagramSocket.receive(inPacket); //STEP 4
                clientAddress = inPacket.getAddress(); //STEP 5
                clientPort = inPacket.getPort(); //STEP 5

                msgIn = new String(inPacket.getData(),0, inPacket.getLength());
//STEP 6
                System.out.println("Message Received");
                numMsgs++;

                msgOut = "Message " + numMsgs + ": " + msgIn;
                outPacket = new DatagramPacket(msgOut.getBytes(),
                        msgOut.length(), clientAddress, clientPort); //STEP 7
                datagramSocket.send(outPacket); //STEP 8
            } while (true);
        } catch (IOException ioException) {
            ioException.printStackTrace();
        } finally {
            System.out.println("\n*CLOSING CONNECTION...*");
            datagramSocket.close(); //STEP 9
        }
    `
```

- Step-by-step code:
    1. Create a class $UDPEchoServer$ with $main$ method and a static constant port number $PORT$.

```
public class UDPEchoServer {
    private static final int PORT = 1234;

    public static void main(String[] args) {

    }
}
```

2. Create $DatagramSocket$ static variable that represents the socket for sending and receiving datagram packets.
3. Create two static variables of $DatagramPacket$ that represent an incoming datagram packet and an outgoing datagram packet.
4. Create a static $byte$ array that will receive incoming data.

```
public class UDPEchoServer {
    private static final int PORT = 1234;
    private static DatagramSocket datagramSocket;
    private static DatagramPacket inPacket, outPacket;
    private static byte[] buffer;

    public static void main(String[] args) {
```

5. In the $main$ method, setup $try - catch$ block.
6. Inside try block, initialize $datagramSocket$ object with port number $PORT$. Catch the exception in the $catch$ block.
7. Call the function $handleClient$.

```
public static void main(String[] args) {
    System.out.println("Opening Port...");
    try { // STEP 1
        datagramSocket = new DatagramSocket(PORT);
        System.out.println("Port opened successfully\n");
    } catch (IOException ioException) {
        System.out.println("Failed to open the port");
        System.exit(1);
    }
    handleClient();
}
```

8. Define static method $handleClient$, and set up $try - catch - finally$ block.

```
private static void handleClient() {
    try {

    } catch () {

    } finally {

    }
}
```

9. Inside try block, define two $String$ objects; one represents incoming message, and the other represents an outgoing message.
10. Inside try block, define an integer for counting messages.
11. Inside try block, define an integer for defining the client port.
12. Inside try block, define an $InetAddress$ object for defining the IP address of the client.

```
try {
    String msgIn, msgOut;
    int numMsgs = 0;
    InetAddress clientAddress = null;
    int clientPort;
```

13. Inside try block, set up a do-while loop with the condition true. The loop will handle the client connections with the server.
14. Inside do, initialize the $byte$ array to of size 256 bytes.
15. Inside do, initialize $inPacket$ object that holds the byte array and its length.

```
do {
    buffer = new byte[256]; //STEP 2
    inPacket = new DatagramPacket(buffer,
buffer.length); //STEP 3

}while(true);
```

16. Now, the $datagramSocket$ object is ready to receive an incoming packet from the client.
17. From the received packet $inPacket$, extract client's port and IP address.

```
datagramSocket.receive(inPacket); //STEP 4
clientAddress = inPacket.getAddress(); //STEP 5
clientPort = inPacket.getPort(); //STEP 5
```

18. From $inPacket$, we extract the data (client's message) into the string object $msgIn$.
19. Print "message received" to the server console, then increment the counter.

```
msgIn = new String(inPacket.getData(),
        0, inPacket.getLength()); //STEP 6
System.out.println("Message Received");
numMsgs++;
```

20. Define the response of the server that will be sent to client into the String object $msgOut$.
21. Wrap the $msgOut$ object, the message size, client's IP address, and client's port number into the datagram packet $outPacket$.
22. Send the $outPacket$ to the client via $datagramSocket$ object.

```
msgOut = "Message " + numMsgs + ": " + msgIn;
outPacket = new DatagramPacket(msgOut.getBytes(),
        msgOut.length(), clientAddress,
clientPort); //STEP 7
datagramSocket.send(outPacket); //STEP 8
```

23. Catch the exception in $catch$ block.
24. In the $finally$ block, close the connection.

```
catch (IOException ioException) {
    ioException.printStackTrace();
} finally {
    System.out.println("\n*CLOSING
CONNECTION...*");
    datagramSocket.close(); //STEP 9
}
```

UDP Client

Step	Code
1. Create a DatagramSocket object.	$DatagramSocket\ datagramSocket\ = \ new\ DatagramSocket();$
2. Create the outgoing datagram.	$DatagramPacket\ outPacket\ = new\ DatagramPacket(message.getBytes(), message.length(), host, PORT);$
3. Send the datagram message.	$\mathrm{datagramSocket.send(outPacket);}$
4. Create a buffer for incoming datagrams.	$byte[]\ buffer\ = \ new\ byte[256];$
5. Create a DatagramPacket object for the incoming datagrams.	$DatagramPacket\ inPacket = \ new\ DatagramPacket(buffer, buffer.length);$
6. Accept an incoming datagram.	$datagramSocket.receive(inPacket);$
7. Retrieve the data from the buffer.	$String\ response = \ new\ String(inPacket.getData(),0, inPacket.getLength());$
8. Close the DatagramSocket.	$datagramSocket.close();$

- Example

UDPEchoClient

```
public class UDPEchoClient {
    private static InetAddress host;
    private static final int PORT = 1234;
    private static DatagramSocket datagramSocket;
    private static DatagramPacket inPacket, outPacket;
    private static byte[] buffer;

    public static void main(String[] args) {
        try {
            host = InetAddress.getLocalHost();
        } catch (UnknownHostException ex) {
            System.out.println("Host ID not found!");
            System.exit(1);
        }
        accessServer();
    }

    private static void accessServer() {
        try {
            datagramSocket = new DatagramSocket(); //STEP 1
            Scanner userInput = new Scanner(System.in);
            String msg = "", rspns = "";
            do {
                System.out.print("Enter a message: ");
                msg = userInput.nextLine();

                if (!msg.equals("***CLOSE***")) {
                    outPacket = new DatagramPacket(msg.getBytes(),
                            0, msg.length(),host, PORT); //STEP 2
                    datagramSocket.send(outPacket); //STEP 3
                    buffer = new byte[256]; //STEP 4
                    inPacket = new DatagramPacket
                            (buffer, buffer.length); //STEP 5
                    datagramSocket.receive(inPacket); //STEP 6
                    //STEP 7
                    rspns = new String(inPacket.getData(),
                            0, inPacket.getLength());
                    System.out.println("SERVER> " + rspns);
                }
            } while (!msg.equals("***CLOSE***"));
        } catch (IOException ioException) {
            ioException.printStackTrace();
        } finally {
            System.out.println("\n*CLOSING CONNECTION...*");
            datagramSocket.close(); //STEP 8
            System.out.println();
        }
    }
```

- Step-by-step UDP client code:
    1. Create $UDPEchoClient$ class with $main$ method.
    2. Create static variables: $PORT$, $datagramSocket$, $inPacket$, $outPacket$, $buffer$, and $host$.

```
public class UDPEchoClient {
    private static InetAddress host;
    private static final int PORT = 1234;
    private static DatagramSocket datagramSocket;
    private static DatagramPacket inPacket, outPacket;
    private static byte[] buffer;

    public static void main(String[] args) {
    }
}
```

3. Inside $main$, set up $try - catch$ block.
4. Inside try block, initialize the $host$ object to get the IP address of the local machine. The local machine will act as the server and the client, so both have the same IP address.
5. Call the $accessServer$ method.

```
public static void main(String[] args) {
    try {
        host = InetAddress.getLocalHost();
    } catch (UnknownHostException ex) {
        System.out.println("Host ID not found!");
        System.exit(1);
    }
    accessServer();
}
```

6. Define static method $accessServer$ that will establish client's connection with the server.
7. Set up the $try - catch - finally$ block.

```
private static void accessServer() {
    try {
    } catch () {

    } finally {

    }
}
```

8. Inside try block, initialize $datagramSocket$ object.
9. Create $Scanner$ object that will get user’s input from console.
10. Create two $String$ objects, one for receiving message from server, and the other for sending response to the server.
11. Set up $do - while$ loop, with the condition that the user’s input is not “***CLOSE***”.

```
try {
    datagramSocket = new DatagramSocket(); //STEP 1
    Scanner userInput = new Scanner(System.in);
    String msg = "", rspns = "";
    do {

    }
} while (!msg.equals("***CLOSE***"));
```

12. Inside do block, we prompt the user to enter a message, and read it via $userInput$ object.
13. After reading the user’s input, we check that it is not “***CLOSE***” statement. If the user enters “***CLOSE***”, the loop terminates and the connection closes.

```
do {
    System.out.print("Enter a message: ");
    msg = userInput.nextLine();
    if (!msg.equals("***CLOSE***")) {

    }
} while (!msg.equals("***CLOSE***"));
```

14. Inside if block, wrap the user’s input (message), the message’s length, the server’s IP address and port into a $outPacket$.
15. Send the $outPacket$ to the server via $datagramSocket$ object.

```
if (!msg.equals("***CLOSE***")) {
     outPacket = new DatagramPacket(msg.getBytes(),
             0, msg.length(), host, PORT); //STEP 2
     datagramSocket.send(outPacket); //STEP 3
```

16. Now, the client is ready to receive the response from the server. We initialize our $buffer$ array to receive the server's message.
17. Initialize the $inPacket$ object to hold the $buffer$ and its size.
18. Receive the $inPacket$ from server via $datagramSocket$ object.
19. Extract the $String$ message from $inPacket$, and print the response in the console.

```
buffer = new byte[256]; //STEP 4
inPacket = new DatagramPacket(buffer,buffer.length);//STEP 5
datagramSocket.receive(inPacket); //STEP 6
//STEP 7
rspns = new String(inPacket.getData(), 0,
inPacket.getLength());
System.out.println("SERVER> " + rspns);
```

20. Catch the exception in the $catch$ block.
21. In the $finally$ block, terminate the connection.
22. Print the appropriate messages to the console.

```
catch (IOException ioException) {
    ioException.printStackTrace();
} finally {
    System.out.println("\n*CLOSING CONNECTION...*");
    datagramSocket.close(); //STEP 8
    System.out.println();
}
```

- Now, run the server then the client.

✓ CHECKPOINT: Why we did not define the closing string "***CLOSE***" in the server side in $UDPEchoServer$?

Exercise

1. Create a TCP server that accepts a username and password from a client. If the username and password are valid, the server echoes back user messages. Otherwise, the server prompts the client to enter the username and password again.
2. Write a java application for printing the open ports of the local machine.

❖ Create the same server-client application explained above but with GUI.