Java Socket Programming

Computer Network Systems

slides are modified from **Dave Hollinger** and **Joonbok Lee**

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`

Sample Code: Lookup.java

- Uses InetAddress class to lookup hostnames found on command line.

```
> java Lookup cse.unr.edu www.yahoo.com
cse.unr.edu:134.197.40.9
www.yahoo.com:209.131.36.158
```

```
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

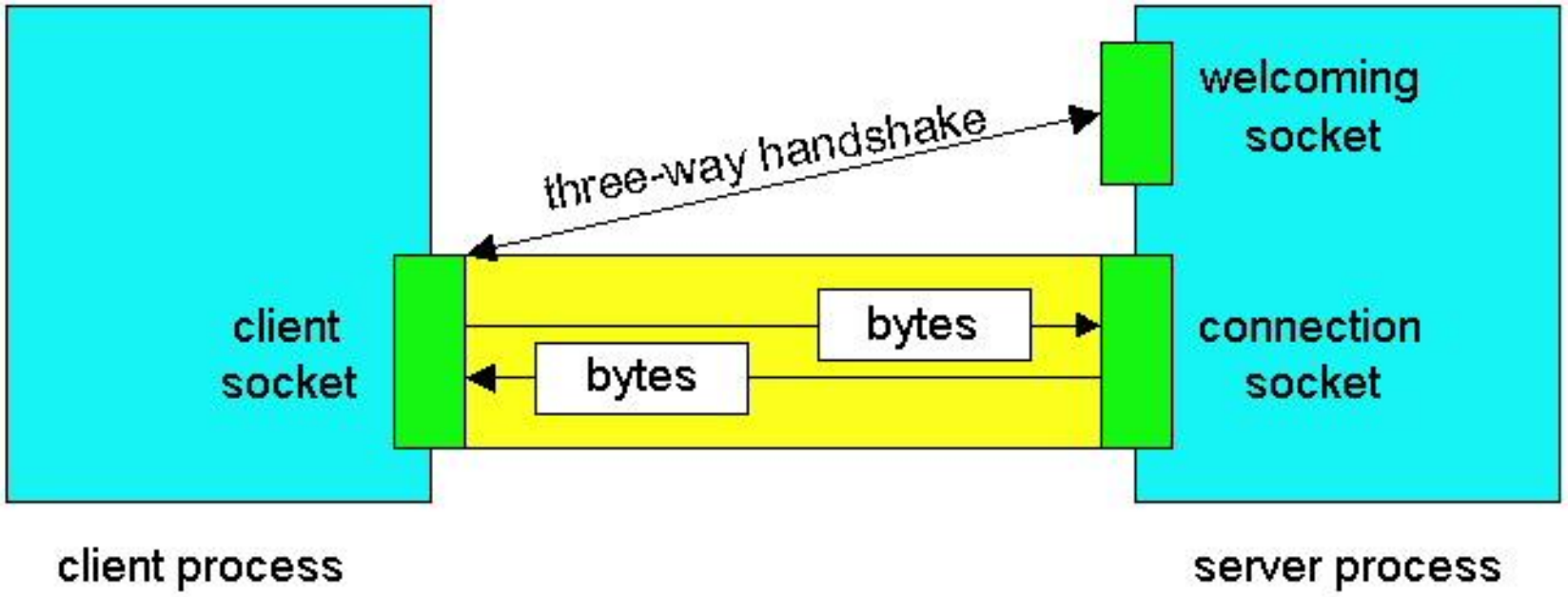
- Corresponds to active TCP sockets only!
  - client sockets
  - socket returned by accept();
- Passive sockets are supported by a different class:
  - ServerSocket
- UDP sockets are supported by
  - DatagramSocket

JAVA TCP Sockets

- 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()

- 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

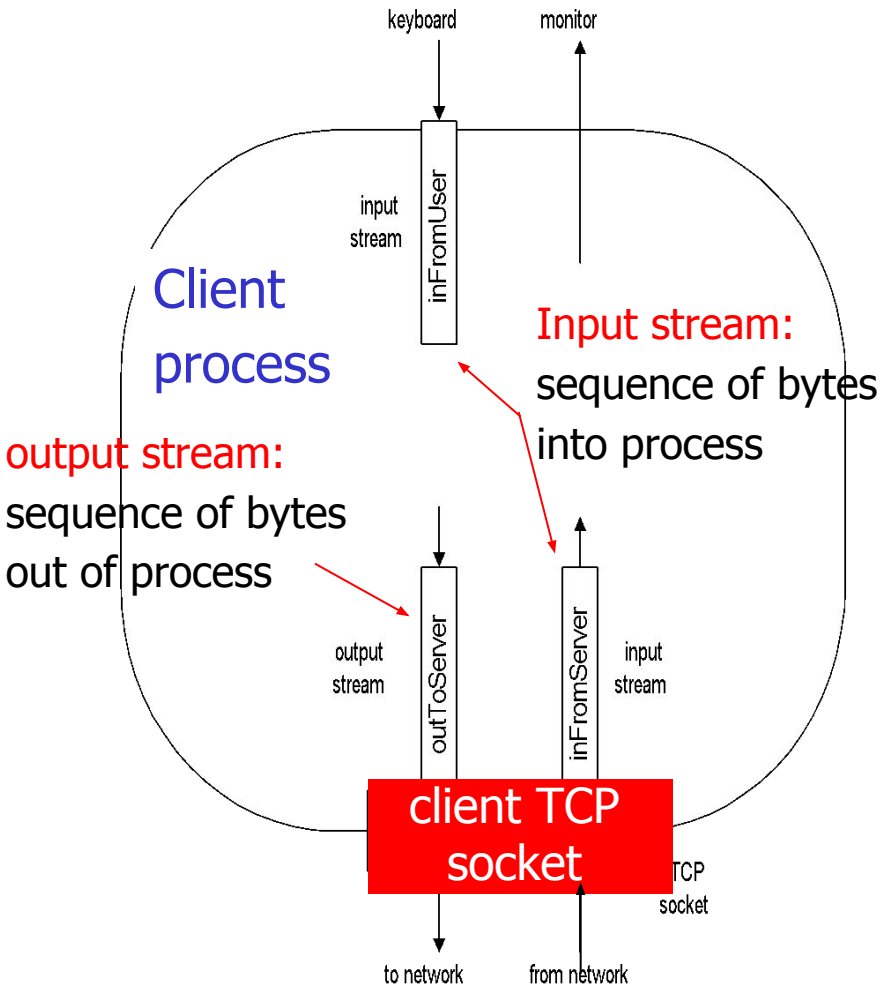
```
Socket accept();

void close();

InetAddress getInetAddress();

int getLocalPort();
```

throw `IOException, SecurityException`

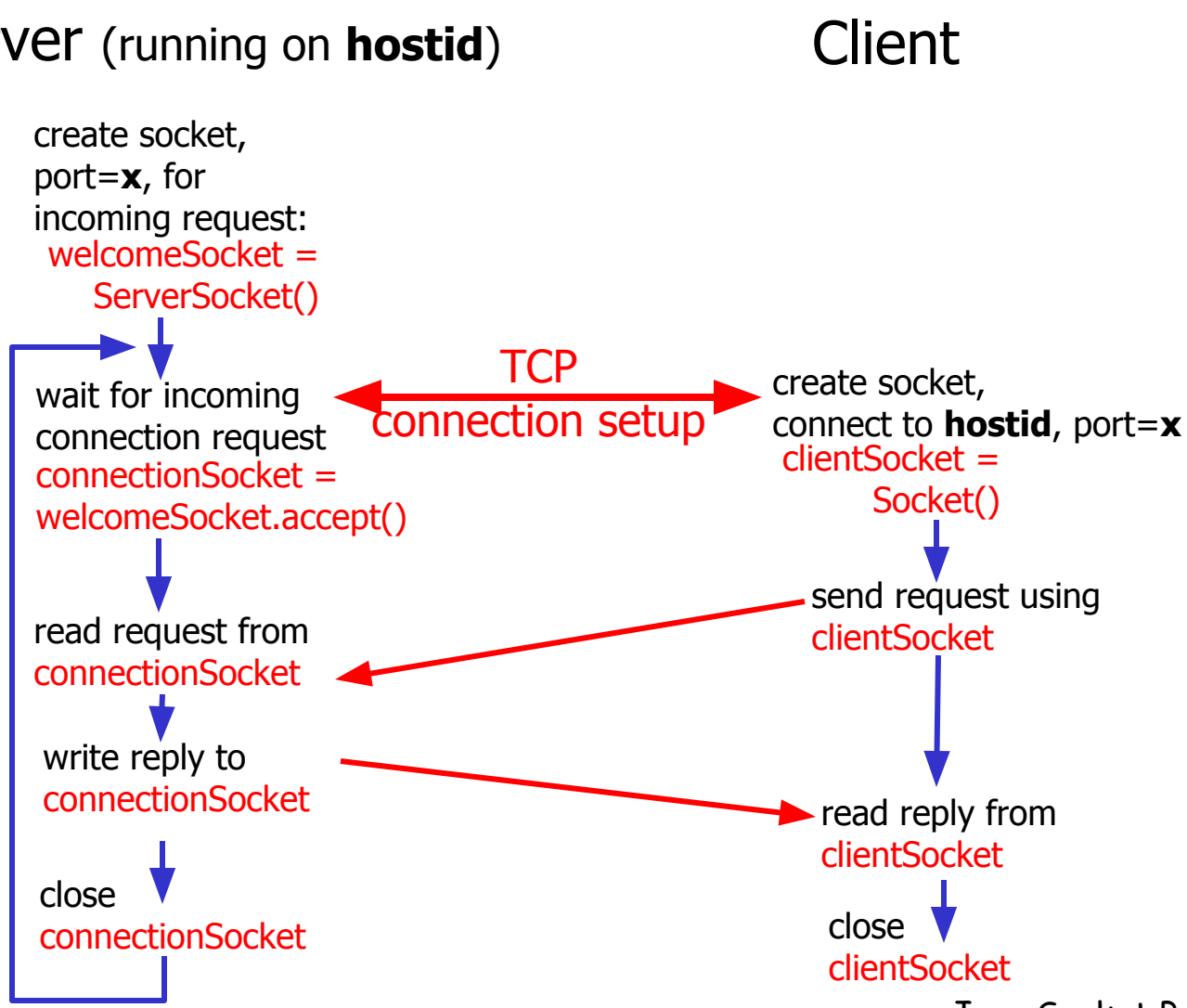
Socket programming with TCP

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



TCPClient.java

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

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());
```

TCPClient.java

```
        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();

    }
}
```

TCPServer.java

```
import java.io.*;
import java.net.*;
class TCPServer {
    public static void main(String argv[]) throws Exception
        {
            String clientSentence;
            String capitalizedSentence;

            ServerSocket welcomeSocket = new ServerSocket(6789);

            while(true) {

              Socket connectionSocket = welcomeSocket.accept();

             BufferedReader inFromClient = new BufferedReader(new
                   InputStreamReader(connectionSocket.getInputStream()));
```

TCPServer.java

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

        clientSentence = inFromClient.readLine();

        capitalizedSentence = clientSentence.toUpperCase() + '\n';

        outToClient.writeBytes(capitalizedSentence);

      }
    }
}
```

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.
  - Doesn't have a pipe.
  - 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!

Datagram Packet

- Contain the payload
  - (a byte array
- Can also be used to specify the destination address
  - when not using connected mode UDP

DatagramPacket Constructors

For receiving:

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

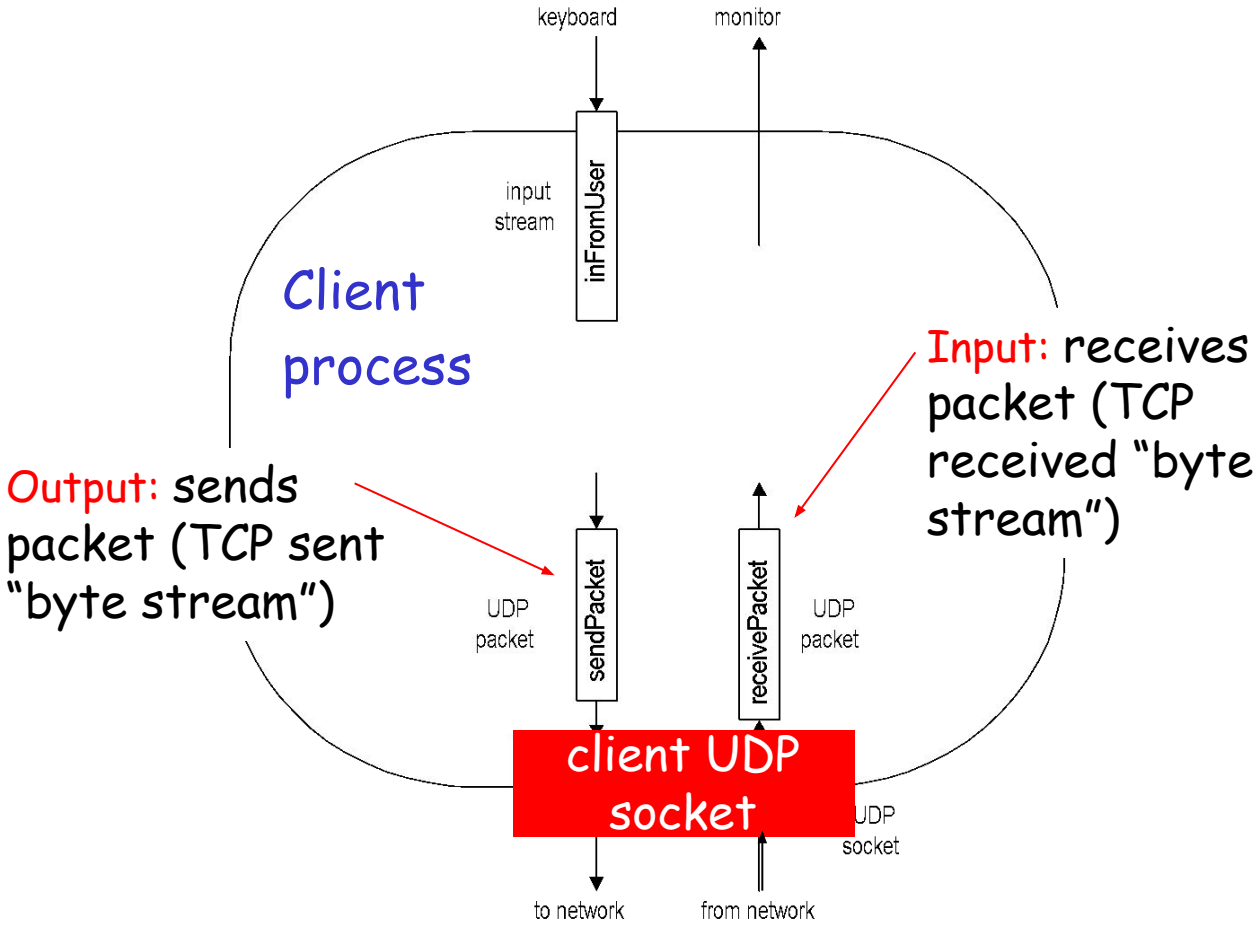
For sending:

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

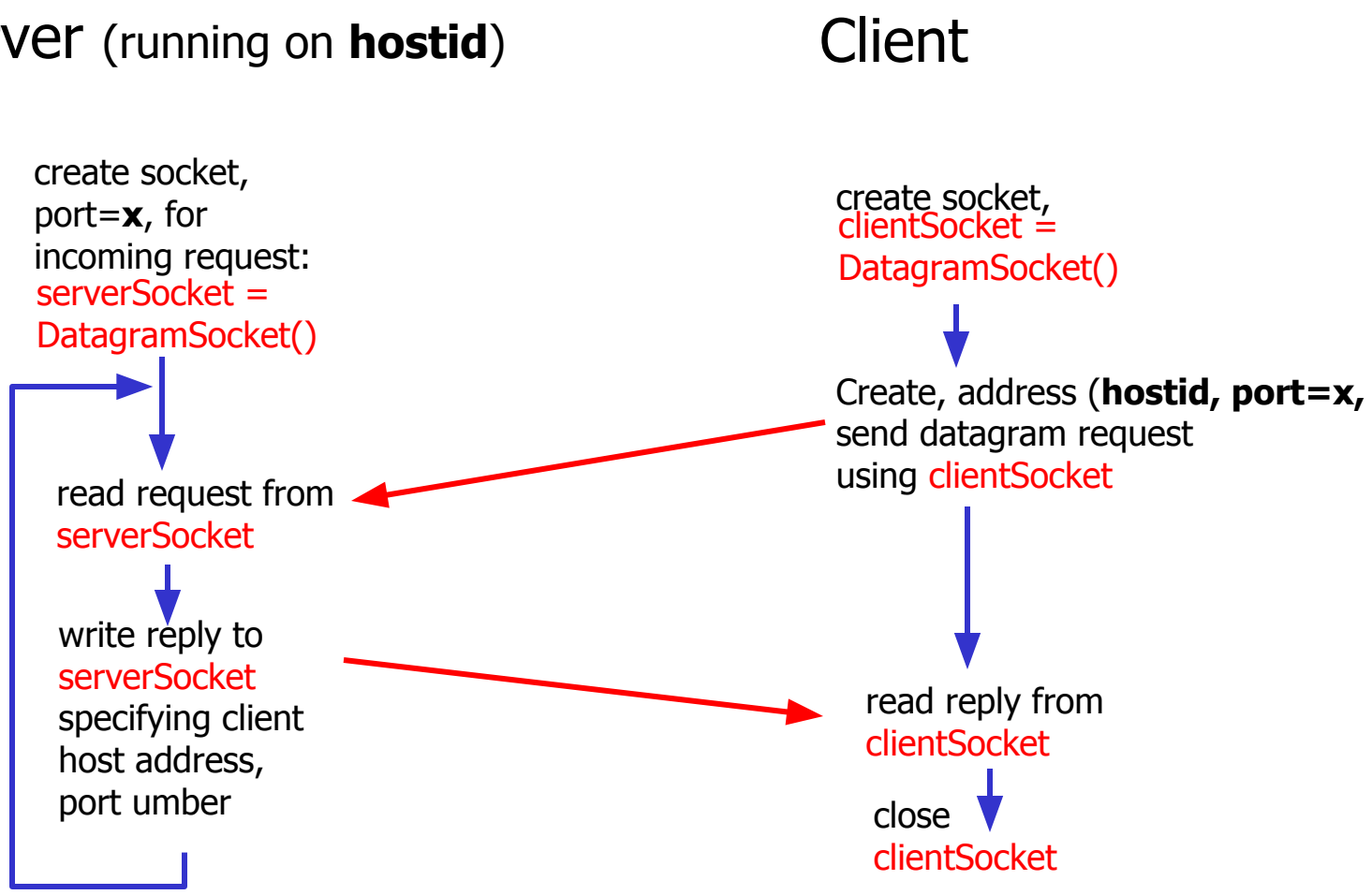
DatagramPacket methods

```
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



UDPClient.java

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

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

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

          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();
```

UDPClient.java

```
 DatagramPacket sendPacket =
        new DatagramPacket(sendData, sendData.length,
IPAddress, 9876);

 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();

    }
}
```

UDPServer.java

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

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

          DatagramSocket serverSocket = new
    DatagramSocket(9876);

          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());
```

UDPServer.java

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

int port = receivePacket.getPort();

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

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

 serverSocket.send(sendPacket);

    }
  }
}
```

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