Computación en Internet I

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2023-1

Agenda

1. **Java Socket Programming**
   - Introduction
   - Types of sockets
   - The Connectionless Datagram Socket
   - Examples
   - Exercises

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What is the interprocess communication (IPC)?

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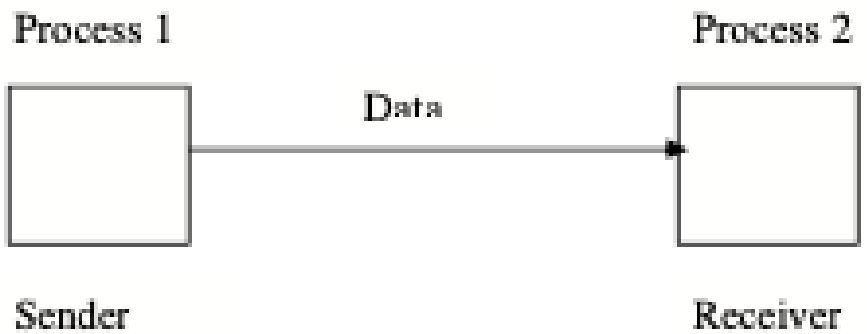
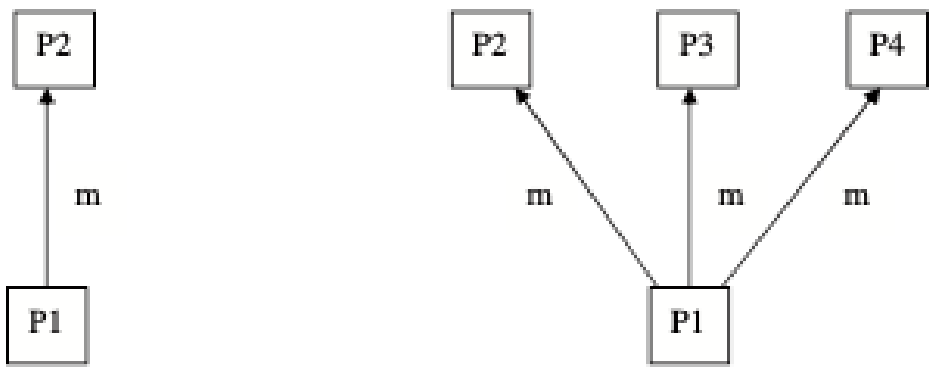
- The backbone of distributed computing.
- Ability for separate, independent processes to communicate among themselves to collaborate on a task.



How does this communication take place?

How does this communication take place?

- Two or more processes engage in a protocol.
- A process can be a sender at some instant of the communication.
- Can be a receiver of the data at another instant of the communication.
- Unicast: data is sent from one process to another single process.
- Multicast: data is sent from one process to more than one process at the same time.



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- Message queues.
- Semaphores.
- Shared memory.

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How to spare the programmer with the complexities associated to system-level details?

- IPC application programming interface (API).
- The Socket API is a low-level programming facility for implementing IPC.
  - Provides a programming construct called a *s*ocket.
  - A process wishing to communicate with another must instantiate a socket.
  - After instantiating sockets processes may send and receive data by using operations provided by the API.

How are sockets identified?

How are sockets identified?

- Uniquely identified by the IP address and the port number at which the socket is opened.
  - Port numbers can be at most 66535.
  - Well-known processes have their sockets opened on dedicated port numbers ≤ 1024.
  - User-defined processes have to be run on port numbers > 1024.

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Types of sockets

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- Datagram sockets (use UDP)
  - Transports packets in a connectionless manner.
  - Each datagram is addressed and routed individually.
  - It may arrive at the receiver in any order.
- Stream sockets (use TCP)
  - It is connection-oriented.
  - Transports a stream of data over a logical connection established between sender and receiver.
  - Data sent from a sender to a receiver is guaranteed to be received in the order they were sent.

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The Connectionless Datagram Socket

Which classes are provided for the datagram socket API?

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- The DatagramSocket class for the sockets.
- The DatagramPacket class for the packets exchanged.

The Connectionless Datagram Socket

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What are the steps to be followed?

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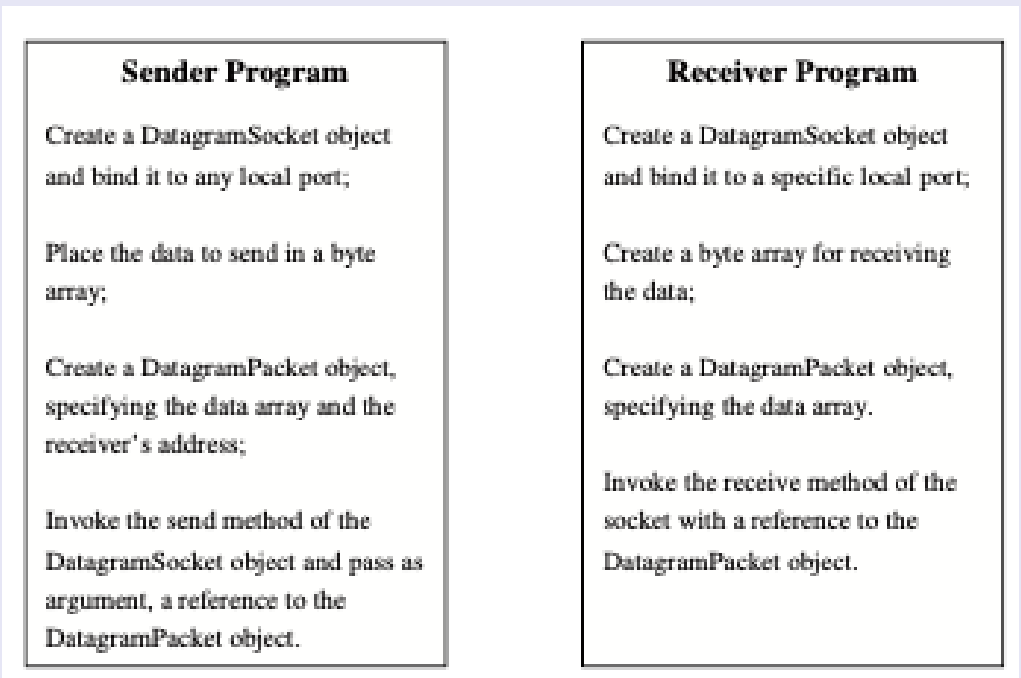

Which are the key methods for the DatagramSocket class?

Which are the key methods for the DatagramSocket class?

- DatagramSocket()
  - Constructs objects and binds it to any available port on the local host machine.
- DatagramSocket(int port)
  - Constructs object and binds it to the specified port on the local host machine.
- DatagramSocket(int port, InetAddress laddr)
  - Constructs object and binds it to the specified local address and port.
- void close()
  - Closes the datagram socket.

Which are the key methods for the DatagramSocket class?

- void connect(InetAddress address, int port)
  - Connects the datagram socket to the specified remote address and port number on the machine with that address.
- InetAddress getLocalAddress()
  - Returns the local InetAddress to which the socket is connected.
- int getLocalPort()
  - Returns the port number on the local host to which the datagram socket is bound.
- InetAddress getInetAddress()
  - Returns the IP address to which the datagram socket is connected to at the remote side.

Which are the key methods for the DatagramSocket class?

- int getPort()
  - Returns the port number at the remote side of the socket.
- void receive(DatagramPacket packet)
  - Receives a datagram packet object from this socket.
- void send(DatagramPacket packet)
  - Sends a datagram packet object from this socket.
- void setSoTimeout(int timeout)
  - Set the timeout value for the socket, in milliseconds.

Which are the key methods for the DatagramPacket class?

Which are the key methods for the DatagramPacket class?

- DatagramPacket(byte[] buf, int length, InetAddress, int port)
  - Constructs a datagram packet object with the contents stored in a byte array, buf, of specified length to a machine with the specified IP address and port number.
- InetAddress getAddress()
  - Returns the IP address of the machine at the remote side to which the datagram is being sent or from which the datagram was received.
- byte [] getData()
  - Returns the data buffer stored in the packet as a byte array.
- int getLength()
  - Returns the length of the data buffer in the datagram packet sent or received.

Which are the key methods for the DatagramPacket class?

- int getPort()
  - Returns the port number to which the datagram socket is bound to which the datagram is being sent or from which the datagram is received.
- void setData(byte [])
  - Sets the data buffer for the datagram packet.
- void setAddress(InetAddress iaddr)
  - Sets the datagram packet with the IP address of the remote machine to which the packet is being sent.
- void setPort(int port)
  - Sets the datagram packet with the port number of the datagram socket at the remote host to which the packet is sent.

The Connectionless Datagram Socket

To take into account

- With connectionless sockets, a DatagramSocket object bound to a process can be used to send datagrams to different destinations.
- Multiple processes can simultaneously send datagrams to the same socket bound to a receiving process.
- The send operations are non-blocking and the receive operations are blocking.

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Program to receive-send a single Datagram

- Server:
  - Defines a maximum size for the received message.
  - Gets the local port number as a parameter.
  - Creates a socket associated to the local port.
  - Creates a buffer of bytes where to receive.
  - Creates a packet with the buffer and its length.
  - By means of the socket it receives the packet.
  - Gets the info from the buffer and prints it.
  - Closes the socket.

Program to receive-send a single Datagram

- Client:
  - Receives and stores, address, port and message form user.
  - Creates a socket.
  - Creates buffer of bytes and stores the message in it.
  - Creates a packet with the buffer, its size, the address and the port.
  - Sends the packet via the socket.
  - Closes the socket.

Program to receive-send a single Datagram

Server

```
import java.net.*;
import java.io.*;
public class DatagramReceiver{
    public static void main(String[] args) {
        try {
            int MAX_LEN = 40;
            int localPortNum = Integer.parseInt(args[0]);
            DatagramSocket mySocket = new DatagramSocket(localPortNum);
            byte[] buffer = new byte[MAX_LEN];
            DatagramPacket packet = new DatagramPacket(buffer, MAX_LEN);
            mySocket.receive(packet);
            String message = new String(buffer);
            System.out.println(message);
            mySocket.close();
        }
        catch(Exception e) {
            e.printStackTrace();
        }
    }
}
```

Program to receive-send a single Datagram

Client

```
import java.net.*;
import java.io.*;
public class DatagramSender {
    public static void main(String[] args) {
        try {
            BufferedReader input = new BufferedReader(new InputStreamReader(System.in));
            System.out.println("Input the address:");
            InetAddress receiverHost = InetAddress.getByName(input.readLine());
            System.out.println("Input the port:");
            int receiverPort = Integer.parseInt(input.readLine());
            System.out.println("Input the message:");
            String message = input.readLine();
            input.close();
            DatagramSocket mySocket = new DatagramSocket();
            byte[] buffer = message.getBytes();
            DatagramPacket packet = new DatagramPacket(buffer, buffer.length, receiverHost, receiverPort);
            mySocket.send(packet);
            mySocket.close();
        }
        catch(Exception e) {
            e.printStackTrace();
        }
    }
}
```

Program to Send and Receive a Message in both Directions

- Server:
  - Defines a maximum size for the received message.
  - Gets the local port number as a parameter.
  - Creates a socket associated to the local port.
  - Creates a buffer of bytes where to receive.
  - Creates a packet with the buffer and its length.
  - By means of the socket it receives the packet.
  - Gets the info from the buffer and prints it.
  - Creates a buffer of bytes and stores the new message in it.
  - Gets the source address and port from the packet.
  - Constructs a new message.
  - Creates a packet with the buffer, its size, the address and the port.
  - Sends the packet via the socket.
  - Closes the socket.

Program to Send and Receive a Message in both Directions

- Client:
  - Receives and stores, address, port and message form user.
  - Creates a socket.
  - Creates a buffer of bytes and stores the message in it.
  - Creates a packet with the buffer, its size, the address and the port.
  - Sends the packet via the socket.
  - Defines a maximum size for the received message.
  - Creates a buffer of bytes where to receive.
  - Creates a packet with the buffer and its length.
  - By means of the socket it receives the packet.
  - Gets the info from the buffer and prints it.

Program to Send and Receive a Message in both Directions

Server

```
import java.net.*;
import java.io.*;
public class DatagramReceiverSender {
    public static void main(String[] args) {
        try {
            int MAX_LEN = 60;
            int localPortNum = Integer.parseInt(args[0]);
            DatagramSocket mySocket = new DatagramSocket(localPortNum);
            byte[] recvBuffer = new byte[MAX_LEN];
            DatagramPacket packet = new DatagramPacket(recvBuffer, MAX_LEN);
            mySocket.receive(packet);
            String message = new String(recvBuffer);
            System.out.println("\n"+message);
            InetAddress senderAddress = packet.getAddress();
            int senderPort = packet.getPort();
            String messageToSend = "This was the received message: "+message;
            byte[] sendBuffer = messageToSend.getBytes();
            DatagramPacket datagram = new DatagramPacket(sendBuffer, sendBuffer.length, senderAddress, senderPort);
            mySocket.send(datagram);
            mySocket.close();
        }
        catch(Exception e){
            e.printStackTrace();
        }
    }
}
```

Program to Send and Receive a Message in both Directions

Client

```
import java.net.*;
import java.io.*;
public class DatagramSenderReceiver {
    public static void main(String[] args) {
        try {
            BufferedReader input = new BufferedReader(new InputStreamReader(System.in));
            System.out.println("Input the address:");
            InetAddress receiverHost = InetAddress.getByName(input.readLine());
            System.out.println("Input the port:");
            int receiverPort = Integer.parseInt(input.readLine());
            System.out.println("Input the message:");
            String message = input.readLine();
            DatagramSocket mySocket = new DatagramSocket();
            byte[] sendBuffer = message.getBytes();
            DatagramPacket packet = new DatagramPacket(sendBuffer, sendBuffer.length, receiverHost, receiverPort);
            mySocket.send(packet);
            int MESSAGE_LEN = 60;
            byte[] recvBuffer = new byte[MESSAGE_LEN];
            DatagramPacket datagram = new DatagramPacket(recvBuffer, MESSAGE_LEN);
            mySocket.receive(datagram);
            String recvdString = new String(recvBuffer);
            System.out.println("\n"+recvdString);
            mySocket.close();
        }
        catch(Exception e) {
            e.printStackTrace();
        }
    }
}
```

Program to calculate the factorial of a number

- Server:
  - Creates the input and output buffers of bytes.
  - Creates the socket associated to a port.
  - Creates a datagram by using the buffer.
  - Receives the datagram by means of the socket.
  - Extracts the info from the datagram.
  - Gets the address and port from the datagram.
  - Converts the data as a number.
  - Calculates the factorial.
  - Saves the result in the buffer of bytes.
  - Creates the datagram to be sent.
  - Sends the datagram via the socket.
  - Prints what was sent.

Program to calculate the factorial of a number

- Client:
  - Receives the address as a parameter.
  - Creates the input and output buffers of bytes.
  - Reads the input number from the standard input.
  - Creates a socket.
  - Stores the message in the output buffer of bytes.
  - Creates a packet with the buffer, its size, the address and the port.
  - Sends the packet via the socket.
  - Prints what is sent to the server.
  - Creates a datagram with the input buffer and its length.
  - By means of the socket it receives the packet.
  - Gets the info from the buffer and prints it.

Program to calculate the factorial of a number

Server

```
import java.net.*;
public class FactServer {
    public static void main(String args[]) throws Exception {
        byte[] rbuf = new byte[10];
        byte[] sbuf = new byte[10];
        DatagramSocket socket = new DatagramSocket(5000);
        System.out.println("Server ready");
        DatagramPacket rpkt = new DatagramPacket(rbuf, rbuf.length);
        socket.receive(rpkt);
        String data = new String(rpkt.getData(), 0, rpkt.getLength());
        InetAddress addr = rpkt.getAddress();
        int port = rpkt.getPort();
        int fact = 1;
        int n = Integer.parseInt(data);
        System.out.println("Received: " + n + " from " + addr + ":" + port);
        for (int i = 2; i <= n; i++)
            fact *= i;
        sbuf = String.valueOf(fact).getBytes();
        DatagramPacket spkt = new DatagramPacket(sbuf, sbuf.length, addr, port);
        socket.send(spkt);
        System.out.println("Sent: " + fact);
    }
}
```

Program to calculate the factorial of a number

Client

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

public class FactClient {
    public static void main(String args[]) throws Exception {
        byte[] rbuf = new byte[1024];
        byte[] sbuf = new byte[1024];
        BufferedReader fromUser = new BufferedReader(new InputStreamReader(System.in));
        DatagramSocket socket = new DatagramSocket();
        InetAddress addr = InetAddress.getByName(args[0]);
        System.out.print("Enter an integer: ");
        String data = fromUser.readLine();
        sbuf = data.getBytes();
        DatagramPacket spkt = new DatagramPacket(sbuf, sbuf.length, addr, 5000);
        socket.send(spkt);
        System.out.println("Sent to server: " + data);
        DatagramPacket rpkt = new DatagramPacket(rbuf, rbuf.length);
        socket.receive(rpkt);
        data = new String(rpkt.getData(), 0, rpkt.getLength());
        System.out.println("Received from server: " + data);
        socket.close();
    }
}
```

Program to calculate the factorial of a number

Handler

```
import java.io.*;
import java.net.*;
public class Handler extends Thread {
    DatagramSocket socket;
    DatagramPacket pkt;
    public Handler(DatagramSocket socket) {
        byte[] rbuf = new byte[10];
        this.socket = socket;
        this.pkt = new DatagramPacket(rbuf, rbuf.length);
    }
```

Program to calculate the factorial of a number

Handler

```
    public void run() {
        try {
         while (true) {
              socket.receive(pkt);
              byte[] sbuf = new byte[10];
              String data = new String(pkt.getData(), 0, pkt.getLength());
              InetAddress addr = pkt.getAddress();
               int port = pkt.getPort();
               int fact = 1;
               int n = Integer.parseInt(data);
              System.out.println("Received: " + n + " from " + addr + ":" + port);
              for (int i = 2; i <= n; i++)
                    fact *= i;
              sbuf = String.valueOf(fact).getBytes();
              DatagramPacket spkt = new DatagramPacket(sbuf, sbuf.length, addr, port);
              socket.send(spkt);
              System.out.println("Sent: " + fact);
              socket.close();
          }
        }
        catch (IOException e) {
        }
    }
}
```

Program to calculate the factorial of a number

Server

```
import java.io.*;
import java.net.*;
public class FactServerT {
    public static void main(String args[]) throws Exception {
            DatagramSocket socket = new DatagramSocket(5000);
            System.out.println("Server ready");
            Thread myThread = new Handler(socket);
            myThread.start();
    }
}
```

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Exercises

1. Run the previous examples.
2. Develop a simple chatting application using Connectionless sockets.
   - When the user presses the enter key, whatever characters have been typed by the user until then, are transferred to the other end.
   - You can also assume that for every message entered from one end, a reply must come from the other end, before another message could be sent.
   - More than one message cannot be sent from a side before receiving a response from the other side.
   - Assume the maximum number of characters that can be transferred in a message to be 1000. The chat will be stopped by pressing Ctrl+C on both sides.