

Socket programming

Goal: learn how to build client/server application that communicate using sockets

Socket API

- ❑ introduced in BSD4.1 UNIX, 1981
- ❑ explicitly created, used, released by apps
- ❑ client/server paradigm
- ❑ two types of transport service via socket API:
 - unreliable datagram
 - reliable, byte stream-oriented

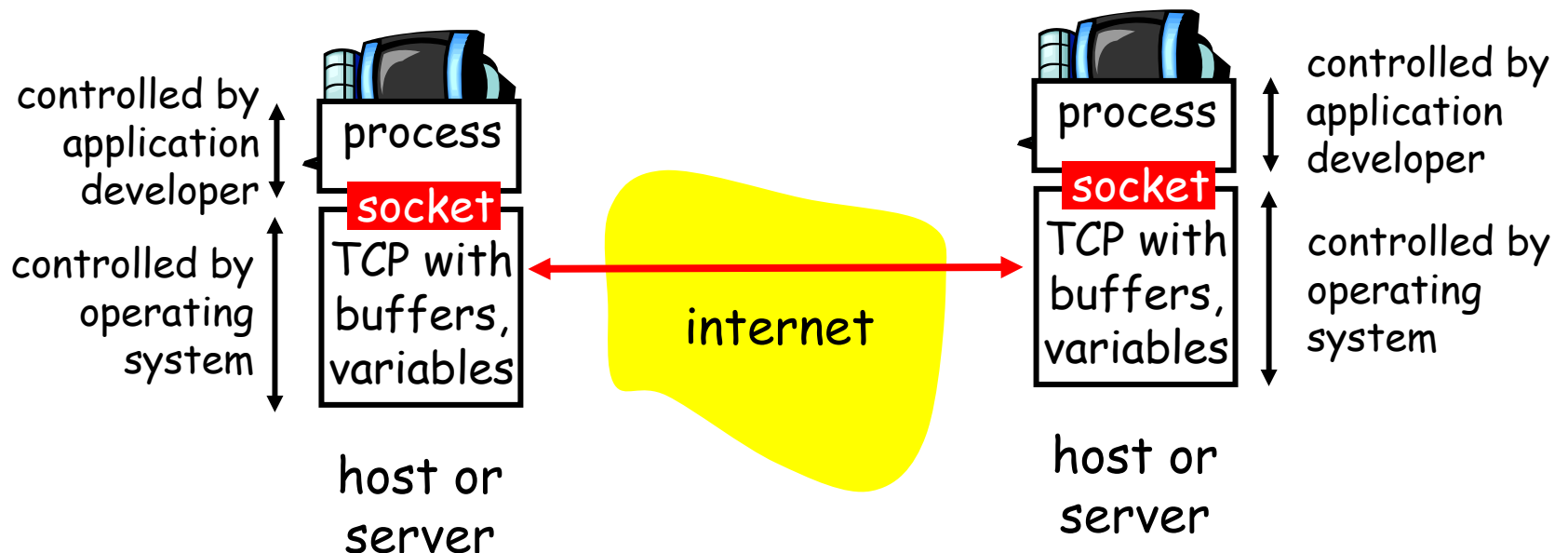
socket

a *host-local, application-created/owned, OS-controlled* interface (a "door") into which application process can **both send and receive** messages to/from another (remote or local) application process

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

application viewpoint

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

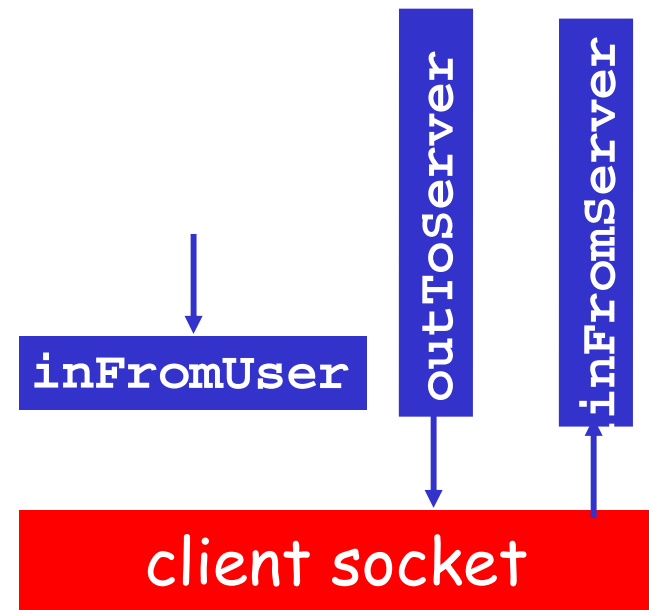
Socket programming with TCP

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)

Input stream: sequence of bytes into process

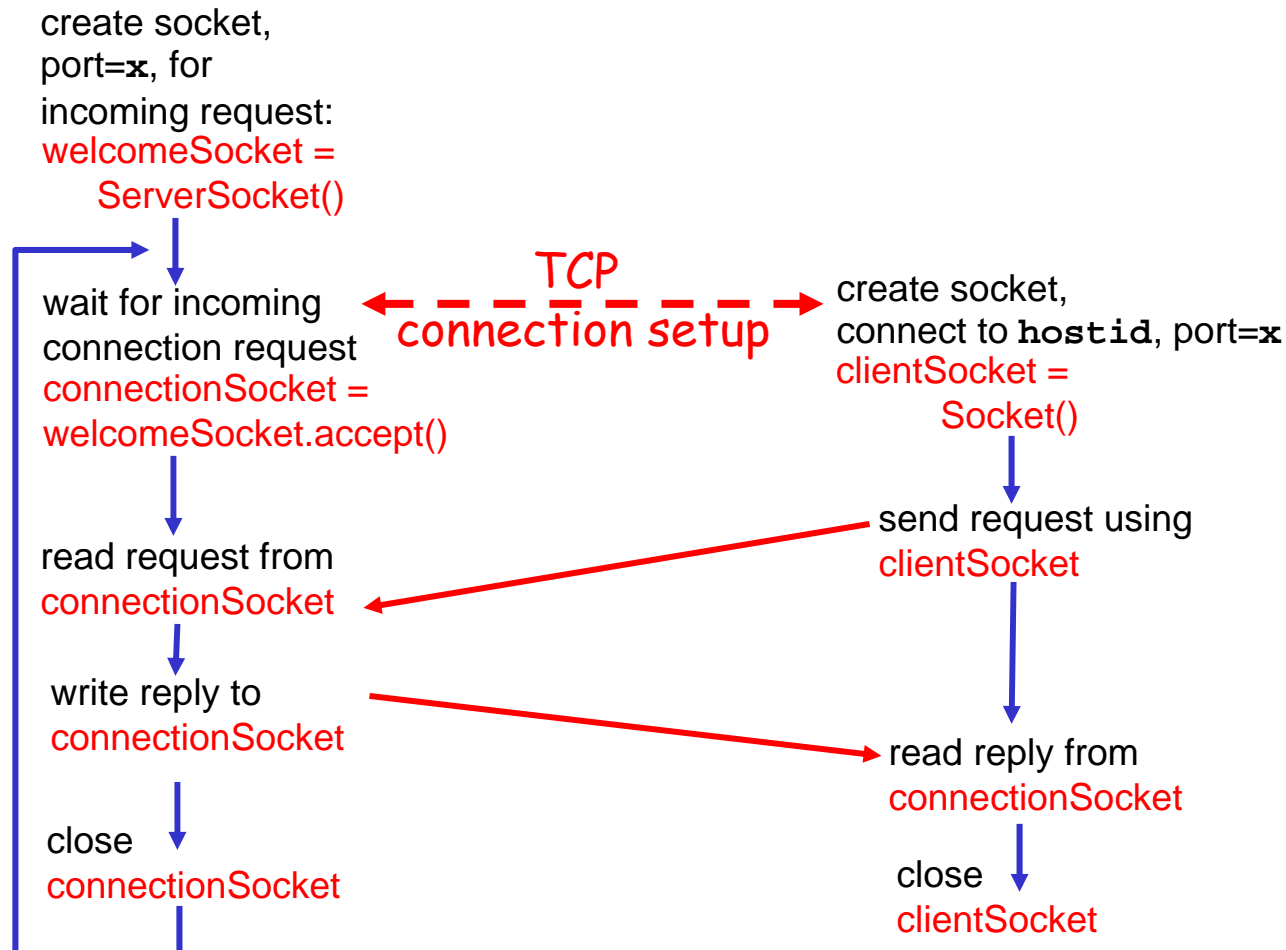
Output stream: sequence of bytes out of process



Client/server socket interaction: TCP

Server (running on `hostid`)

Client



Example: Java client (TCP)

```
import java.io.*;
import java.net.*;
class TCPClient {
```

```
    public static void main(String argv[]) throws Exception
    {
```

```
        String sentence;
        String modifiedSentence;
```

Create
input stream



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

Create
client socket,
connect to server



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

Create
output stream
attached to socket



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

Example: Java client (TCP), cont.

Create
input stream
attached to socket

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

Send line
to server

```
sentence = inFromUser.readLine();  
  
outToServer.writeBytes(sentence + '\n');
```

Read line
from server

```
modifiedSentence = inFromServer.readLine();  
  
System.out.println("FROM SERVER: " + modifiedSentence);  
  
clientSocket.close();
```

```
    }  
}
```

Example: Java server (TCP)

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

```
class TCPServer {
```

```
    public static void main(String argv[]) throws Exception  
    {
```

```
        String clientSentence;  
        String capitalizedSentence;
```

Create
welcoming socket
at port 6789

```
        ServerSocket welcomeSocket = new ServerSocket(6789);
```

Wait, on welcoming
socket for contact
by client

```
        while(true) {
```

```
            Socket connectionSocket = welcomeSocket.accept();
```

Create input
stream, attached
to socket

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

Example: Java server (TCP), cont

Create output stream, attached to socket

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

Read in line from socket

```
clientSentence = inFromClient.readLine();
```

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

Write out line to socket

```
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
- ❑ server must extract IP address, port of sender from received datagram

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

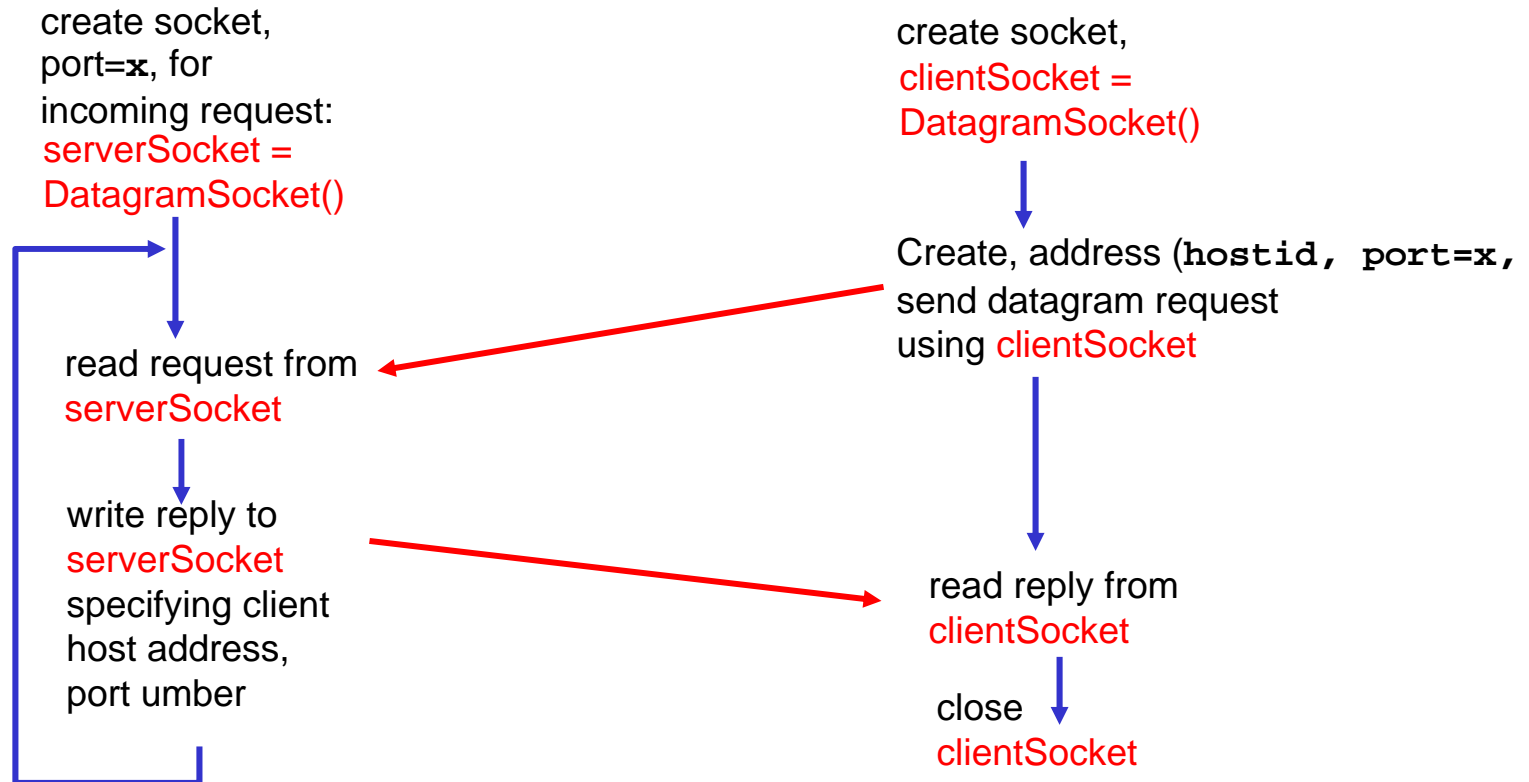
application viewpoint

UDP provides unreliable transfer of groups of bytes ("datagrams") between client and server

Client/server socket interaction: UDP

Server (running on `hostid`)

Client



Example: Java client (UDP)

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

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

Create
input stream

```
        BufferedReader inFromUser =
```

```
            new BufferedReader(new InputStreamReader(System.in));
```

Create
client socket

```
        DatagramSocket clientSocket = new DatagramSocket();
```

Translate
hostname to IP
address using DNS

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

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

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

```
        String sentence = inFromUser.readLine();
```

```
        sendData = sentence.getBytes();
```

Example: Java client (UDP), cont.

```
    Create datagram  
    with data-to-send,  
    length, IP addr, port } DatagramPacket sendPacket =  
                           → new DatagramPacket(sendData, sendData.length, IPAddress, 9876);  
  
    Send datagram  
    to server } clientSocket.send(sendPacket);  
  
               DatagramPacket receivePacket =  
               new DatagramPacket(receiveData, receiveData.length);  
  
    Read datagram  
    from server } 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  
    {
```

Create
datagram socket
at port 9876



```
        DatagramSocket serverSocket = new DatagramSocket(9876);
```

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

```
        while(true)  
        {
```

Create space for
received datagram



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

Receive
datagram



```
            serverSocket.receive(receivePacket);
```

Example: Java server (UDP), cont

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

Get IP addr
port #, of
sender

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

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

```
String capitalizedSentence = sentence.toUpperCase();
```

```
sendData = capitalizedSentence.getBytes();
```

Create datagram
to send to client

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

Write out
datagram
to socket

```
serverSocket.send(sendPacket);
```

```
}  
}  
}
```

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