MAWLANA BHASHANI SCIENCE AND TECHNOLOGY UNIVERSITY

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LAB REPORT

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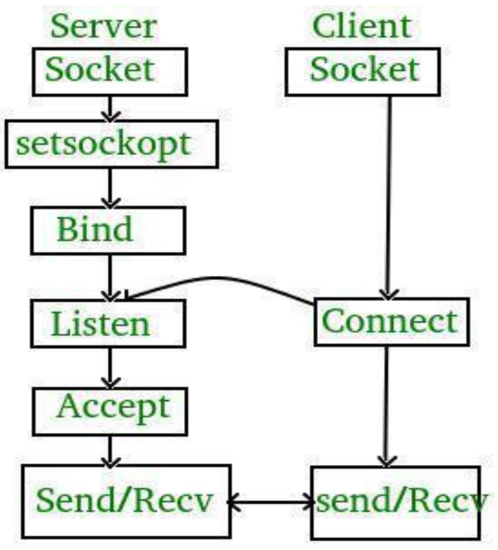
Socket Programming:

What is socket programming?

Socket programming is a way of connecting two nodes on a network to communicate with each other. One socket(node) listens on a particular port at an IP, while other socket reaches out to the other to form a connection. Server forms the listener socket while client reaches out to the server.

State diagram for server and client model



Stages for server

Socket creation:

int sockfd = socket(domain, type, protocol)

sockfd: socket descriptor, an integer (like a file-handle)

domain: integer, communication domain e.g., AF_INET (IPv4 protocol) ,
AF_INET6 (IPv6 protocol)

type: communication type

SOCK_STREAM: TCP(reliable, connection oriented)

SOCK_DGRAM: UDP(unreliable, connectionless)

protocol: Protocol value for Internet Protocol(IP), which is 0. This is the same number which appears on protocol field in the IP header of a packet.(man protocols for more details)

Setsockopt:

int setsockopt(int sockfd, int level, int optname,

```
               const void *optval, socklen_t optlen);
```

This helps in manipulating options for the socket referred by the file descriptor sockfd. This is completely optional, but it helps in reuse of address and port. Prevents error such as: “address already in use”.

Bind:

```
int bind(int sockfd, const struct sockaddr *addr,

                  socklen_t addrlen);
```

After creation of the socket, bind function binds the socket to the address and port number specified in addr(custom data structure). In the example code, we bind the server to the localhost, hence we use INADDR_ANY to specify the IP address.

Listen:

```
int listen(int sockfd, int backlog);
```

It puts the server socket in a passive mode, where it waits for the client to approach the server to make a connection. The backlog, defines the maximum length to which the queue of pending connections for sockfd may grow. If a connection request arrives when the queue is full, the client may receive an error with an indication of ECONNREFUSED.

Accept:

```
int new_socket= accept(int sockfd, struct sockaddr *addr, socklen_t *addrlen);
```

It extracts the first connection request on the queue of pending connections for the listening socket, sockfd, creates a new connected socket, and returns a new file descriptor referring to that socket. At this point, connection is established between client and server, and they are ready to transfer data.

Stages for Client

Socket connection: Exactly same as that of server’s socket creation

Connect:

```
int connect(int sockfd, const struct sockaddr *addr,

                   socklen_t addrlen);
```

The connect() system call connects the socket referred to by the file descriptor sockfd
to the address specified by addr. Server's address and port is specified in addr.

Implementation

Here we are exchanging one hello message between server and client to demonstrate the client/server model.

server.c

client.c

1) Briefly explain the term IPC in terms of TCP/IP communication.

Answer:

InterProcess Communication is a term we use for interactions between two processes on the same host. William Westlake mentions TCP/IP, which is used for interactions with another host. It can be used locally as well, but it is relatively inefficient. Unix domain sockets are used in the same way, but are only for local use and a bit more efficient.

The answer will be different each Operating System. Unix offers System V IPC, which
gives you message queues, shared memory, and semaphores.

Message queues are easy to use: processes and threads can send variable-sized messages by appending them to some queue and others can receive messages from them so that each message is received at most once. Those operatings can be blocking or non-blocking. The difference with UDP is that messages are received in the same order as they are sent. Pipes are simpler, but pass a stream of data instead of distinct messages. Line feeds can be used as delimiters.

Shared memory allows different processes to share fixed regions of memory in the same way that threads have access to the same memory. Unix allocates a certain amount of memory after which it can be accessed like private memory. Since two threads updating the same data can lead to inconsistencies, semaphores can be used to achieve mutual exclusion. A similar mechanism is the memory-mapped file: the difference is that the memory segment it initialised from a disc file and changes can be permanent. The size of a file can change, which complicates shared files.

2) What is the maximum size of a UDP datagram? What are the implications of using a packet-based Protocol as opposed to a stream protocol for transfer of large files?

Answer:

It depends on the underlying protocol i.e., whether you are using IPv4 or IPv6.

• In IPv4, the maximum length of packet size is 65,536. So, for UDP datagram
you have maximum data length as:

65,535 bytes - 20 bytes(Size of IP header) = 65, 515 bytes (including 8 bytes UDP header)

• In IPv6, the maximum length of packet size allowed is 64 kB, so, you can have UDP
datagram of size greater than that.

NOTE: This size is the theoretical maximum size of UDP Datagram, in practice though, this limit is further constrained by the MTU of data-link layer(which varies for each data-link layer technology, but cannot be less than 576 bytes), considering that, maximum size of UDP datagram can be further calculated as (for IPv4):

• 576 bytes - 20 bytes(IP header) = 556 (including 8 bytes UDP header)

3) TCP is a reliable transport protocol, briefly explain what techniques are used to provide this reliability.

<u>Answer:</u>

A number of mechanisms help provide the reliability TCP guarantees. Each of these
is described briefly below.

Checksums. All TCP segments carry a checksum, which is used by the receiver to detect
errors with either the TCP header or data

. Duplicate data detection. It is possible for packets to be duplicated in packet switched network; therefore TCP keeps track of bytes received in order to discard duplicate copies of data that has already been received.

Retransmissions. In order to guarantee delivery of data, TCP must implement retransmission schemes for data that may be lost or damaged. The use of positive acknowledgements by the receiver to the sender confirms successful reception of data. The lack of positive acknowledgements, coupled with a timeout period calls for a retransmission.

Sequencing. In packet switched networks, it is possible for packets to be delivered out
of order. It is TCP's job to properly sequence segments it receives so it can deliver the
byte stream data to an application in order.

Timers. TCP maintains various static and dynamic timers on data sent. The sending TCP waits for the receiver to reply with an acknowledgement within a bounded length of time. If the timer expires before receiving an acknowledgement, the sender can retransmit the segment.

4) Why are the htons(), htonl(), ntohs(), ntohl() functions used?

Answer:

These are used for:

htons() host to network short

htonl() host to network long

ntohs() network to host short

ntohl() network to host long

5) What is the difference between a datagram socket and a stream socket?

Answer:

The difference is given below:

- Stream sockets enable processes to communicate using TCP. A stream socket provides a bidirectional, reliable, sequenced, and unduplicated flow of data with no record boundaries. After the connection has been established, data can be read from and written to these sockets as a byte stream. The socket type is SOCK_STREAM.

- Datagram sockets enable processes to use UDP to communicate. A datagram socket supports a bidirectional flow of messages. A process on a datagram socket might receive messages in a different order from the sending sequence. A process on a datagram socket might receive duplicate messages. Messages that are sent over a datagram socket might be dropped. Record boundaries in the data are preserved. The socket type is SOCK_DGRAM.

Time Protocol implementation: 2.2.2

A java program where the following GreetingClient is a client program that connects to a server by using a socket and sends a greeting, and then waits for a response.

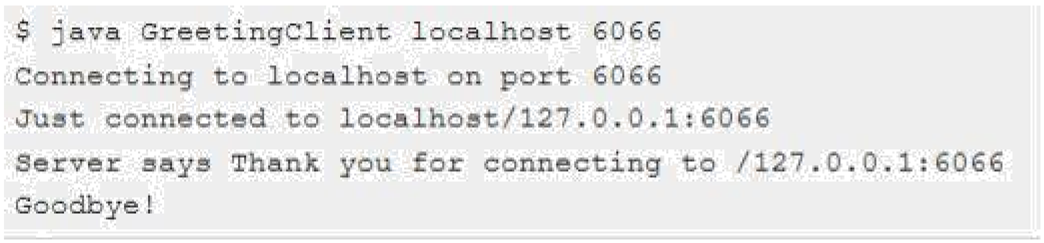
```
// File Name GreetingClient.java

import java.net.*;

import java.io.*;
```

```
public class GreetingClient {

public static void main(String [] args) {

String serverName = args[0];

int port = Integer.parseInt(args[1]);

try {

System.out.println("Connecting to " + serverName + " on port " + port);

Socket client = new Socket(serverName, port);

System.out.println("Just connected to " + client.getRemoteSocketAddress());

OutputStream outToServer = client.getOutputStream();

DataOutputStream out = new DataOutputStream(outToServer);


 out.writeUTF("Hello from " + client.getLocalSocketAddress());

 InputStream inFromServer = client.getInputStream();

 DataInputStream in = new DataInputStream(inFromServer);

 System.out.println("Server says " + in.readUTF());

 client.close();

 } catch (IOException e)
 { e.printStackTrace();

 }

 }

}
```

The following GreetingServer program is an example of a server application that uses the Socket class to listen for clients on a port number specified by a command-line argument –

```
// File Name GreetingServer.java
 import java.net.*;
 import java.io.*;

public class GreetingServer extends Thread {
private ServerSocket serverSocket;

public GreetingServer(int port) throws IOException {
serverSocket = new ServerSocket(port);
serverSocket.setSoTimeout(10000); }

 public void run() {
 while(true) {
 try {
 System.out.println("Waiting for client on port " + serverSocket.getLocalPort()
+ "..."); Socket server = serverSocket.accept();
System.out.println("Just connected to " + server.getRemoteSocketAddress());
DataInputStream in = new DataInputStream(server.getInputStream());

 System.out.println(in.readUTF());
 DataOutputStream out = new DataOutputStream(server.getOutputStream());
 out.writeUTF("Thank you for connecting to " + server.getLocalSocketAddress()
+ "\nGoodbye!");
server.close();
} catch (SocketTimeoutException s) {
System.out.println("Socket timed out!");
break;
 } catch (IOException e)
 { e.printStackTrace();
 break;
 }
 }
 }

 public static void main(String [] args) {
 int port = Integer.parseInt(args[0]);
 try {
Thread t = new GreetingServer(port);
 t.start();
 } catch (IOException e)
{ e.printStackTrace();
 }
 }
 }
```

Output:



```
$ java GreetingClient localhost 6066
Connecting to localhost on port 6066
Just connected to localhost/127.0.0.1:6066
Server says Thank you for connecting to /127.0.0.1:6066
Goodbye!
```

Discussion: The Time Protocol may be implemented over the Transmission Control Protocol (TCP) or the User Datagram Protocol (UDP). A host connects to a server that supports the Time Protocol on port 37. The server then sends the time as a 32-bit unsigned integer in binary format and in network byte order, representing the number of seconds since 00:00 (midnight) 1 January, 1900 GMT, and closes the connection. Operation over UDP requires the sending of any datagram to the server port, as there is no connection setup for UDP.