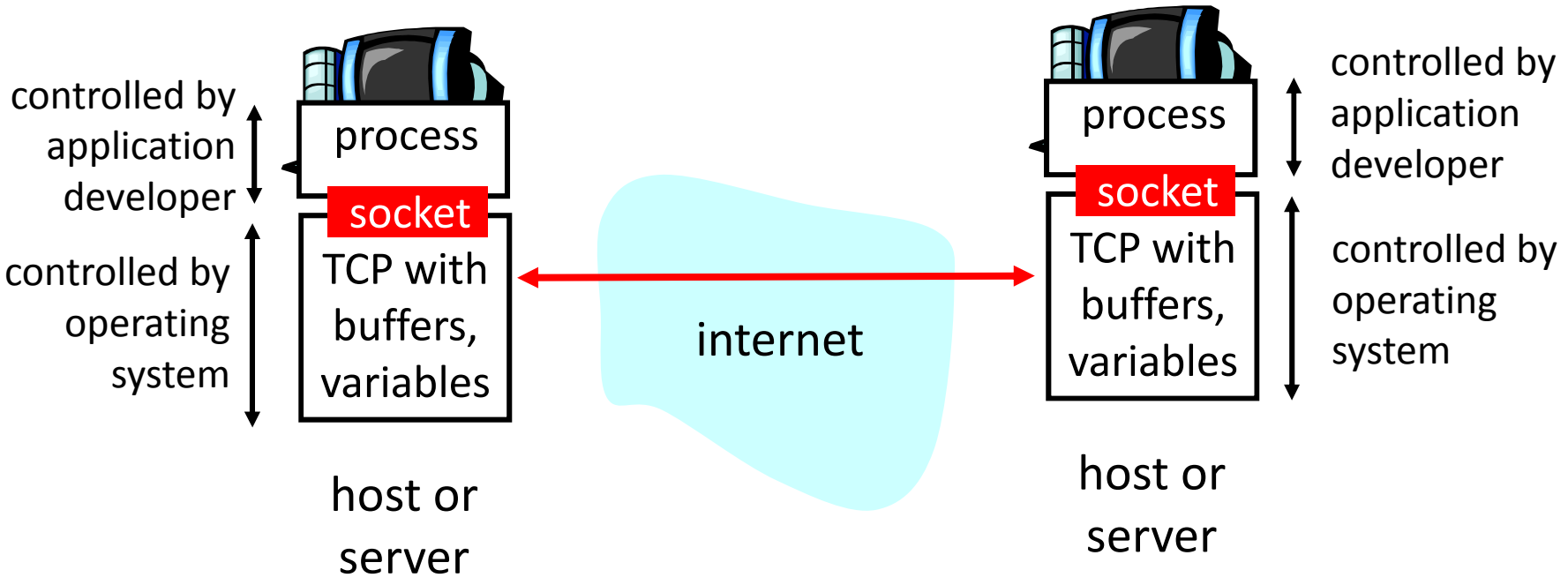
3. Socket Programming

Socket-programming using TCP

Socket: a door between application process and end-end-transport protocol (UCP or TCP)

TCP service: reliable transfer of **bytes** from one process to another



Socket programming *with TCP*

Client must contact server
server process must first be running
server must have created socket (door) that welcomes client's contact

Client contacts server by:
creating client-local TCP socket
specifying IP address, port number of server process
When client creates socket: client TCP establishes connection to server TCP

When contacted by client, server TCP creates new socket for server process to communicate with client
- allows server to talk with multiple clients
- source port numbers used to distinguish clients

application viewpoint

- *TCP provides reliable, in-order transfer of bytes ("pipe") between client and server*

Stream jargon

A stream is a sequence of characters that flow into or out of a process.

An input stream is attached to some input source for the process, eg, keyboard or socket.

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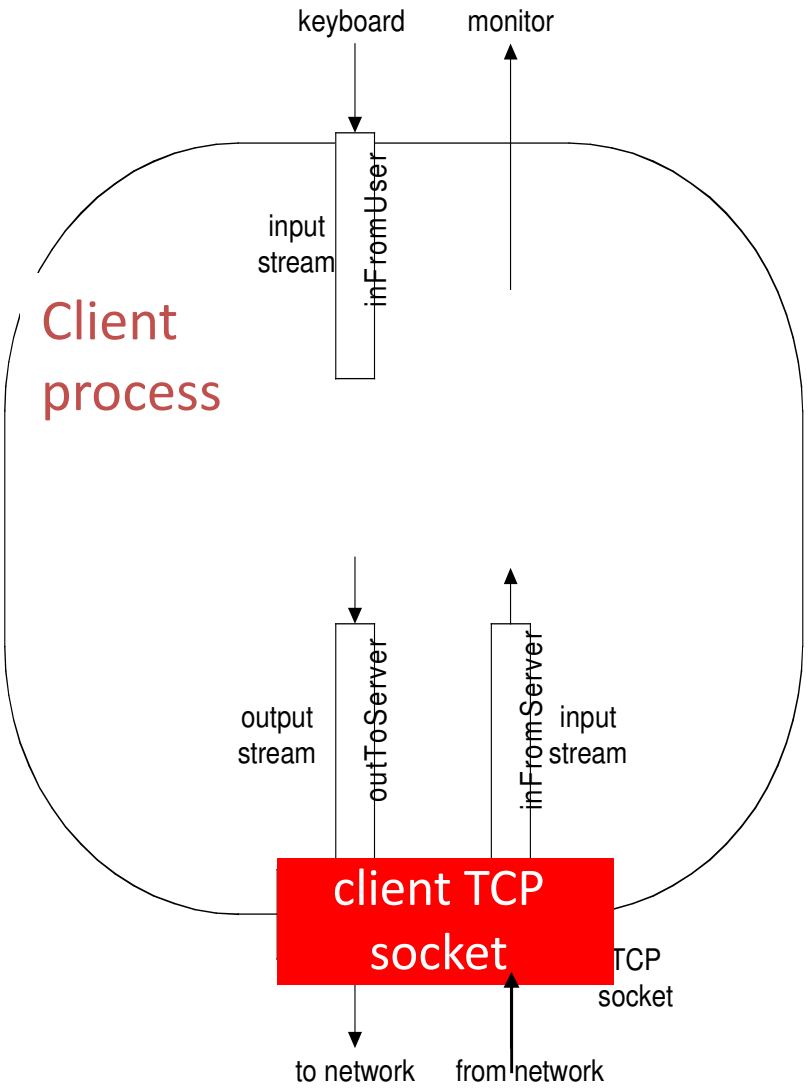

Socket programming with TCP

Example client-server app:

1) client reads line from standard input (**`inFromUser`** stream) , sends to server via socket (**`outToServer`** stream)
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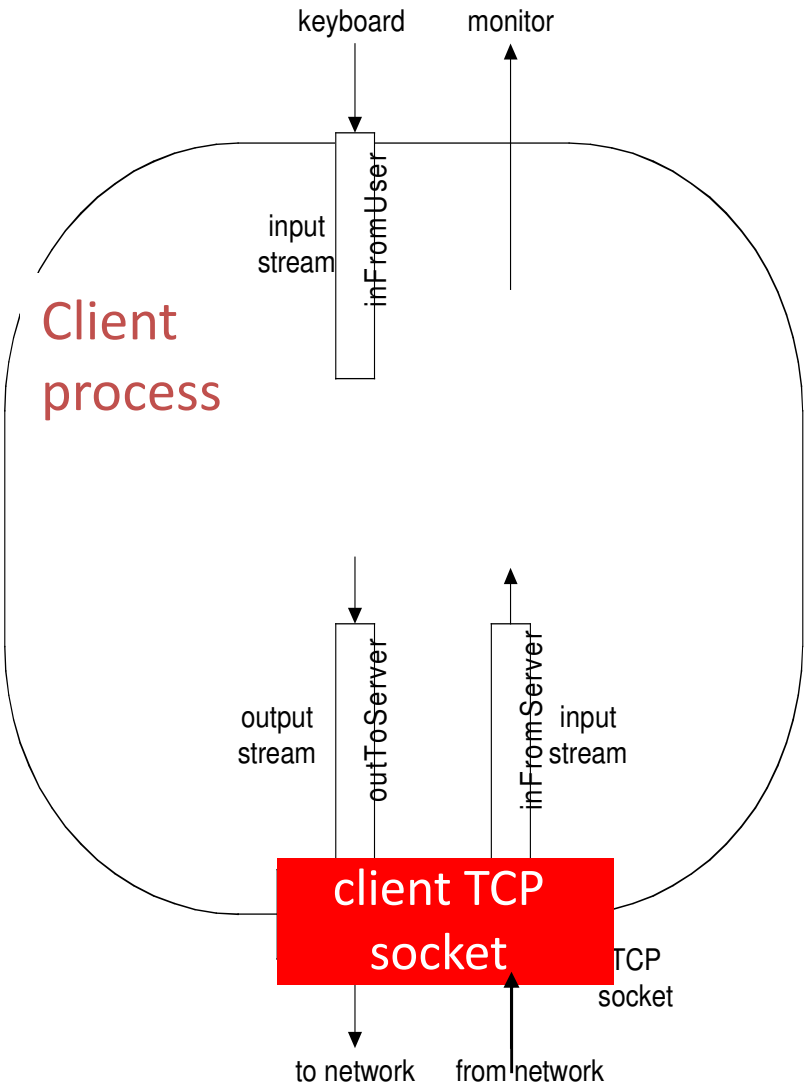
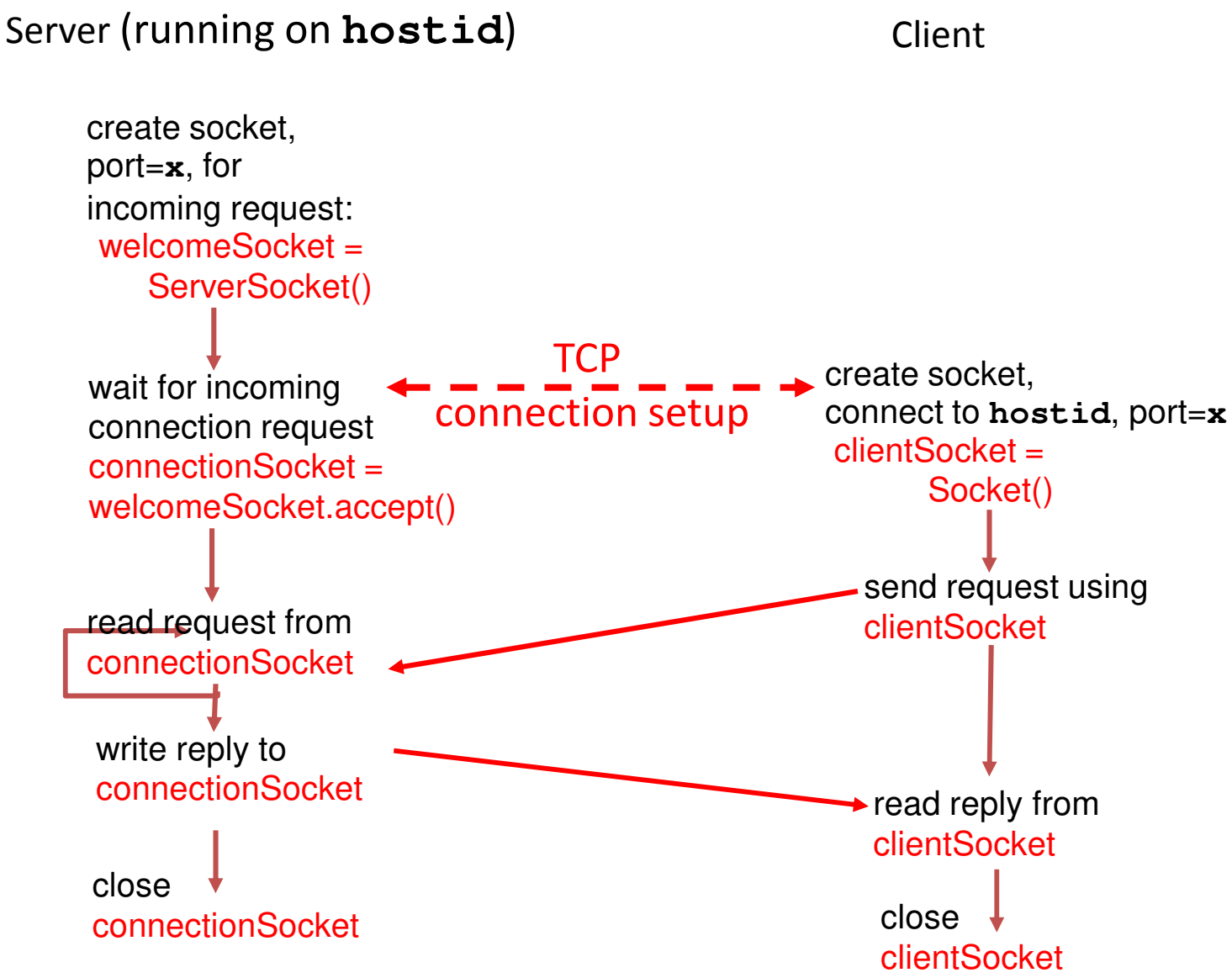


Client/server socket interaction: TCP



Java TCP Client: Reading

1 Make a Socket connection to the server

```
Socket chatSocket = new Socket("127.0.0.1", 5000);
```

The port number, which you know because we TOLD you that 5000 is the port number for our chat server.

127.0.0.1 is the IP address for "localhost", in other words, the one this code is running on. You can use this when you're testing your client and server on a single, stand-alone machine.

2 Make an InputStreamReader chained to the Socket's low-level (connection) input stream

```
InputStreamReader stream = new InputStreamReader(chatSocket.getInputStream());
```

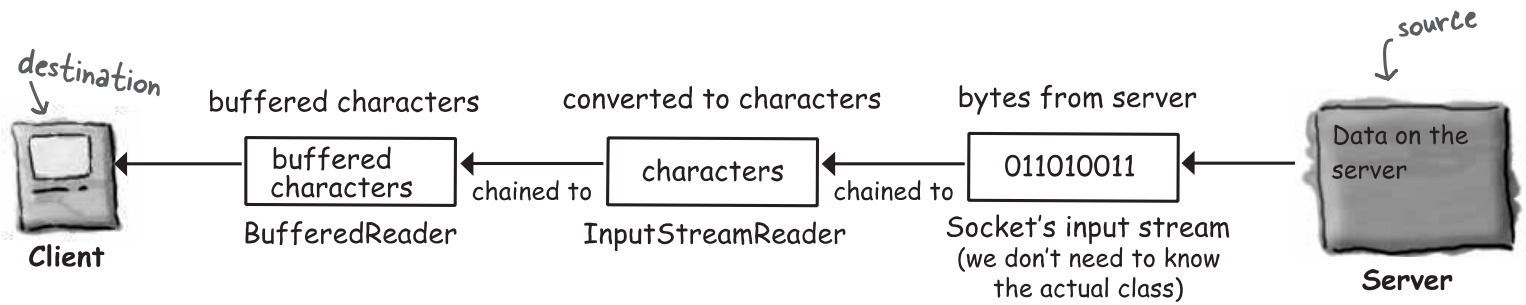
InputStreamReader is a 'bridge' between a low-level byte stream (like the one coming from the Socket) and a high-level character stream (like the BufferedReader we're after as our top of the chain stream).

All we have to do is ASK the socket for an input stream! It's a low-level connection stream, but we're just gonna chain it to something more text-friendly.

3 Make a BufferedReader and read!

Chain the BufferedReader to the InputStreamReader(which was chained to the low-level connection stream we got from the Socket.)

```
BufferedReader reader = new BufferedReader(stream);
String message = reader.readLine();
```



Java TCP Client: Writing

this part's the same as it was on the opposite page -- to write to the server, we still have to connect to it.

1 Make a Socket connection to the server

```
Socket chatSocket = new Socket("127.0.0.1", 5000);
```

2 Make a PrintWriter chained to the Socket's low-level (connection) output stream

```
PrintWriter writer = new PrintWriter(chatSocket.getOutputStream());
```

PrintWriter acts as its own bridge between character data and the bytes it gets from the Socket's low-level output stream. By chaining a PrintWriter to the Socket's output stream, we can write Strings to the Socket connection.

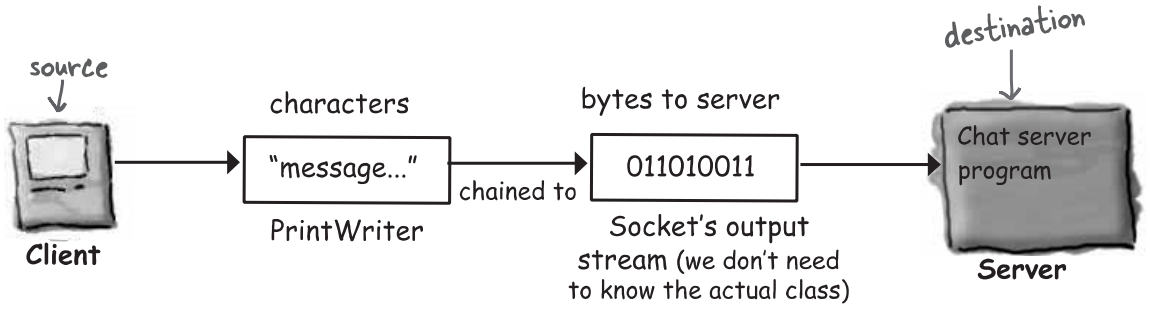
The Socket gives us a low-level connection stream and we chain it to the PrintWriter by giving it to the PrintWriter constructor.

3 Write (print) something

```
writer.println("message to send");
writer.print("another message");
```

println() adds a new line at the end of what it sends.

print() doesn't add the new line.



Example: Java client (TCP)

```
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());
```

Create input stream

Create client socket, connect to server

Create output stream attached to socket

Example: Java client (TCP), cont.

Create input stream attached to socket

```
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();

    }
}
```

Send line to server

Read line from server

Example: Java server (TCP)

```
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()));
```

Create welcoming socket at port 6789

Wait, on welcoming socket for contact by client

Create input stream, attached to socket

Example: Java server (TCP), cont

Create output stream, attached to socket

Read in line from socket

Write out line to socket

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

clientSentence = inFromClient.readLine();

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

outToClient.writeBytes(capitalizedSentence);
            }
        }
    }
```

End of while loop, loop back and wait for another client connection

Socket programming *with UDP*

UDP: no "connection" between client and server

no handshaking

sender explicitly attaches IP address and port of destination to each packet

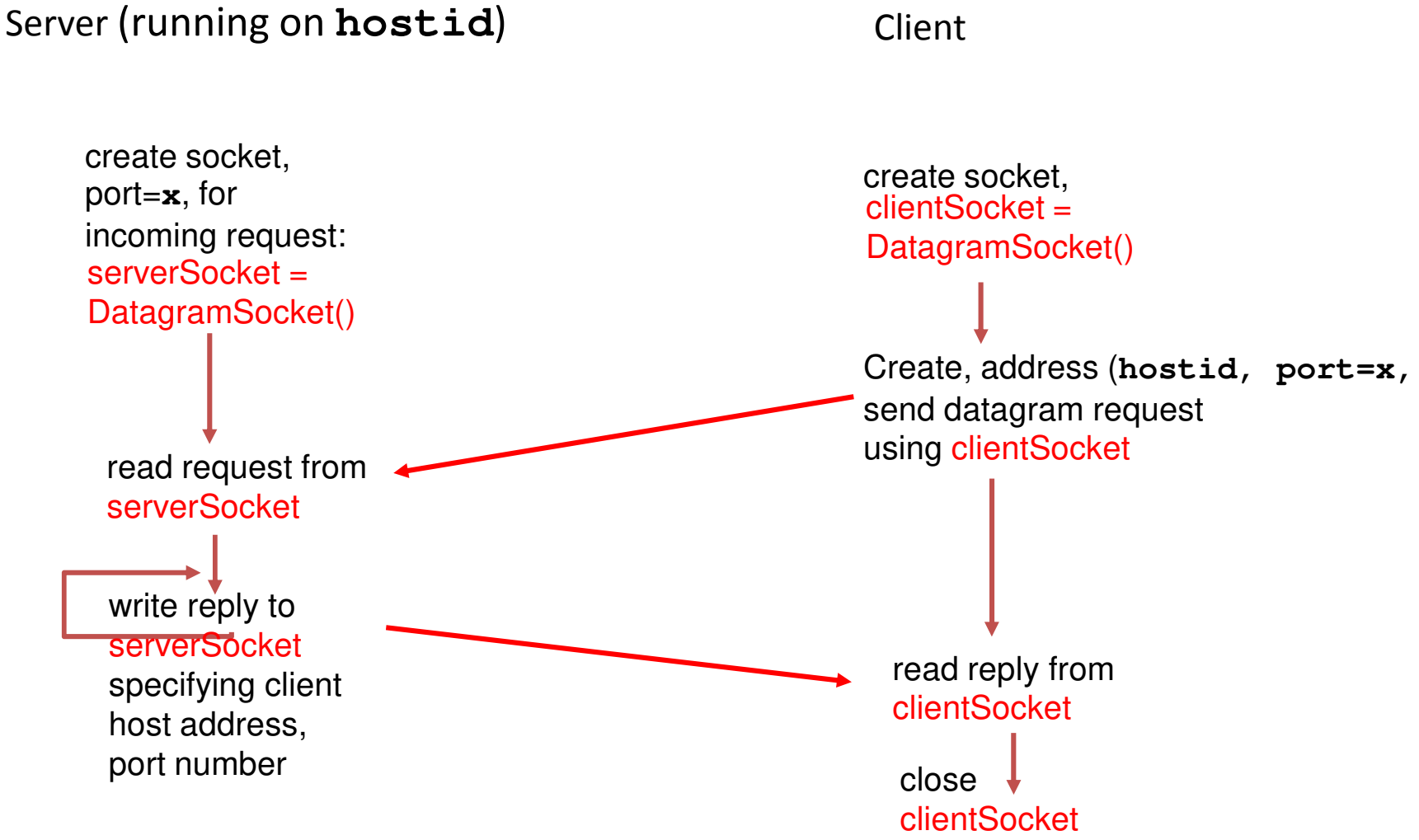
server must extract IP address, port of sender from received packet

UDP: transmitted data may be received out of order, or lost

application viewpoint

- *UDP provides <u>unreliable</u> transfer of groups of bytes ("datagrams") between client and server*

Client/server socket interaction: UDP



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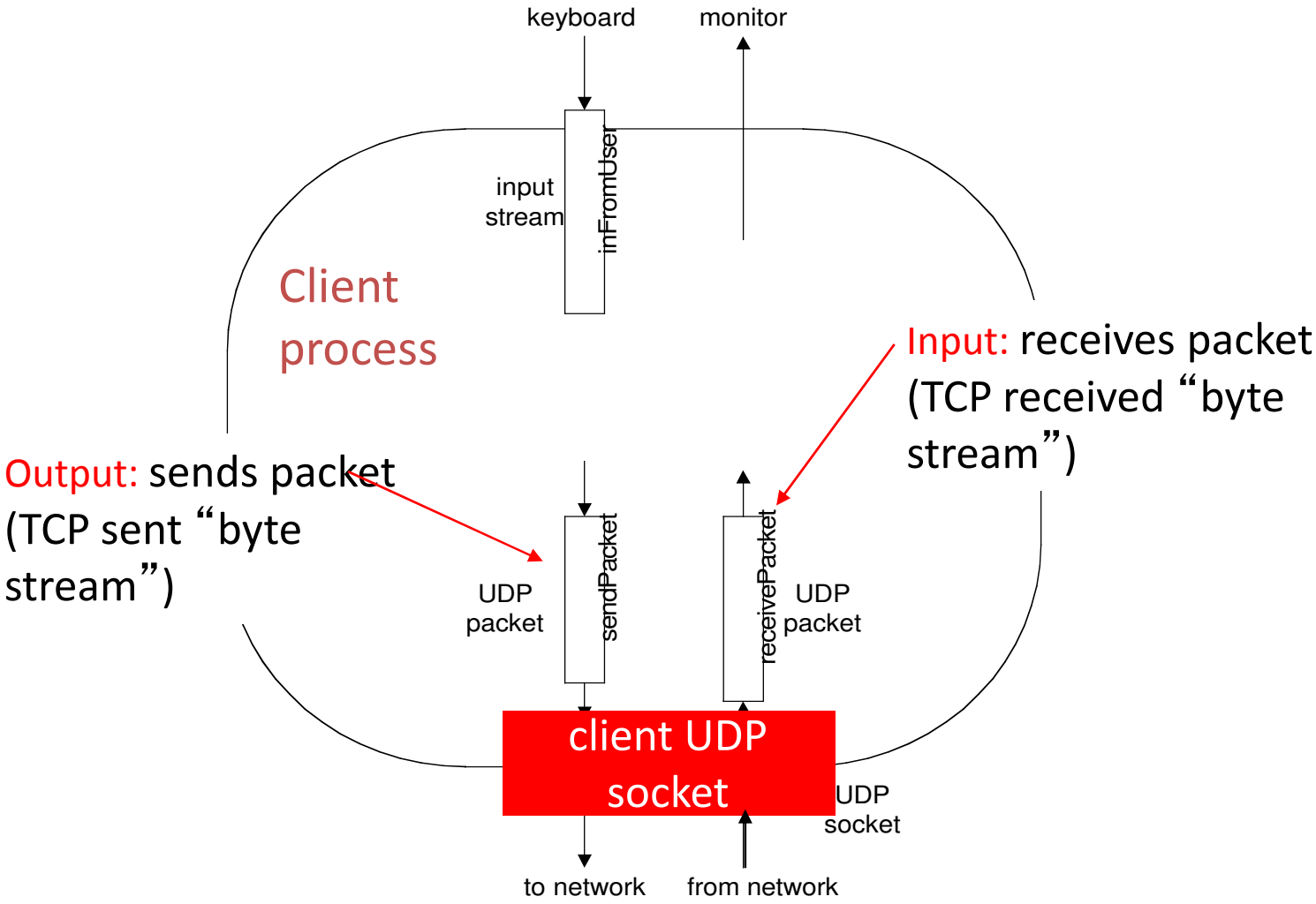

Example: Java client (UDP)

```
import java.io.*;
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class UDPClient {
   public static void main(String args[]) throws Exception
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      DatagramSocket clientSocket = new DatagramSocket();

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Create input stream

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Translate hostname to IP address using DNS

Example: Java client (UDP), cont.

Create datagram with data-to-send, length, IP addr, port

Send datagram to server

Read datagram from server

```
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                clientSocket.close();
                }
            }
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Example: Java server (UDP)

```
import java.io.*;
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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 =
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        serverSocket.receive(receivePacket);
```

Create datagram socket at port 9876

Create space for received datagram

Receive datagram

Example: Java server (UDP), cont

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

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);
    }
  }
}
```

Get IP addr port #, of sender

Create datagram to send to client

Write out datagram to socket

End of while loop, loop back and wait for another datagram

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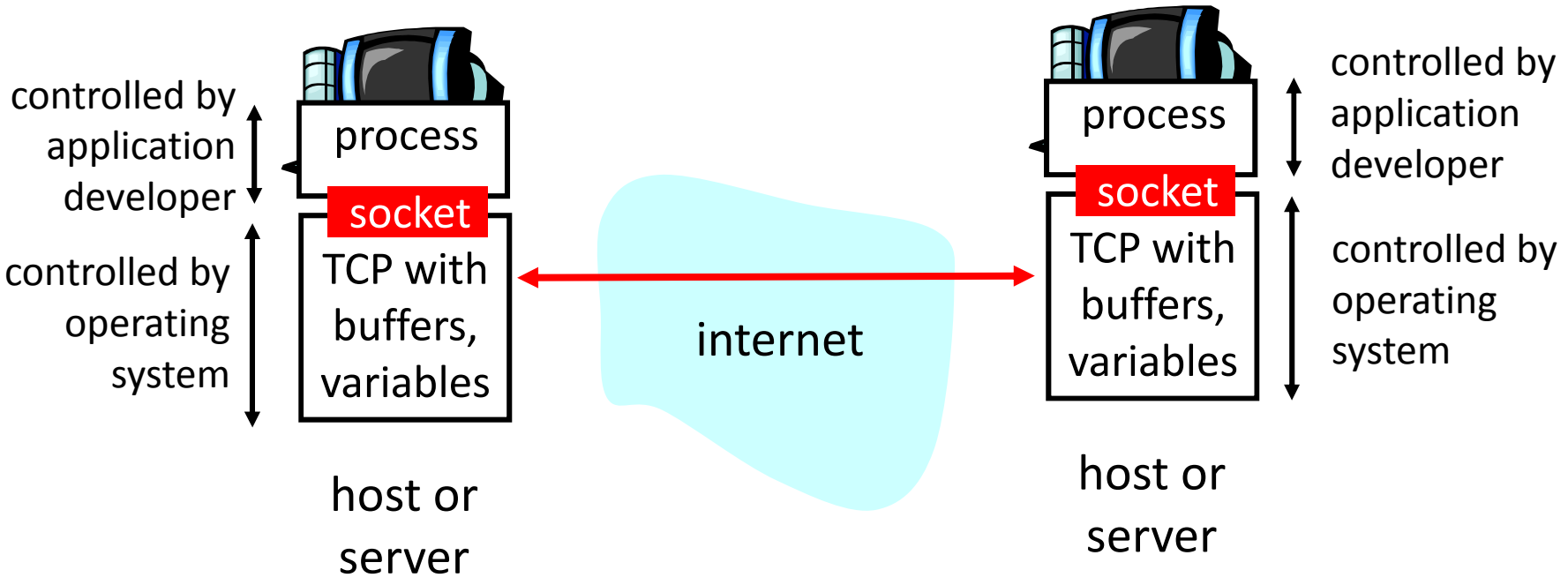

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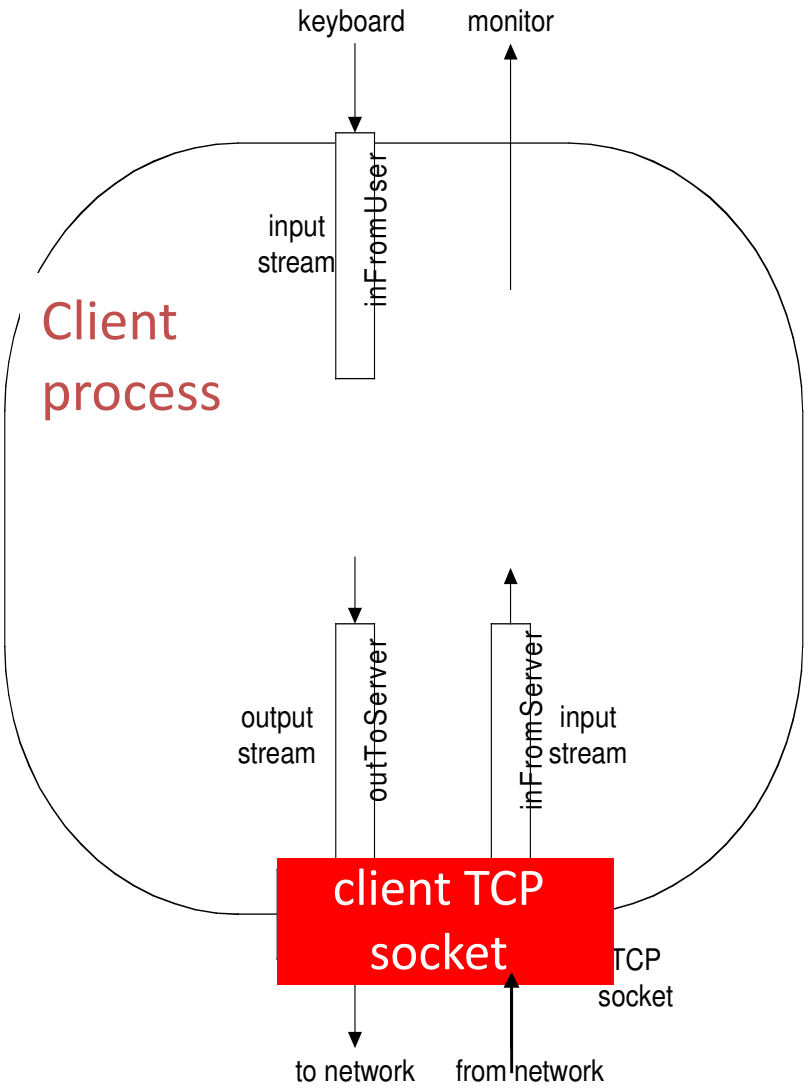

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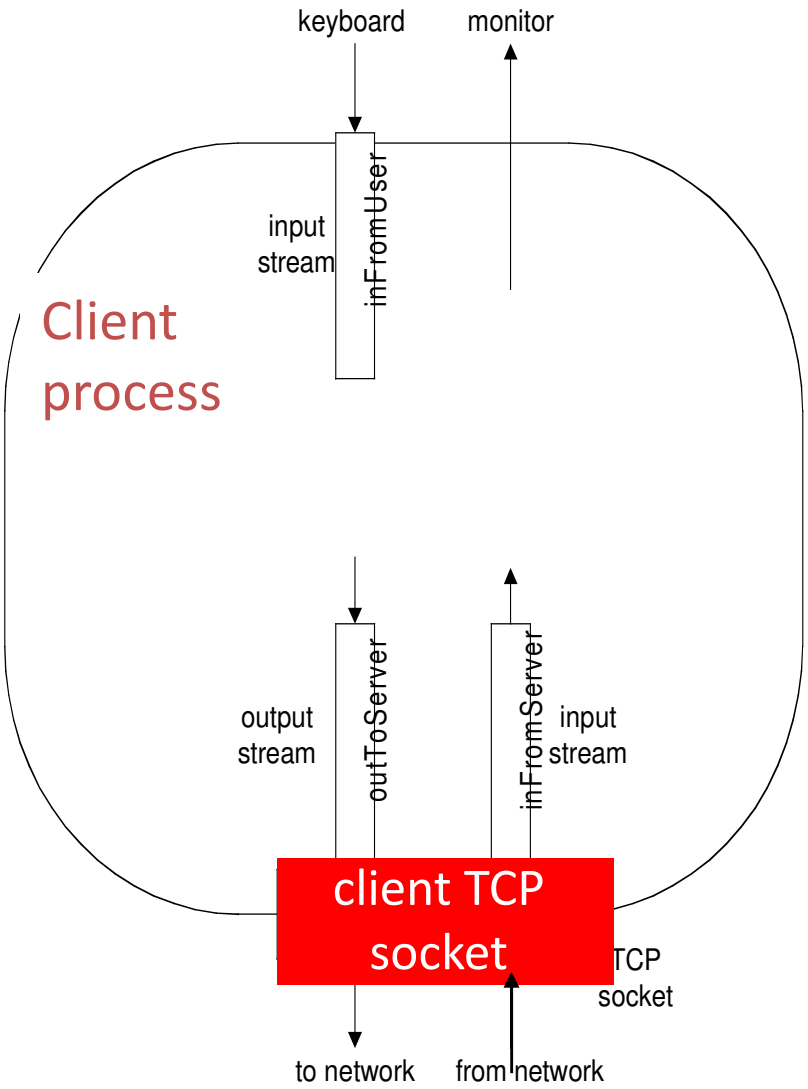

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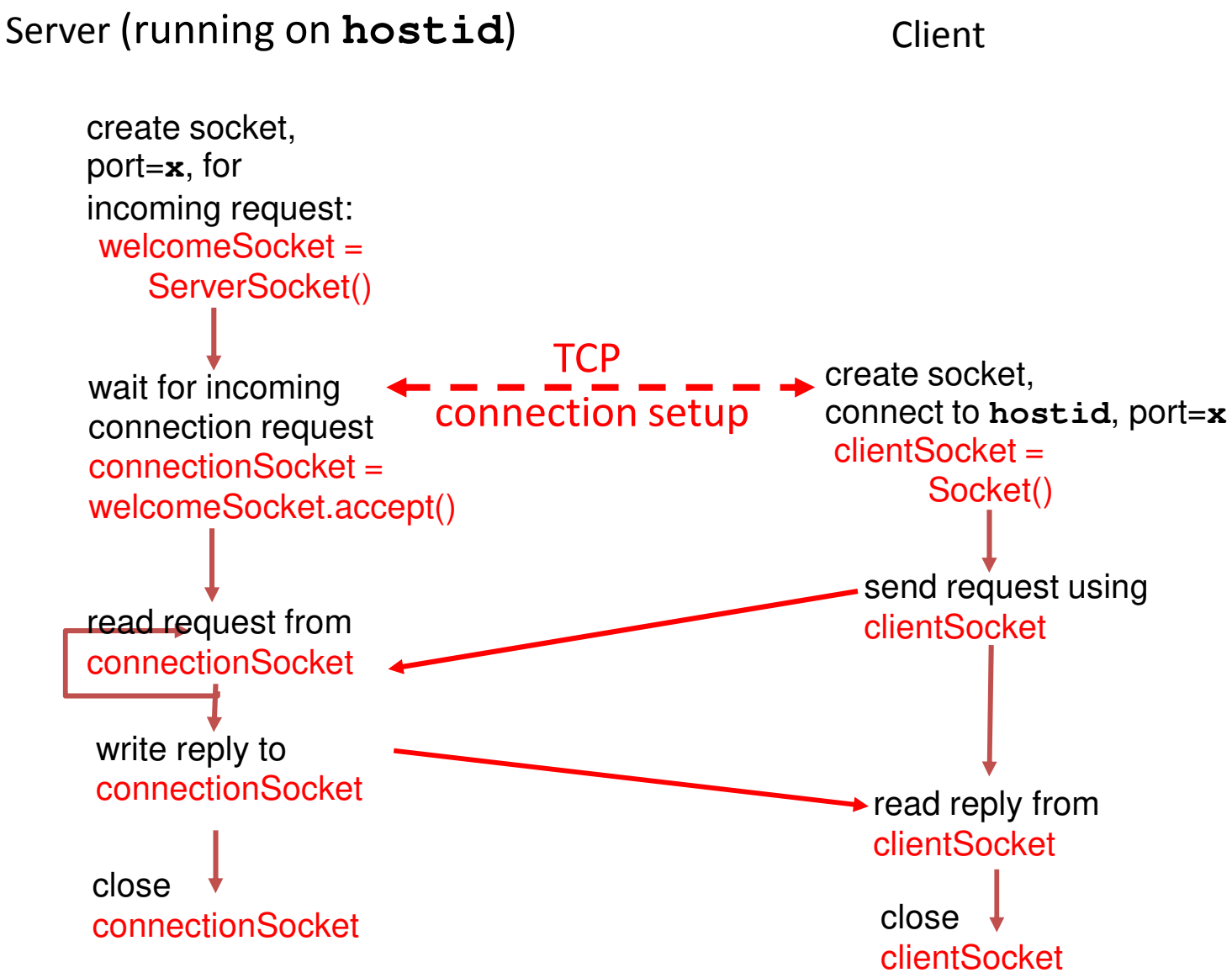

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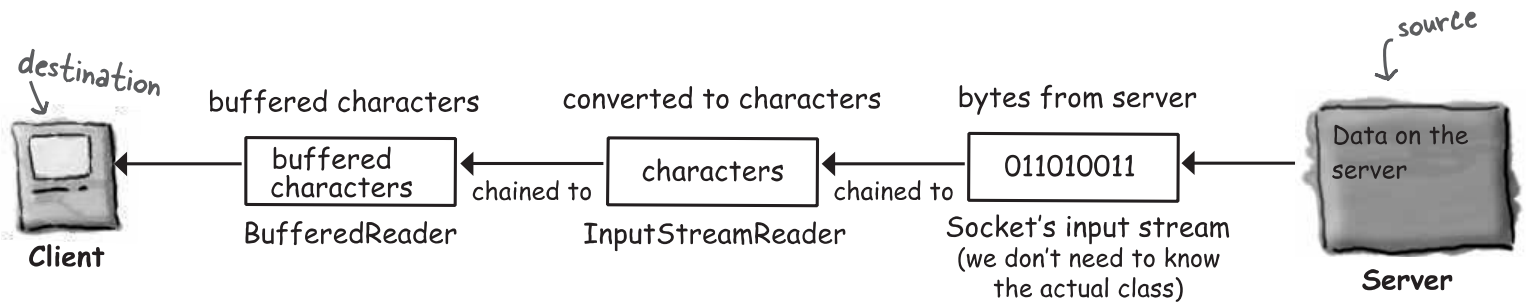

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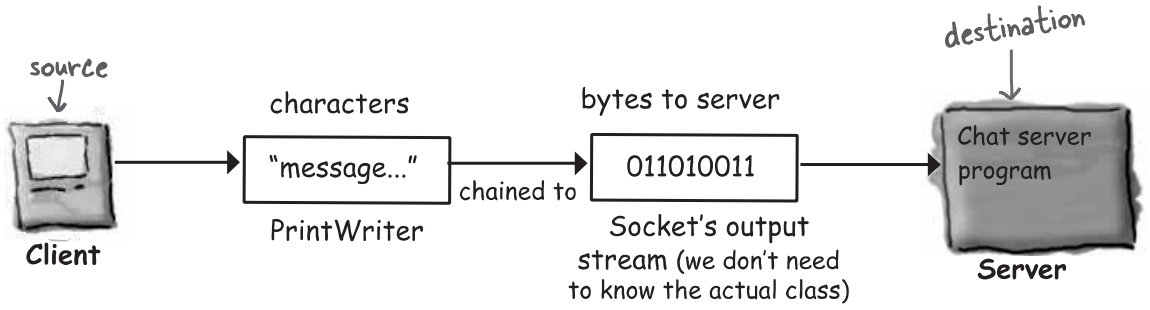

Example: Java client (TCP)

```
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());
```

Create input stream

Create client socket, connect to server

Create output stream attached to socket

Example: Java client (TCP), cont.

Create input stream attached to socket

```
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();

    }
}
```

Send line to server

Read line from server

Example: Java server (TCP)

```
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()));
```

Create welcoming socket at port 6789

Wait, on welcoming socket for contact by client

Create input stream, attached to socket

Example: Java server (TCP), cont

Create output stream, attached to socket

Read in line from socket

Write out line to socket

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

clientSentence = inFromClient.readLine();

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

outToClient.writeBytes(capitalizedSentence);
            }
        }
    }
```

End of while loop, loop back and wait for another client connection

Socket programming *with UDP*

UDP: no "connection" between client and server

no handshaking

sender explicitly attaches IP address and port of destination to each packet

server must extract IP address, port of sender from received packet

UDP: transmitted data may be received out of order, or lost

application viewpoint

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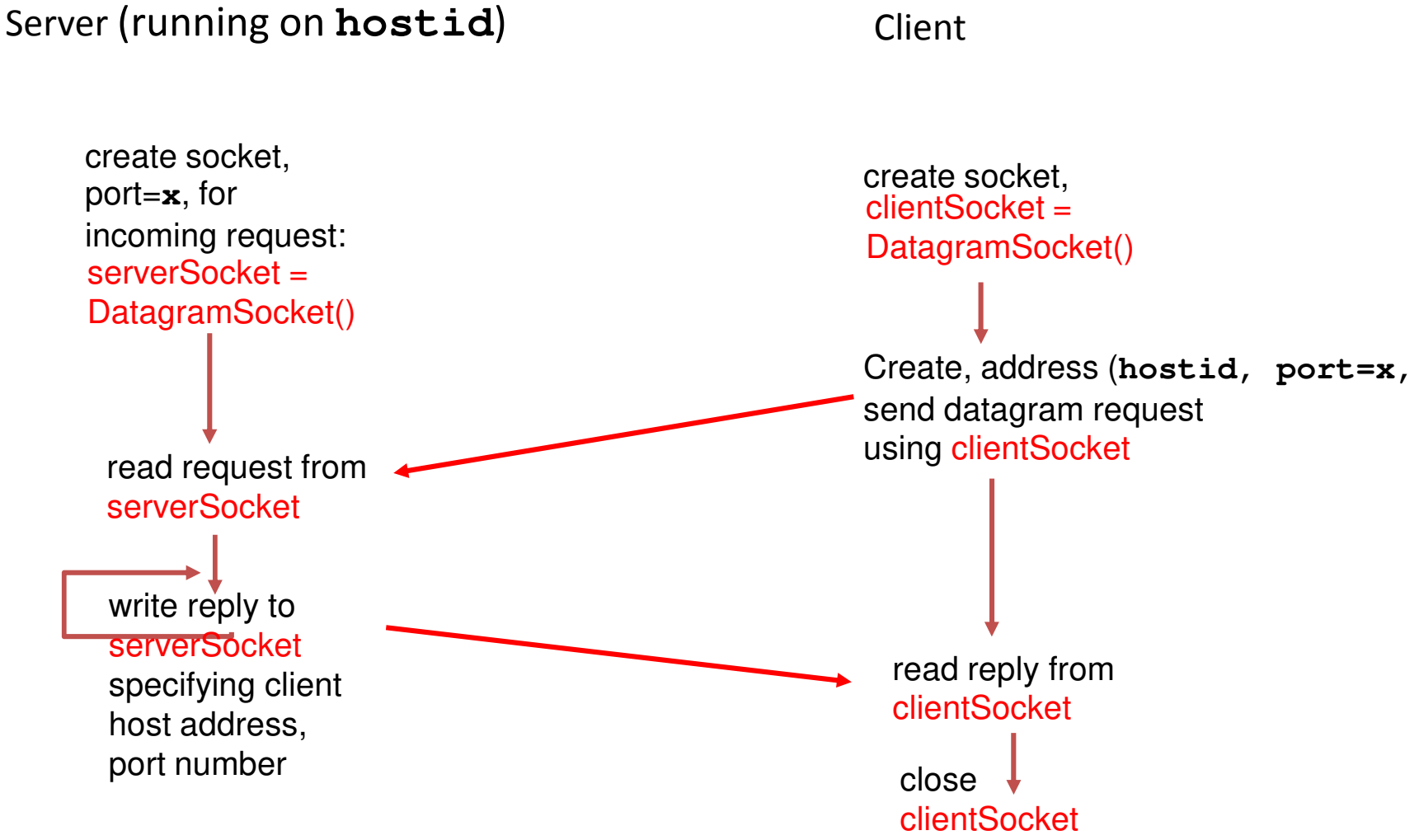
Client/server socket interaction: UDP



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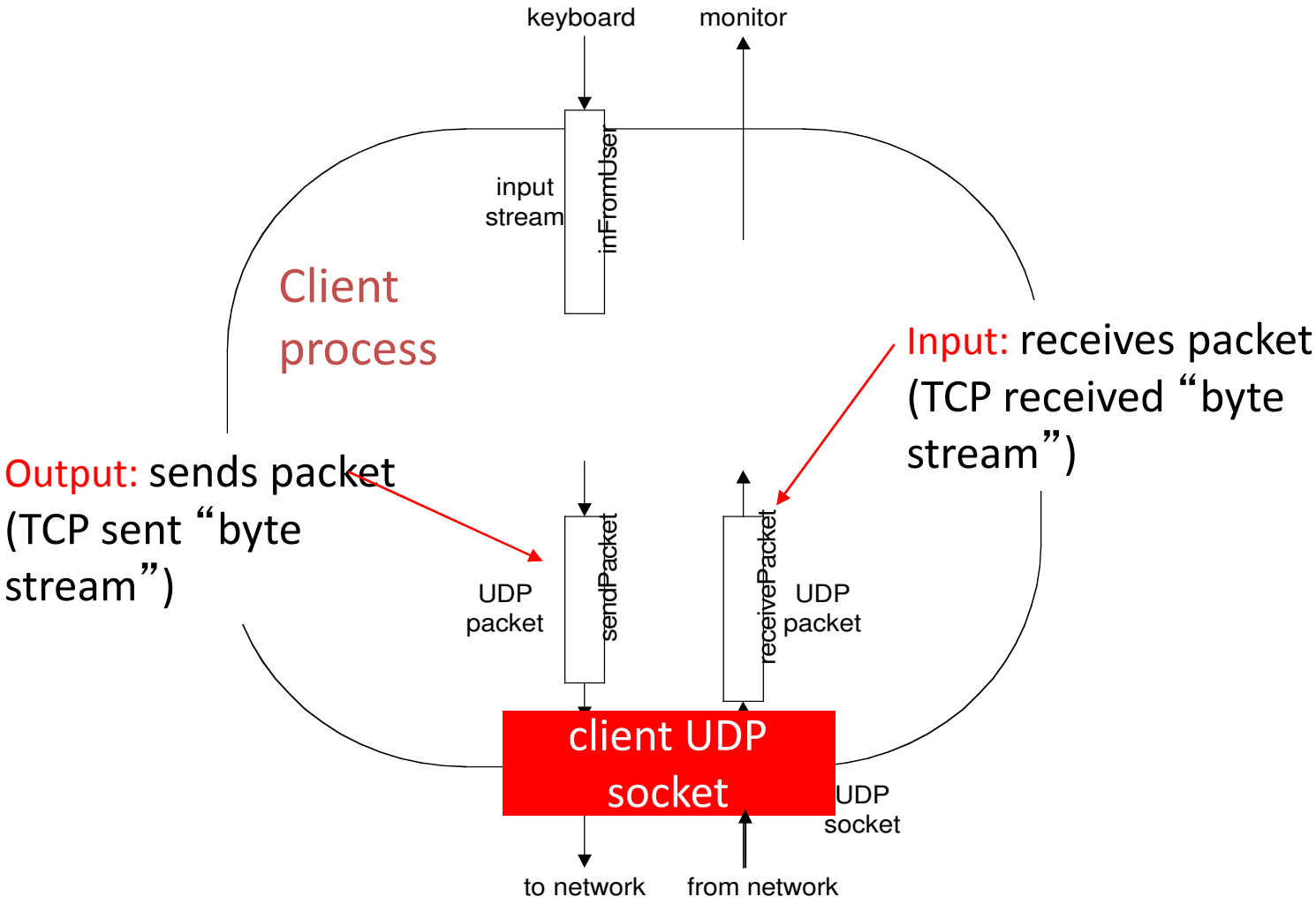

Example: Java client (UDP)

```
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();
```

Create input stream

Create client socket

Translate hostname to IP address using DNS

Example: Java client (UDP), cont.

Create datagram with data-to-send, length, IP addr, port

Send datagram to server

Read datagram from server

```
                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();
                }
            }
```

Example: Java server (UDP)

```
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);
```

Create datagram socket at port 9876

Create space for received datagram

Receive datagram

Example: Java server (UDP), cont

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

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);
        }
    }
}
```

Get IP addr port #, of sender

Create datagram to send to client

Write out datagram to socket

End of while loop, loop back and wait for another datagram