Introduction

Lecture 1

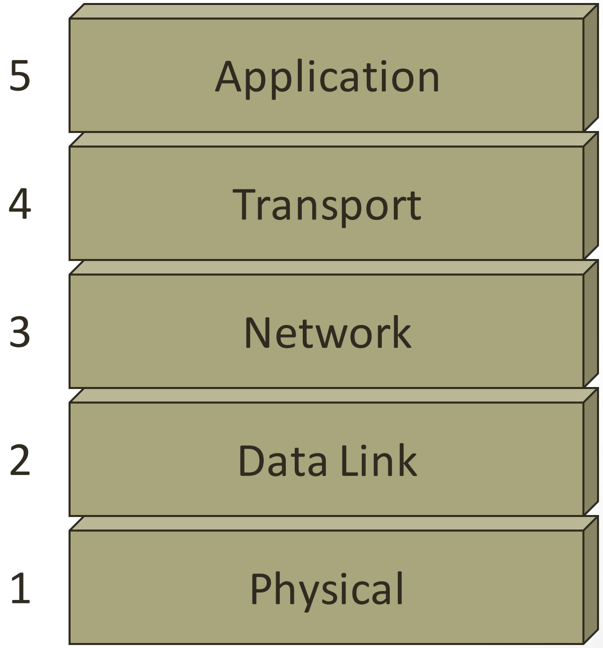
Topic Outline

- Review of TCP/IP
- Overview of network programming.
- Simple client-server programs.

Internet Layered Architecture

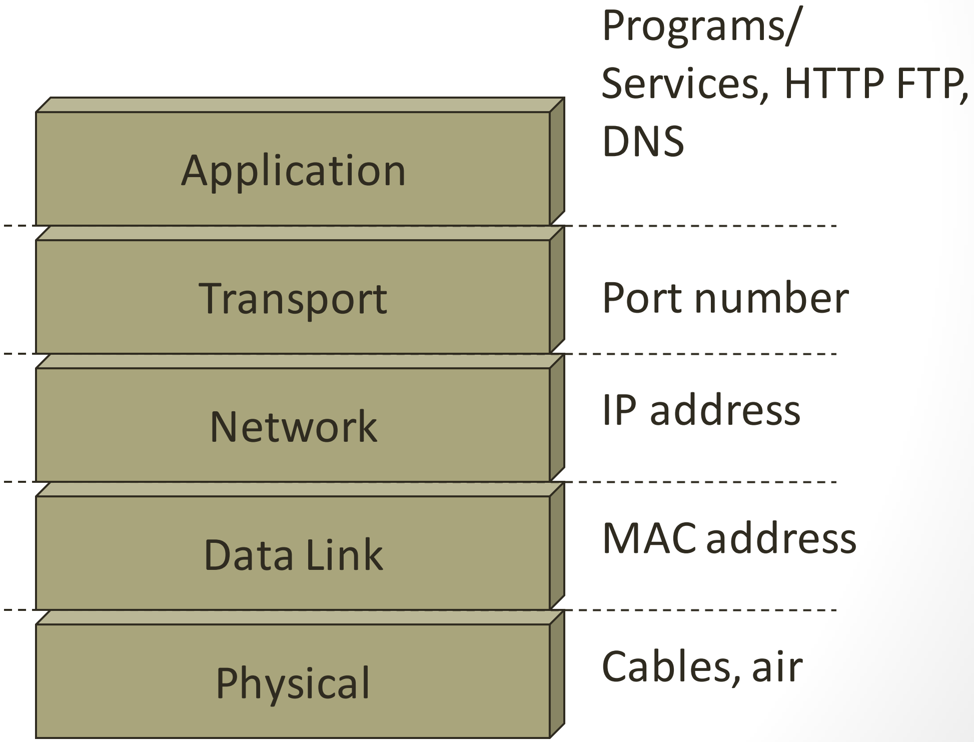
- Internet Layered Architecture is a “standard” of how data should be organized in the network by the hosts.

- There are 5 layers in Internet model.
  - Layer 1 is called physical layer
  - Layer 2 is called data link layer
  - Layer 3 is called network layer
  - Layer 4 is called transport layer
  - Layer 5 is called application layer



Corresponding Layer in Addressing

- Layer in the address scheme:
- Application Layer
  - Deals with client program and services such as FTP, HTTP, DNS, telnet, etc
- Transport Layer
  - Deals with port numbers
- Network Layer
  - Deals with IP address
- Data Link Layer
  - Deals with MAC address
- Physical Layer
  - Deals with electrical signal, cables and air



Application

Programs/ Services, HTTP FTP, DNS

Transport

Port number

Network

IP address

Data Link

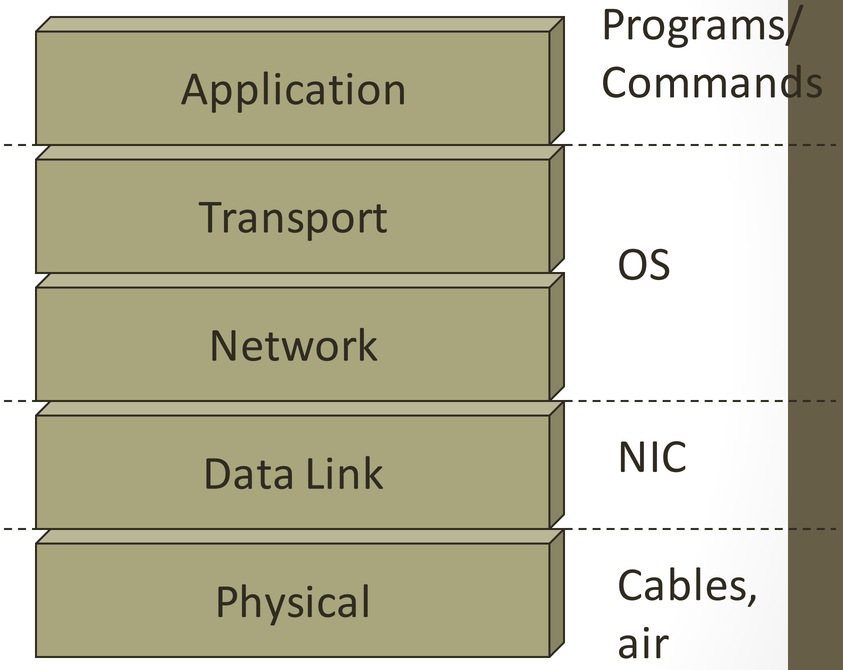
MAC address

Physical

Cables, air

Corresponding Layer in a Host

- For easy visualization of layered model in PC
- Layer 1 is made up of
  - Cables, transmission and reception of NIC
- Layer 2
  - Processing part of NIC
- Layer 3, 4, 5
  - CPU, and RAM



Why Layered Model?

Dealing with complex systems:

- Explicit structure allows identification, relationship of complex system's pieces
- Modularization eases maintenance, updating of system
  - change of implementation of layer's service transparent to rest of system
  - e.g., change in gate procedure doesn't affect rest of system
- Easy to swap in and out (upgrade) for each layer.
- Special people trained for each layer.

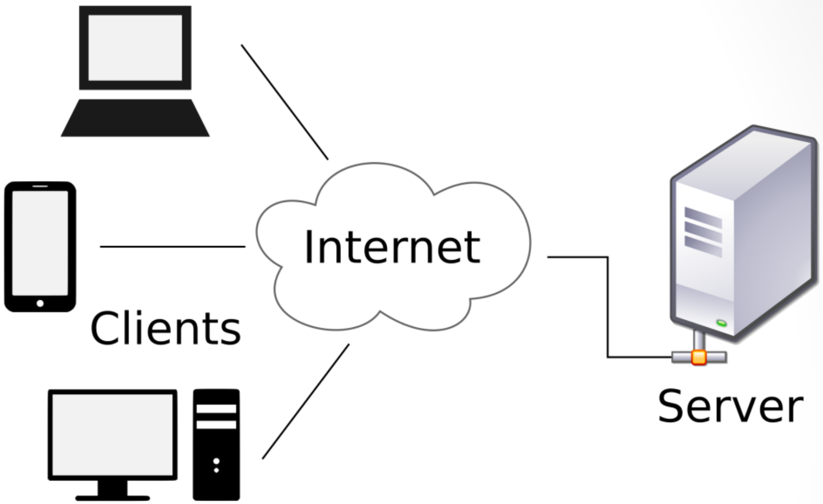
Overview of Network Programming

- **Network applications** are widely used
  - Web, email, & even many of the mobile apps that we use daily (e.g. WhatsApp, WeChat, etc.)

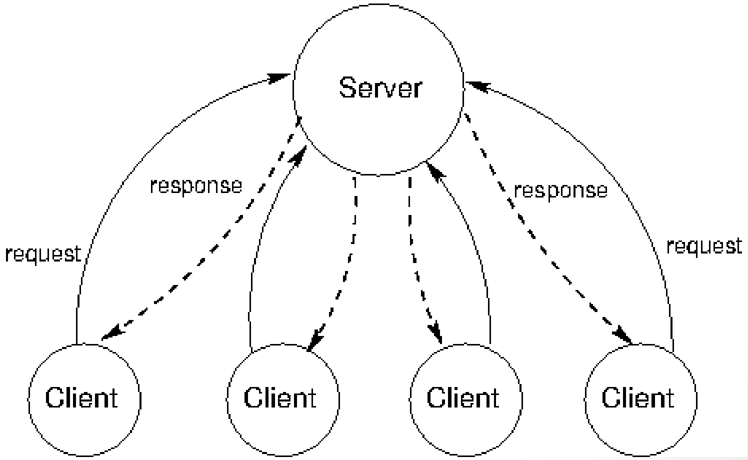
- **Network Programming** involves writing computer programs that enable processes to communicate with each other across a computer network.
  - Interestingly, all network applications are based on the same basic programming model, have similar overall logical structures, and rely on the same programming interface.

Client-Server Model

- Distributed application structure that partitions tasks or workloads between the providers of a resource or service, called **servers**, and service requesters, called **clients**.

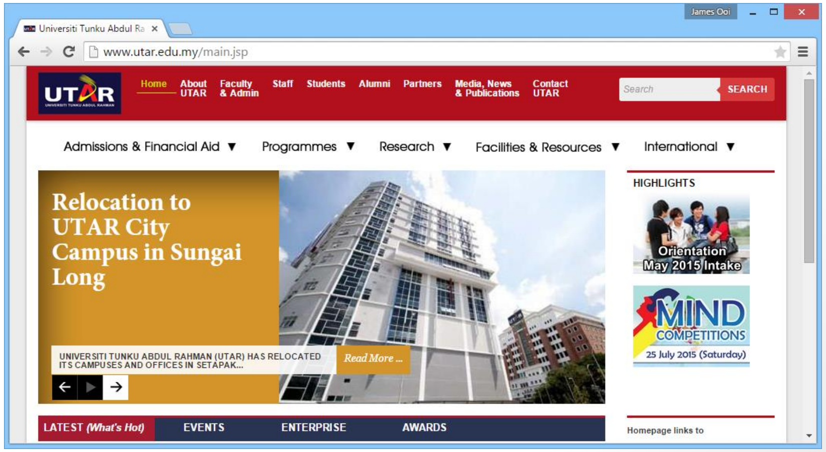


- A server host runs one or more server programs which share their resources with clients. A client does not share any of its resources, but requests a server's content or service function.



Examples of Client-Server Applications

- Web
  - Web server – e.g. Apache, Nginx, Microsoft IIS, etc.
  - Web browser (client) – e.g. Google Chrome, Mozilla Firefox, Microsoft Edge, Apple Safari, etc.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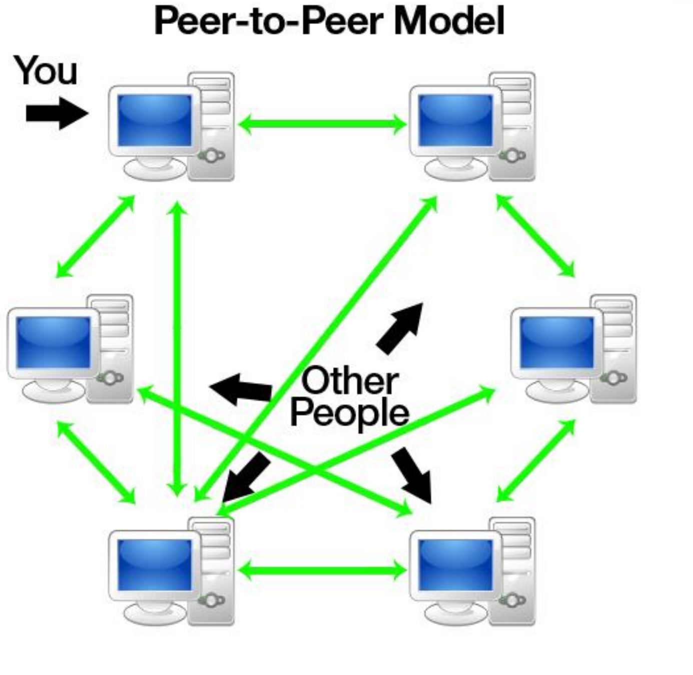
Examples of Client-Server Applications

- Email
  - Email Server – sendmail, qmail, Microsoft Exchange, etc.
  - Email Client – Microsoft Outlook, Mozilla Thunderbird, etc & web-based email such as Gmail, etc.

- Database
  - Database Server – e.g. MySQL Server
  - Database Client – e.g. phpmyadmin, a web-based MySQL client

Peer-to-Peer Model

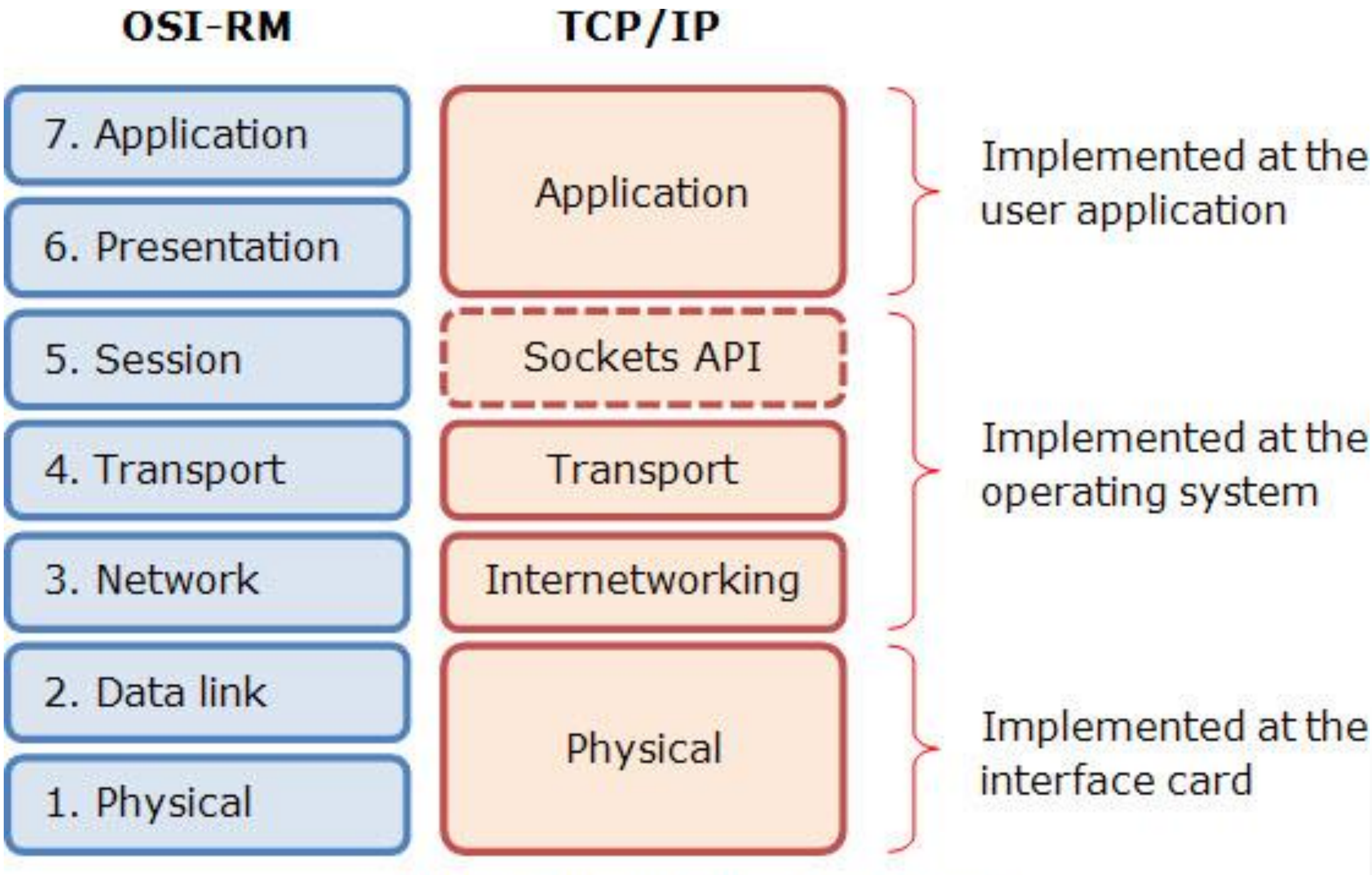
- Distributed application architecture that partitions tasks or work loads between peers.
- Peers are equally privileged, equipotent participants in the application. They are said to form a peer-to-peer network of nodes.
- Peers make a portion of their resources, such as processing power, disk storage or network bandwidth, directly available to other network participants, without the need for central coordination by servers or stable hosts.
- Peers are both suppliers and consumers of resources.



Sockets API

- **Network socket**
  - An endpoint of an inter-process communication across a computer network.
  - Today, most communication between computers is based on the Internet Protocol; therefore most network sockets are Internet sockets.
- **Sockets API**
  - An API that allows application programs to control and use network sockets.
- **Socket address**
  - Combination of an IP address and a port number.
  - Based on this address, internet sockets deliver incoming data packets to the appropriate application process or thread.

Sockets API



OSI-RM

7. Application

6. Presentation

5. Session

4. Transport

3. Network

2. Data link

1. Physical

TCP/IP

Application

Sockets API

Transport

Internetworking

Physical

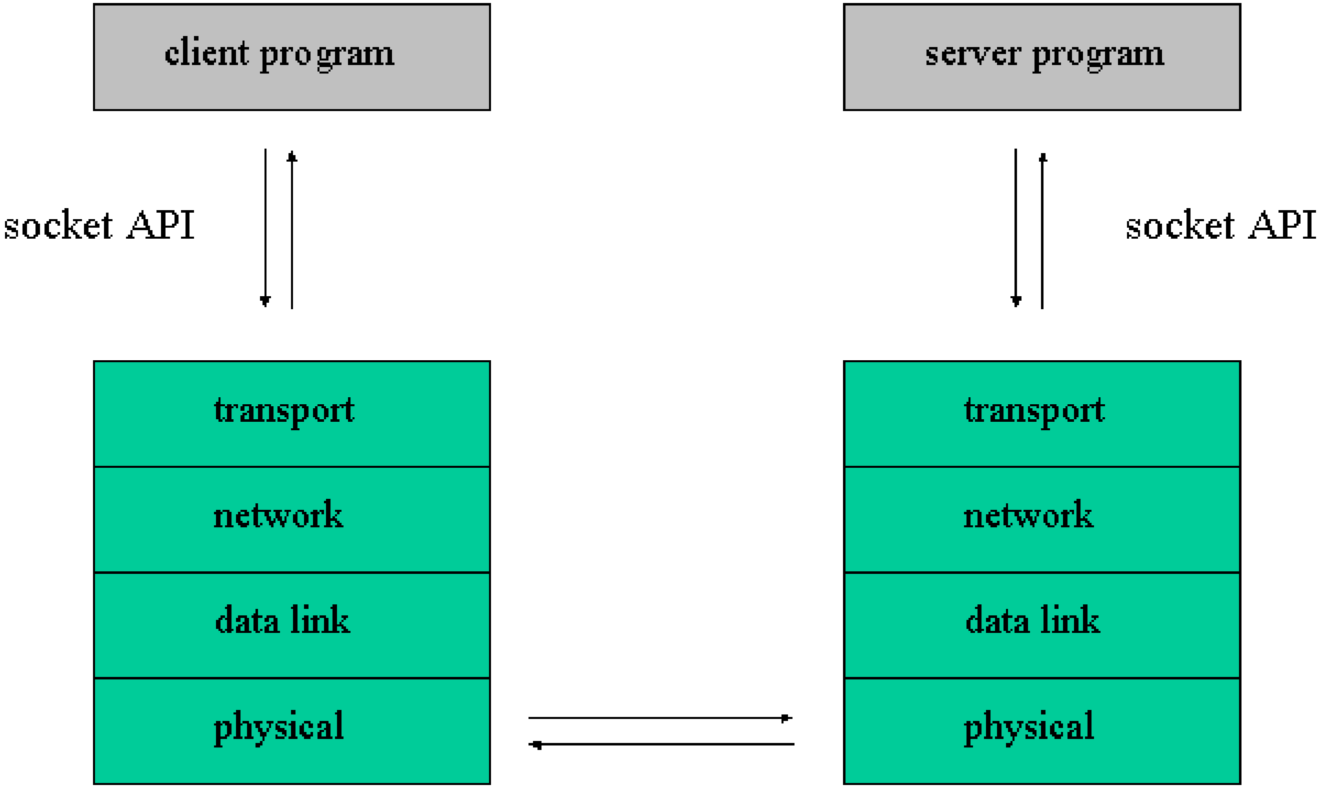
Implemented at the user application

Implemented at the operating system

Implemented at the interface card

OSI-RM and TCP/IP network architectures

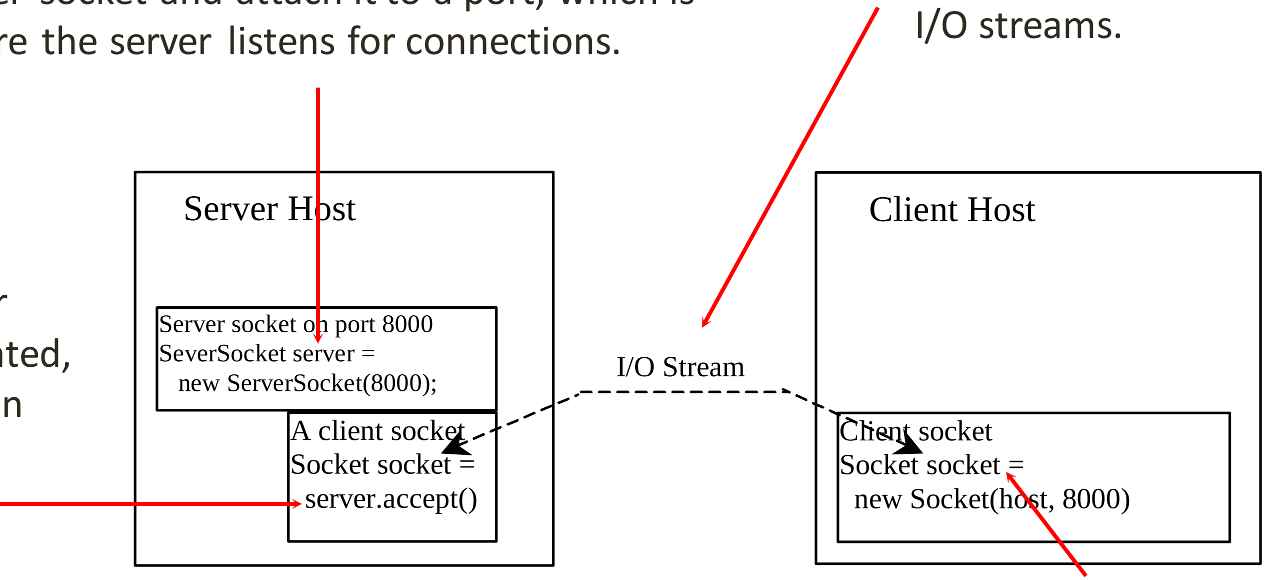
Sockets API


client program
server program
socket API
socket API
transport
network
data link
physical
transport
network
data link
physical

Client-Server Communications using Sockets

The server must be running when a client starts. The server waits for a connection request from a client. To establish a server, you need to create a server socket and attach it to a port, which is where the server listens for connections.

After the server accepts the connection, communication between server and client is conducted the same as for I/O streams.



Server Host

```
Server socket on port 8000
SeverSocket server =
  new ServerSocket(8000);
```

```
A client socket
Socket socket =
  server.accept()
```

I/O Stream

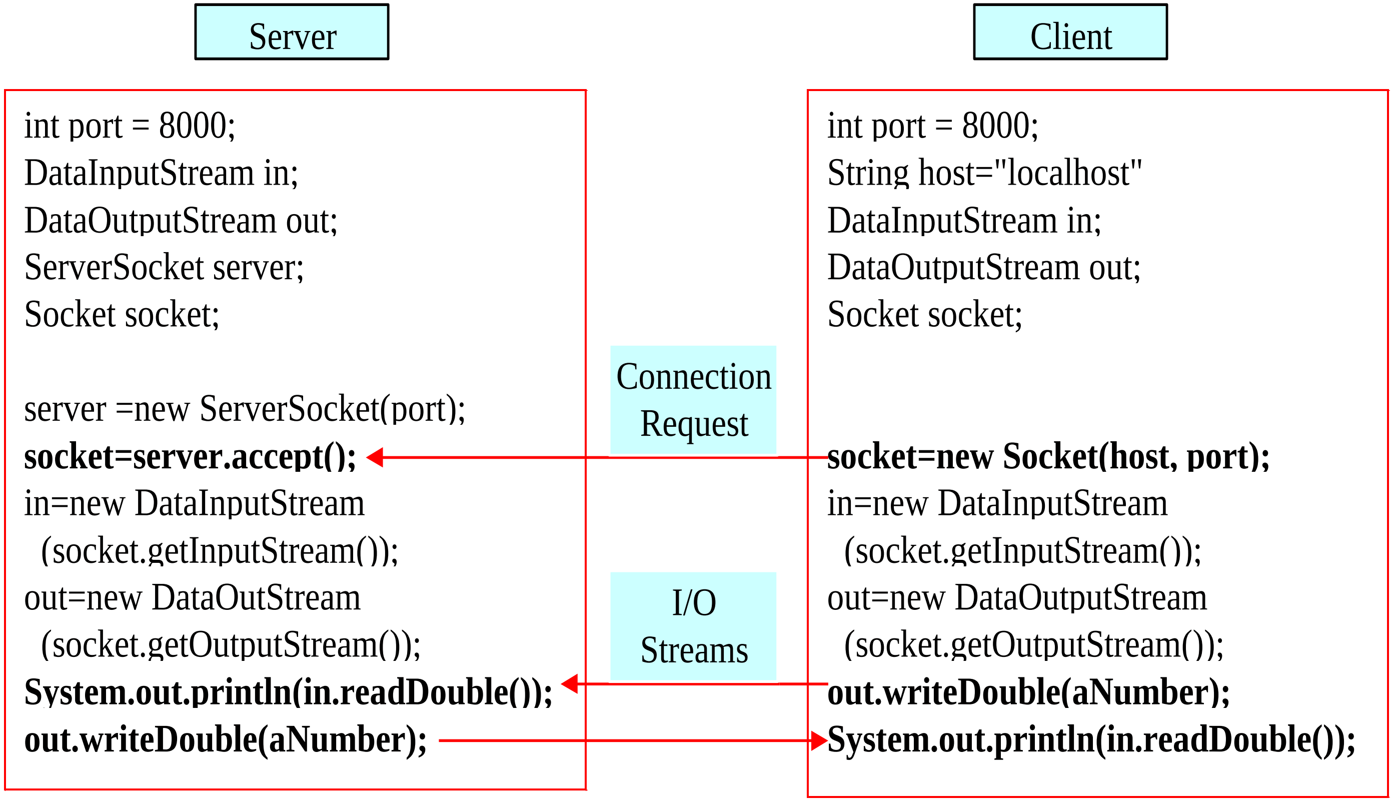
Client Host

```
Client socket
Socket socket =
  new Socket(host, 8000)
```

After a server socket is created, the server can use this statement to listen for connections.

The client issues this statement to request a connection to a server.

Data Transmission through Sockets



Server

```
int port = 8000;
DataInputStream in;
DataOutputStream out;
ServerSocket server;
Socket socket;

server =new ServerSocket(port);
socket=server.accept();
in=new DataInputStream
  (socket.getInputStream());
out=new DataOutStream
  (socket.getOutputStream());
System.out.println(in.readDouble());
out.writeDouble(aNumber);
```

Connection Request

I/O Streams

Client

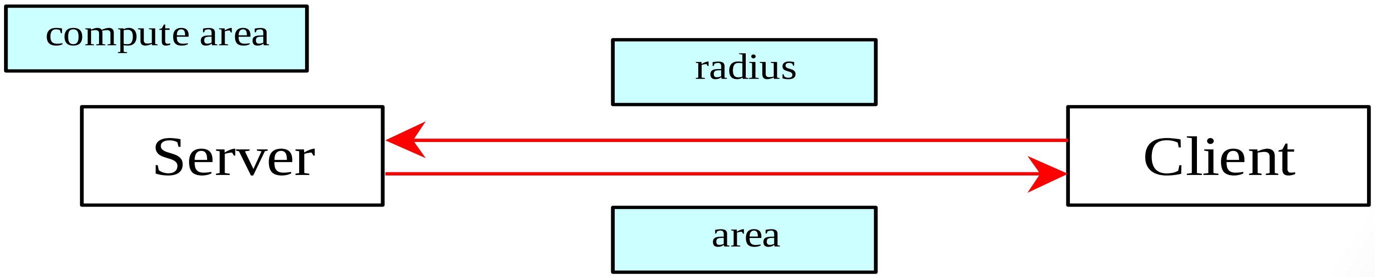
```
int port = 8000;
String host="localhost"
DataInputStream in;
DataOutputStream out;
Socket socket;


socket=new Socket(host, port);
in=new DataInputStream
  (socket.getInputStream());
out=new DataOutputStream
  (socket.getOutputStream());
out.writeDouble(aNumber);
System.out.println(in.readDouble());
```

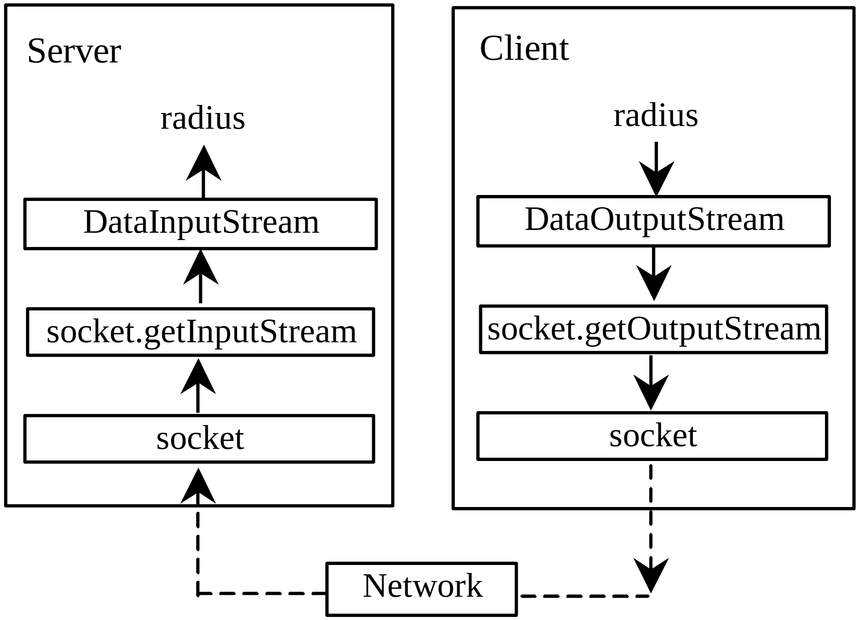
```
InputStream input = socket.getInputStream();
OutputStream output = socket.getOutputStream();
```

A Client/Server Example

- Problem: Write a client to send data to a server. The server receives the data, uses it to produce a result, and then sends the result back to the client. The client displays the result on the console. In this example, the data sent from the client is the radius of a circle, and the result produced by the server is the area of the circle.



A Client/Server Example, cont.



Server

radius

DataInputStream

socket.getInputStream

socket

Client

radius

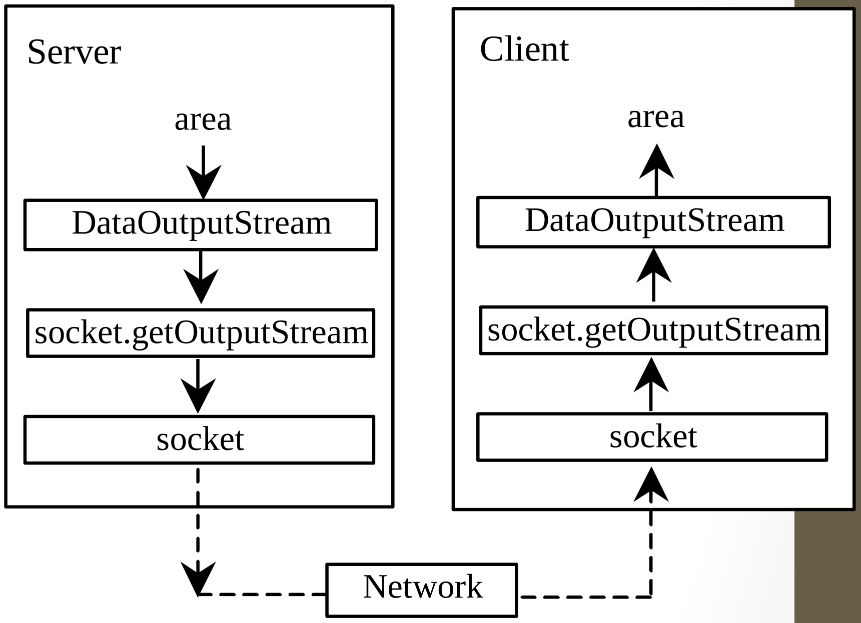
DataOutputStream

socket.getOutputStream

socket

Network

(A)



Server

area

DataOutputStream

socket.getOutputStream

socket

Client

area

DataOutputStream

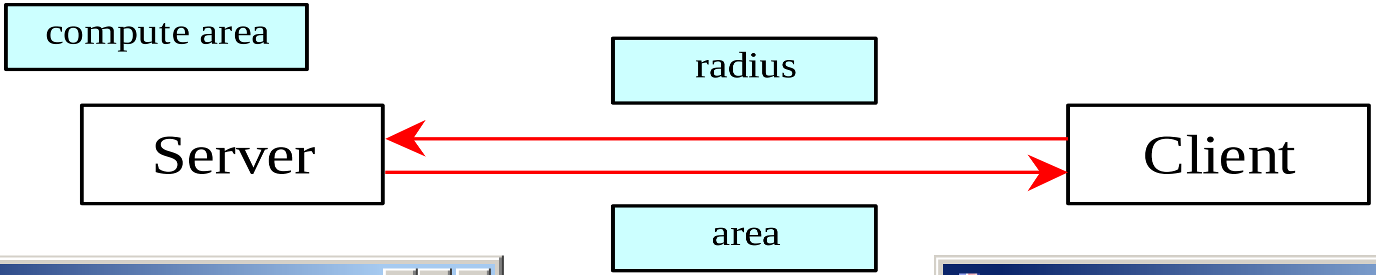
socket.getOutputStream

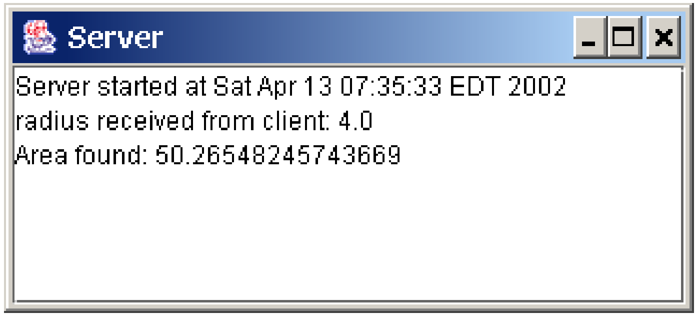
socket

Network

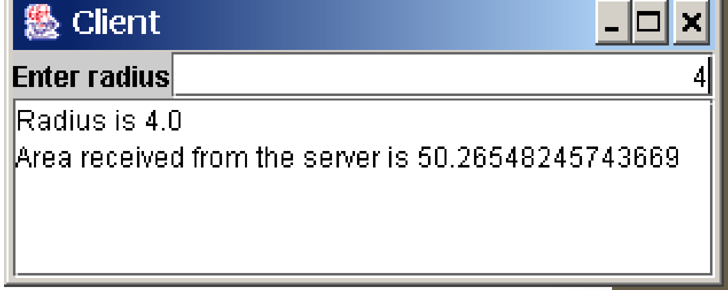
(B)

A Client/Server Example, cont.





```
Server started at Sat Apr 13 07:35:33 EDT 2002
radius received from client: 4.0
Area found: 50.26548245743669
```



Enter radius: 4

```
Radius is 4.0
Area received from the server is 50.26548245743669
```

Server.java

Client.java

Note: Start the server, then the client.