Java Socket Programming

Java Sockets Programming

- The package java.net provides support for sockets programming (and more).
- Typically you import everything defined in this package with:

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

Classes

InetAddress

Socket

ServerSocket

DatagramSocket

DatagramPacket

InetAddress class

- static methods you can use to create new InetAddress objects.
  - `getByName(String host)`
  - `getAllByName(String host)`
  - `getLocalHost()`

```
InetAddress x = InetAddress.getByName(
                                    "cse.unr.edu");
```

- Throws **UnknownHostException**

```
try {

  InetAddress a = InetAddress.getByName(hostname);
  System.out.println(hostname + ":" + a.getHostAddress());

} catch (UnknownHostException e) {

       System.out.println("No address found for " + hostname);

}
```

Socket class

- Corresponds to active TCP sockets only!
  - client sockets
  - socket returned by accept();
- Passive sockets are supported by a different class:
  - ServerSocket
- UDP sockets are supported by
  - DatagramSocket

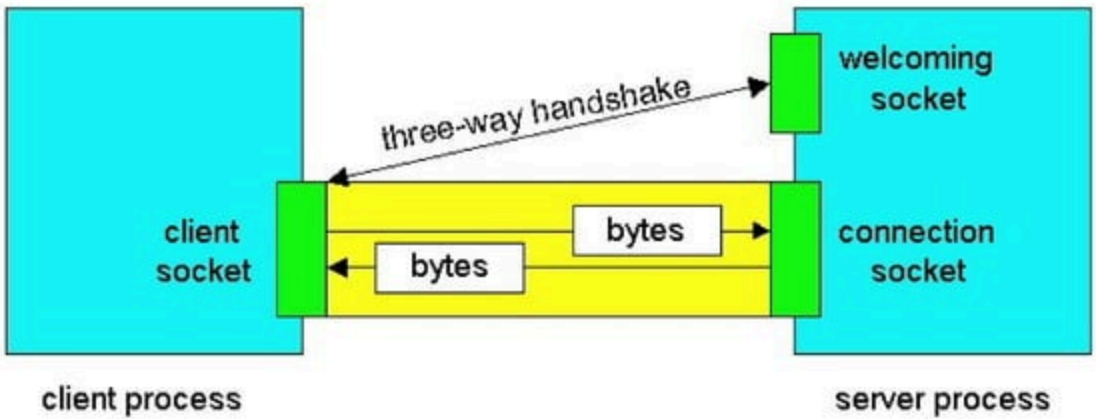
JAVA TCP Sockets (Client Socket)

- java.net.Socket
  - Implements client sockets (also called just "sockets").
  - An endpoint for communication between two machines.
  - Constructor and Methods
    - ***Socket(String host, int port):*** Creates a stream socket and connects it to the specified port number on the named host.
    - ***InputStream getInputStream()***
    - ***OutputStream getOutputStream()***
    - ***close()***

ServerSocket

- java.net.ServerSocket
  - Implements server sockets.
  - Waits for requests to come in over the network.
  - Performs some operation based on the request.
  - Constructor and Methods
    - ServerSocket(int port)
    - Socket Accept(): Listens for a connection to be made to this socket and accepts it. This method blocks until a connection is made.

Sockets



Client socket, welcoming socket (passive) and connection socket (active)

Socket Constructors

- Constructor creates a TCP connection to a named TCP server.
  - There are a number of constructors:

```
Socket(InetAddress server, int port);

Socket(InetAddress server, int port,
       InetAddress local, int localport);

Socket(String hostname, int port);
```

Socket Methods

```
void close();
InetAddress getInetAddress();
InetAddress getLocalAddress();
InputStream getInputStream();
OutputStream getOutputStream();
```

- Lots more (setting/getting socket options, partial close, etc.)

Socket I/O

- Socket I/O is based on the Java I/O support
  - in the package `java.io`
- InputStream and OutputStream are abstract classes
  - common operations defined for all kinds of InputStreams, OutputStreams...

InputStream Basics

```
// reads some number of bytes and
// puts in buffer array b
int read(byte[] b);

// reads up to len bytes
int read(byte[] b, int off, int len);
```

Both methods can throw `IOException`.
Both return -1 on EOF.

OutputStream Basics

```
// writes b.length bytes
void write(byte[] b);

// writes len bytes starting
// at offset off
void write(byte[] b, int off, int len);
```

Both methods can throw `IOException`.

ServerSocket Class (TCP Passive Socket)

- Constructors:

```
ServerSocket(int port);

ServerSocket(int port, int backlog);

ServerSocket(int port, int backlog,
             InetAddress bindAddr);
```

ServerSocket Methods

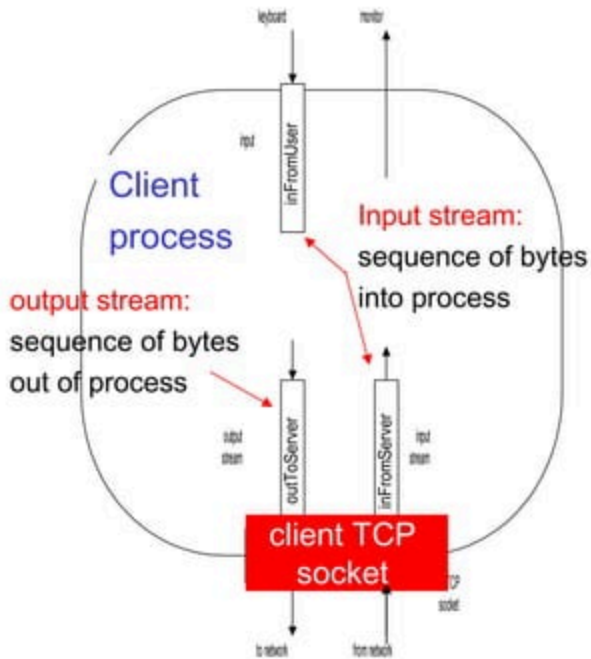
```
Socket accept();

void close();

InetAddress getInetAddress();

int getLocalPort();
```

throw `IOException, SecurityException`

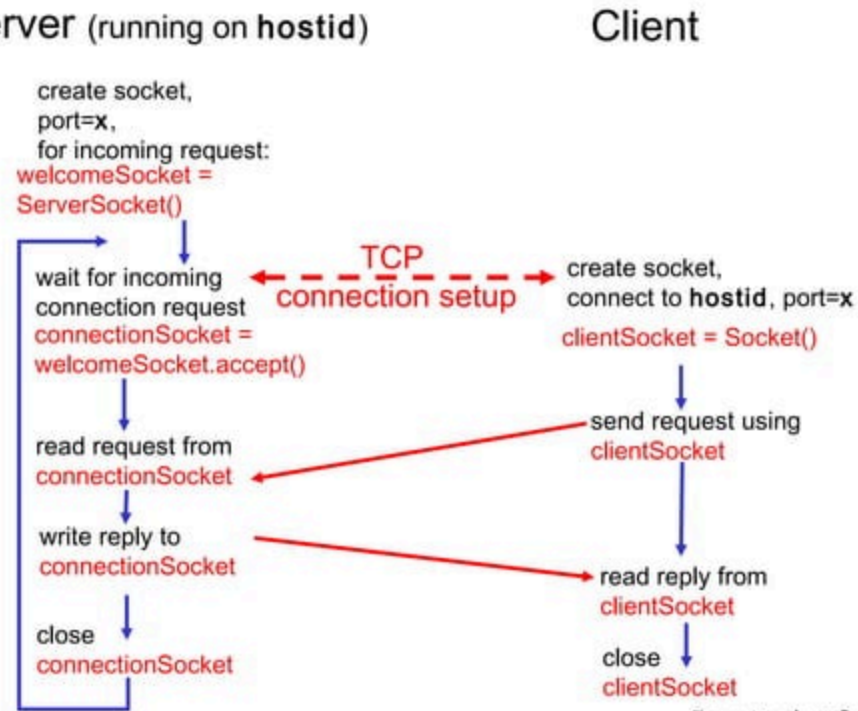
Socket programming with TCP

Example client-server app:

- client reads line from standard input (**inFromUser** stream) , sends to server via socket (**outToServer** stream)
- server reads line from socket
- server converts line to uppercase, sends back to client
- client reads, prints modified line from socket (**inFromServer** stream)



Client/server socket interaction: TCP



Sample Echo Server

TCPEchoServer.java
And TCPClient.java

Save both files, compile and run on separate terminal.
First TCPEchoServer and then TCPClient

Based on code from:

TCP/IP Sockets in Java

TCPEchoServer.java

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

Public class TCPEchoServer {
   public static void main(String argv[]) throws Exception {
       String clientSentence;
       String capitalizedSentence;

       ServerSocket welcomeSocket = new ServerSocket(6789);
       // server running and listening
       while(true) {
           Socket connectionSocket = welcomeSocket.accept();
           // new client connected
           BufferedReader inFromClient = new BufferedReader
              (new InputStreamReader
              (connectionSocket.getInputStream()));

           DataOutputStream  outToClient = new DataOutputStream
              (connectionSocket.getOutputStream());
```

```
        clientSentence = inFromClient.readLine();
        capitalizedSentence = clientSentence.toUpperCase()+ '\n';
        outToClient.writeBytes(capitalizedSentence);
      }
   }
}
```

TCPClient.java

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

Public class TCPClient {
   public static void main(String argv[]) throws Exception {
       String sentence;
       String modifiedSentence;

       BufferedReader inFromUser = new BufferedReader(new
                    InputStreamReader(System.in));

       Socket clientSocket = new Socket("hostname", 6789);

       DataOutputStream outToServer = new DataOutputStream
                    (clientSocket.getOutputStream());

       BufferedReader inFromServer = new BufferedReader(new
             InputStreamReader(clientSocket.getInputStream()));
```

```
        sentence = inFromUser.readLine();

        outToServer.writeBytes(sentence + '\n');

        modifiedSentence = inFromServer.readLine();

        System.out.println("FROM SERVER: " + modifiedSentence);

        clientSocket.close();

    }
}
```

UDP Sockets

- `DatagramSocket` class
- `DatagramPacket` class needed to specify the payload
  - incoming or outgoing

Socket Programming with UDP

- UDP
  - Connectionless and unreliable service.
  - There isn't an initial handshaking phase.
  - Transmitted data may be received out of order, or lost.

- Socket Programming with UDP
  - No need for a welcoming socket.
  - No streams are attached to the sockets.
  - The sending hosts creates "packets" by attaching the IP destination address and port number to each batch of bytes.
  - The receiving process must unravel to received packet to obtain the packet's information bytes.

JAVA UDP Sockets

- In Package java.net
  - java.net.DatagramSocket
    - A socket for sending and receiving datagram packets.
    - Constructor and Methods
      - DatagramSocket(int port): Constructs a datagram socket and binds it to the specified port on the local host machine.
      - void receive (DatagramPacket p)
      - void send (DatagramPacket p)
      - void close()

DatagramSocket Constructors

```
DatagramSocket();

DatagramSocket(int port);

DatagramSocket(int port, InetAddress a);
```

All can throw SocketException or SecurityException

Datagram Methods

```
void connect(InetAddress, int port);

void close();

void receive(DatagramPacket p);

void send(DatagramPacket p);
```

Lots more!

DatagramPacket

- Contain the payload
  - (a byte array, length of byte array, InetAddress, port)
- Can also be used to specify the destination address
  - when not using connected mode UDP

DatagramPacket Constructors

For receiving:

```
DatagramPacket( byte[] buf, int len);
```

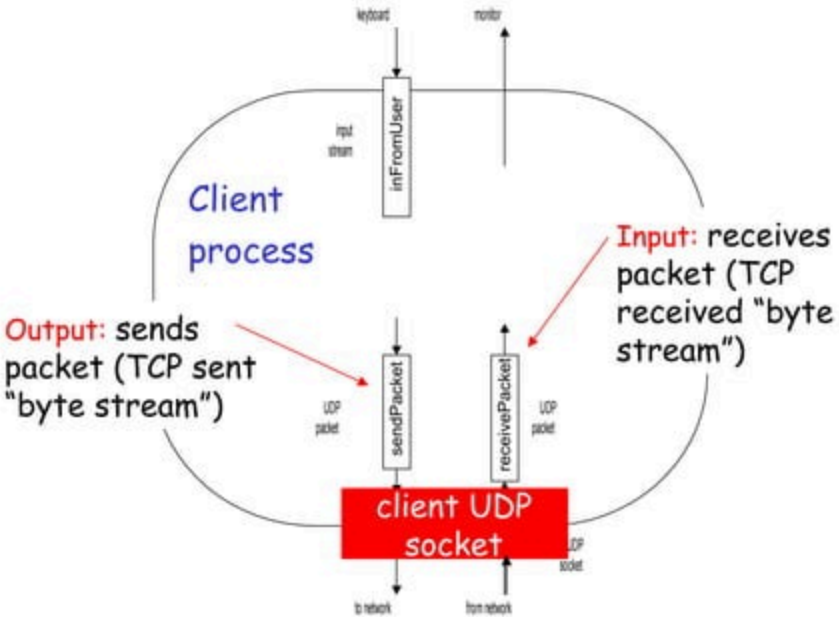
For sending:

```
DatagramPacket( byte[] buf, int len
                InetAddress a, int port);
```

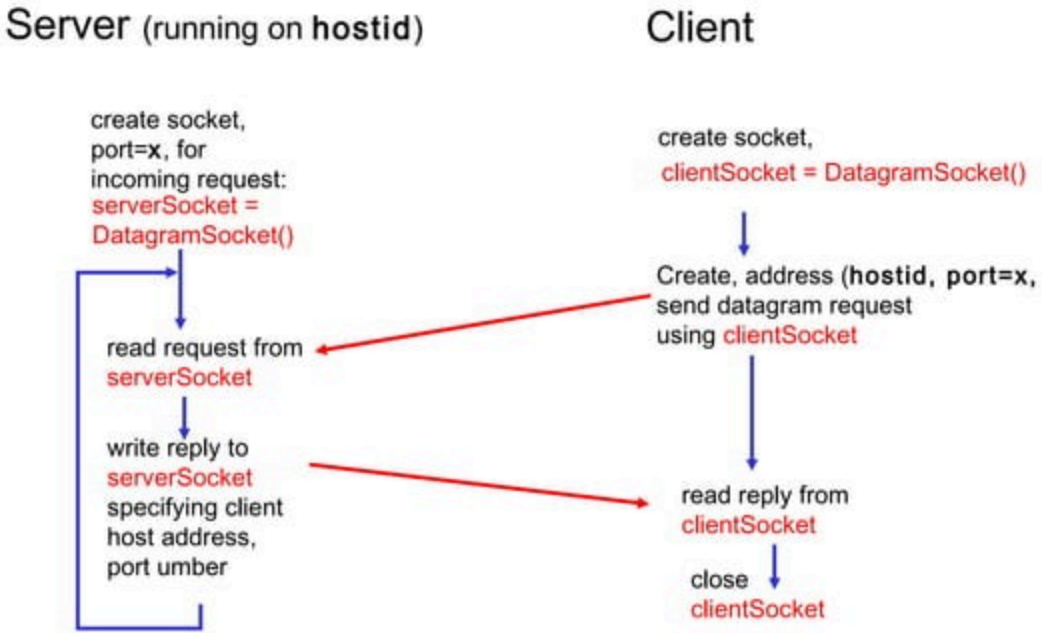
DatagramPacket methods

```
byte[] getData();
void setData(byte[] buf);

void setAddress(InetAddress a);
void setPort(int port);

InetAddress getAddress();
int getPort();
```

Example: Java client (UDP)



Client/server socket interaction: UDP



Sample UDP code

UDPEchoServer.java

Simple UDP Echo server.

Test using nc as the client (netcat):

```
> nc -u hostname port
```

UDPEchoServer.java

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

class UDPEchoServer {
   public static void main(String args[]) throws Exception {
        int port = 9876;
        DatagramSocket serverSocket = new DatagramSocket(port);

        byte[] receiveData = new byte[1024];
        byte[] sendData  = new byte[1024];

        while(true) {
           DatagramPacket receivePacket =
            new DatagramPacket (receiveData, receiveData.length);


           serverSocket.receive(receivePacket);

           String sentence = new String(receivePacket.getData());

           InetAddress IPAddress = receivePacket.getAddress();
```

```
      int clientPort = receivePacket.getPort();

      String capitalizedSentence = sentence.toUpperCase();
         sendData = capitalizedSentence.getBytes();

      DatagramPacket sendPacket = new DatagramPacket
        (sendData, sendData.length, IPAddress, clientPort);

       serverSocket.send(sendPacket);

       }
   }
}
```

UDPClient.java

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

public class UDPClient {
   public static void main(String args[]) throws Exception {

      BufferedReader inFromUser = new BufferedReader
                        (new InputStreamReader (System.in));
      int port = 9876;

      DatagramSocket clientSocket = new DatagramSocket();

      InetAddress IPAddress = InetAddress.getByName("hostname");


      byte[] sendData = new byte[1024];
      byte[] receiveData = new byte[1024];

      String sentence = inFromUser.readLine();

      sendData = sentence.getBytes();
```

```
        DatagramPacket sendPacket = new DatagramPacket (sendData,
                sendData.length, IPAddress, port);

        clientSocket.send(sendPacket);

        DatagramPacket receivePacket = new DatagramPacket
                (receiveData, receiveData.length);

        clientSocket.receive(receivePacket);

        String modifiedSentence =
                new String(receivePacket.getData());

        System.out.println("FROM SERVER:" + modifiedSentence);

        clientSocket.close();

    }
}
```

Socket functional calls

- socket (): Create a socket
- bind(): bind a socket to a local IP address and port #

- listen(): passively waiting for connections
- connect(): initiating connection to another socket
- accept(): accept a new connection

- Write(): write data to a socket
- Read(): read data from a socket
- sendto(): send a datagram to another UDP socket
- recvfrom(): read a datagram from a UDP socket

- close(): close a socket (tear down the connection)

Java URL Class

- Represents a Uniform Resource Locator
  - scheme (protocol)
  - hostname
  - port
  - path
  - query string

Parsing

- You can use a URL object as a *parser*:

```
URL u = new URL("http://www.cs.unr.edu/");

System.out.println("Proto:" + u.getProtocol());

System.out.println("File:" + u.getFile());
```

URL construction

- You can also build a URL by setting each part individually:

```
URL u = new URL("http",
                www.cs.unr.edu,80,"/~mgunes/");

System.out.println("URL:" + u.toExternalForm());

System.out.println("URL: " + u);
```

Retrieving URL contents

- URL objects can retrieve the documents they refer to!
  - actually this depends on the protocol part of the URL.
  - HTTP is supported
  - File is supported ("file://c:\foo.html")
  - You can get "Protocol Handlers" for other protocols.

- There are a number of ways to do this:

```
Object getContent();

InputStream openStream();

URLConnection openConnection();
```

Getting Header Information

- There are methods that return information extracted from response headers:

```
String getContentType();

String getContentLength();

long getLastModified();
```

URLConnection

- Represents the connection (not the URL itself).
- More control than URL
  - can write to the connection (send POST data).
  - can set request headers.
- Closely tied to HTTP