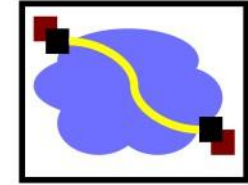


# Socket Programming

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AP/CSE

# Client-Server Paradigm



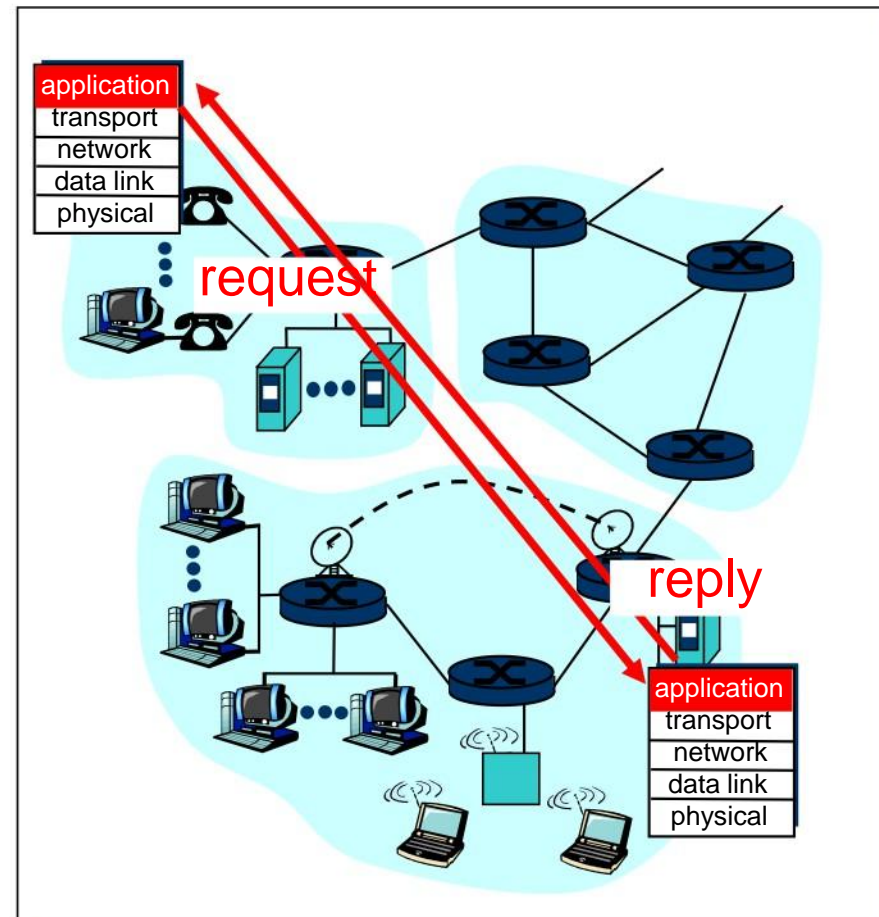
Typical network app has two pieces: *client* and *server*

## Client:

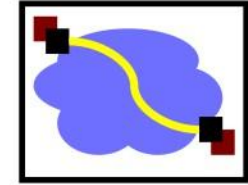
- Initiates contact with server (“speaks first”)
- Typically requests service from server,
- For Web, client is implemented in browser; for e-mail, in mail reader

## Server:

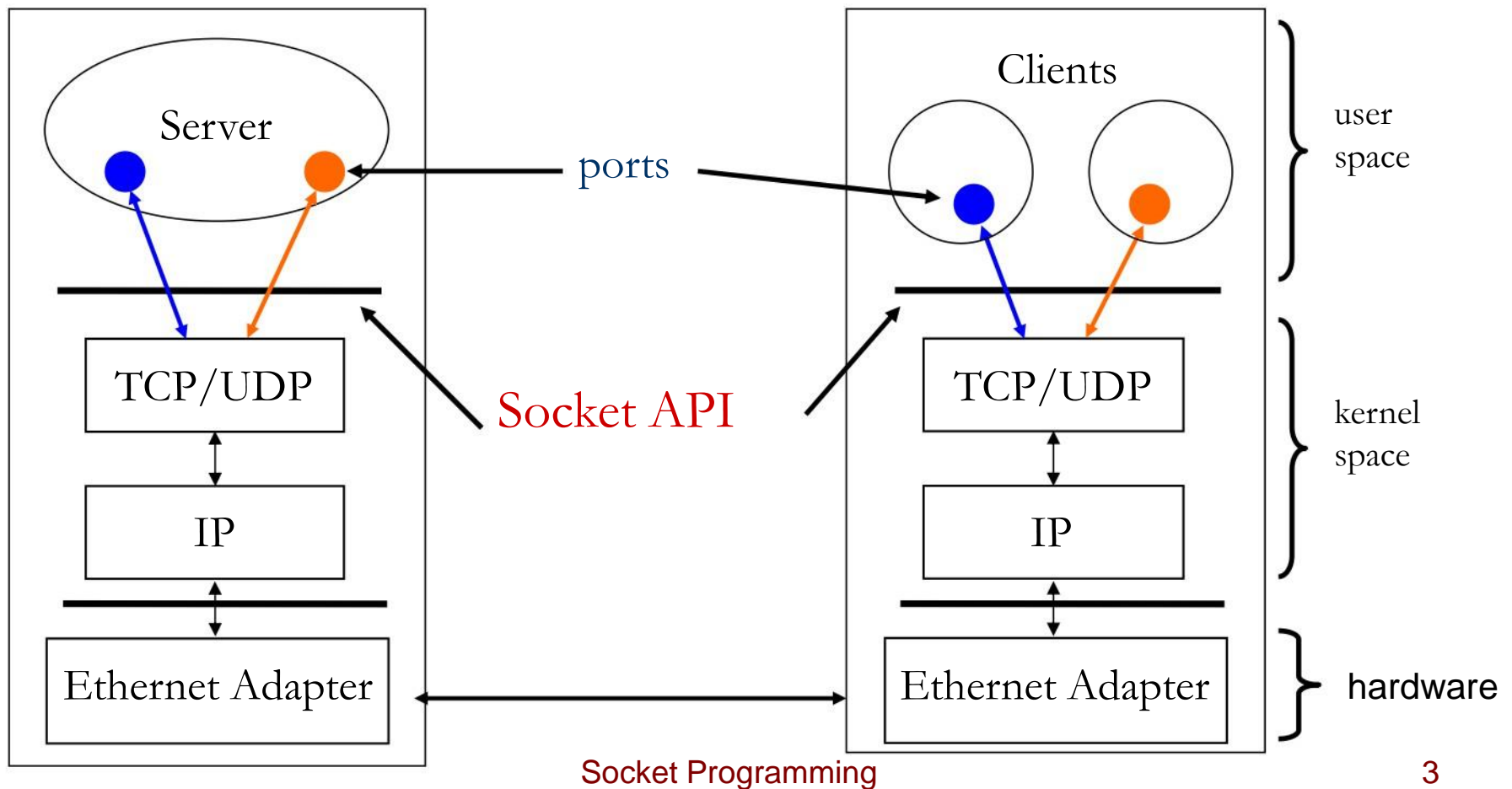
- Provides requested service to client
- e.g., Web server sends requested Web page, mail server delivers e-mail



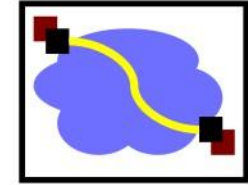
# Server and Client



Server and Client exchange messages over the network through a common **Socket API**



# UDP and TCP



## UDP

- Single socket to receive messages
- No guarantee of delivery
- Not necessarily in-order delivery
- Datagram - independent packets
- Must address each packet

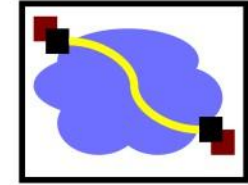
Example UDP applications  
Multimedia, voice over IP

## TCP

- Reliable - guarantee delivery
- Byte stream - in-order delivery
- Connection-oriented - single socket per connection
- Setup connection followed by data transfer

Example TCP applications  
Web, Email, Telnet

# Internet Addressing Data Structure

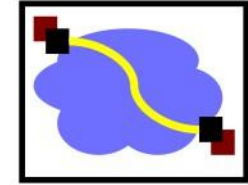


```
#include <netinet/in.h>

/* Internet address structure */
struct in_addr {
    u_long s_addr;          /* 32-bit IPv4 address */
};                          /* network byte ordered */

/* Socket address, Internet style. */
struct sockaddr_in {
    u_char sin_family;      /* Address Family */
    u_short sin_port;       /* UDP or TCP Port# */
                                /* network byte ordered */
    struct in_addr sin_addr; /* Internet Address */
    char sin_zero[8];       /* unused */
};
```

# Byte Ordering



128.2.194.95

- Big Endian →

- Sun Solaris, PowerPC, ...

- Little Endian →

- i386, alpha, ...

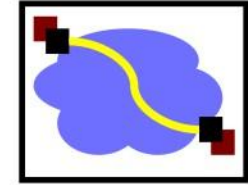
- Network byte order = Big Endian

**c[0] c[1] c[2] c[3]**

|     |   |     |    |
|-----|---|-----|----|
| 128 | 2 | 194 | 95 |
|-----|---|-----|----|

|    |     |   |     |
|----|-----|---|-----|
| 95 | 194 | 2 | 128 |
|----|-----|---|-----|

# Byte Ordering Functions

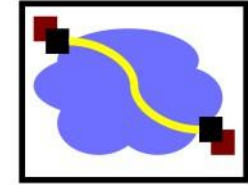


- Converts between **host byte order** and **network byte order**
  - 'h' = host byte order
  - 'n' = network byte order
  - 'l' = long (4 bytes), converts IP addresses
  - 's' = short (2 bytes), converts port numbers

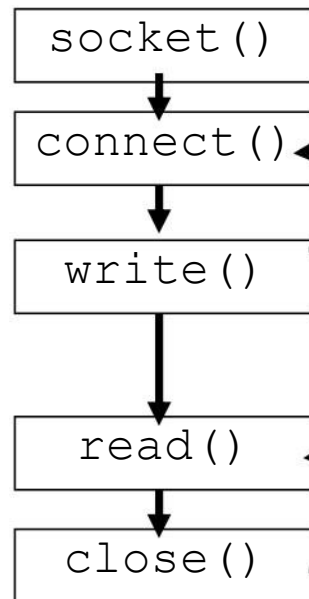
```
#include <netinet/in.h>
```

```
unsigned long int htonl(unsigned long int hostlong);  
unsigned short int htons(unsigned short int  
hostshort);  
unsigned long int ntohl(unsigned long int netlong);  
unsigned short int ntohs(unsigned short int  
netshort);
```

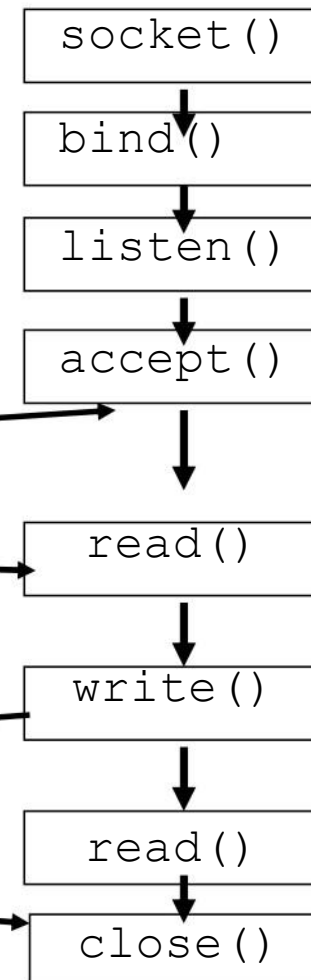
# TCP Client-Server Interaction



## TCP Client



## TCP Server



*connection establishment*

*data request*

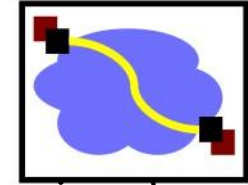
*data reply*

*end-of-file notification*

Socket Programming



# What is a Socket?

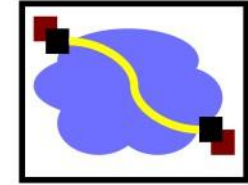


- A socket is a file descriptor that lets an application read/write data from/to the network

**int socket(int domain, int type, int protocol);**

- **Domain / family** : integer, communication domain
  - AF\_INET IPv4 protocol
  - AF\_INET6 IPv6 protocol
  - AF\_LOCAL Unix Domain Protocols
  - AF\_ROUTE Routing Sockets
  - AF\_KEY Key Socket
- **type**: communication type
  - SOCK\_STREAM: reliable, 2-way, connection-based service
  - SOCK\_DGRAM: unreliable, connectionless,
  - SOCK\_RAW: Security
- **protocol**: specifies protocol - usually set to 0

# What is a Socket?

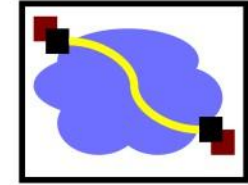


```
int sd;          /* socket descriptor */
if ((sd = socket(AF_INET, SOCK_STREAM, 0)) < 0) {
    perror("socket");
    exit(1);
}
```

**socket** returns an integer (socket descriptor)

- $sd < 0$  indicates that an error occurred
- socket descriptors are similar to file descriptors

**NOTE:** socket call does not specify where data will be coming from, nor where it will be going to - it just creates the interface!



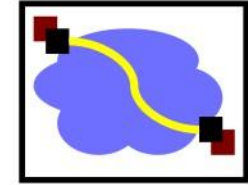
## Binding a Socket to a Port

- A **socket** can be bound to a **port**
- ie. reserves a port for use by the socket

```
int bind(int sockfd, struct sockaddr *address,  
int addrlen);
```

- **sockfd**: integer, socket descriptor
- **address**: struct sockaddr, the (IP) address and port of the machine (address usually set to INADDR\_ANY - chooses a local address)
- **addrlen**: the size (in bytes) of the address structure
- **status**: Successful completion returns 0  
if bind failed = -1

# Binding a Socket to a Port



```
int sd; /* socket descriptor */
struct sockaddr_in server; /* used by bind() */

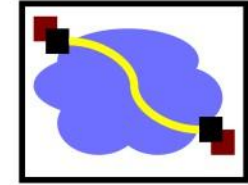
/* 1) create the socket */
server.sin_family = AF_INET; /* use the Internet addr family */

server.sin_port = htons(80); /* bind socket 'sd' to port 80*/

/* bind: a client may connect to any of my addresses */
server.sin_addr.s_addr = htonl(INADDR_ANY);

if(bind(sd, (struct sockaddr*) & server, sizeof(server)) < 0) {
    perror("bind"); exit(1);
}
```

# Listening For Connections

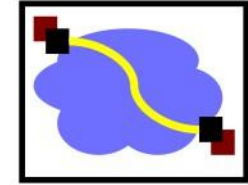


- **listen** indicates that the server will accept a connection

```
int listen(int sockfd, int backlog);
```

- **sockfd**: socket descriptor
- **backlog**: maximum # of active participants that can “wait” for a connection
- **status**: 0 if listening, -1 if error

# Listening For Connections

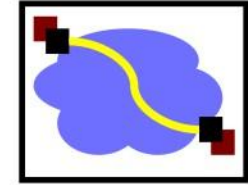


```
int sd;                /* socket descriptor */
struct sockaddr_in srv; /* used by bind() */

/* 1) create the socket */
/* 2) bind the socket to a port */

if(listen(sd, 5) < 0) {
    perror("listen");
    exit(1);
}
```

# Accepting a connection



- Takes the first connection request on the queue, creates another socket with the same properties of sockfd.
- If no connection request pending, blocks the server until it receives a connection request from client

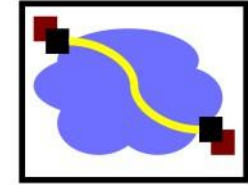
```
int accept(int sockfd, struct sockaddr *addr,  
int *addrlen);
```

- **sockfd**: the orig. socket (being listened on)
- **addr**: address of the active participant
- **addrlen**: value/result parameter
- **status**: the new socket (used for data-transfer)

Successful completion returns 0

Error -1

# Accepting a connection



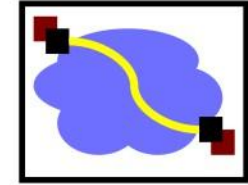
```
int sd;                                /* socket descriptor */
struct sockaddr_in server;             /* used by bind() */
struct sockaddr_in client;            /* used by accept() */
int newfd;                             /* returned by accept() */
int clientlen = sizeof(client);        /* used by accept() */

/* 1) create the socket */
/* 2) bind the socket to a port */
/* 3) listen on the socket */

newfd = accept(sd, (struct sockaddr*) &client &clientlen);
if(newfd < 0) {
    perror("accept");    exit(1);
}
```

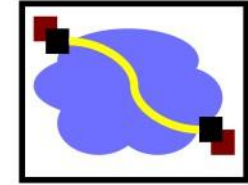


# Accepting a connection



- How does the server know which client it is?
  - **cli.sin\_addr.s\_addr** contains the client's **IP address**
  - **cli.sin\_port** contains the client's **port number**
- Now the server can exchange data with the client by using **read** and **write** on the descriptor **newfd**.

# Connecting a Socket

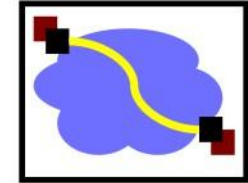


- Attempts to make a connection on a socket

```
int connect(int sockfd, struct sockaddr  
*addr, int addrlen);
```

- **sockfd**: socket to be used in connection
- **addr**: address of passive participant
- **addrlen**: size of addr
- **status**: 0 if successful connect, -1 otherwise

# Connecting a Socket



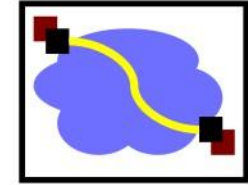
```
int sd; /* socket descriptor */
struct sockaddr_in server; /* used by connect() */
/* 1)create the socket */

server.sin_family = AF_INET; /* connect: use the Internet address
family */
server.sin_port = htons(80); /* connect: socket 'sd' to port 80 */

/* connect: connect to IP Address "128.2.35.50" */
server.sin_addr.s_addr = inet_addr("128.2.35.50");

if(connect(sd, (struct sockaddr*) &server, sizeof(server)) < 0) {
    perror("connect"); exit(1);
}
```

# Sending data to a Socket



- **write** can be used with a socket

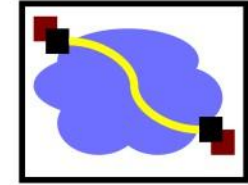
```
int sd;                                /* socket descriptor */
struct sockaddr_in server; /* used by connect() */
char buf[512];                        /* used by write() */
int nbytes;                           /* used by write() */

/* 1) create the socket */

/* 2) connect() to the server */

/* Example: A client could “write” a request to a server */
if((nbytes = write(sd, buf, sizeof(buf))) < 0) {
    perror(“write”);    exit(1);
}
```

# Receiving data from a socket



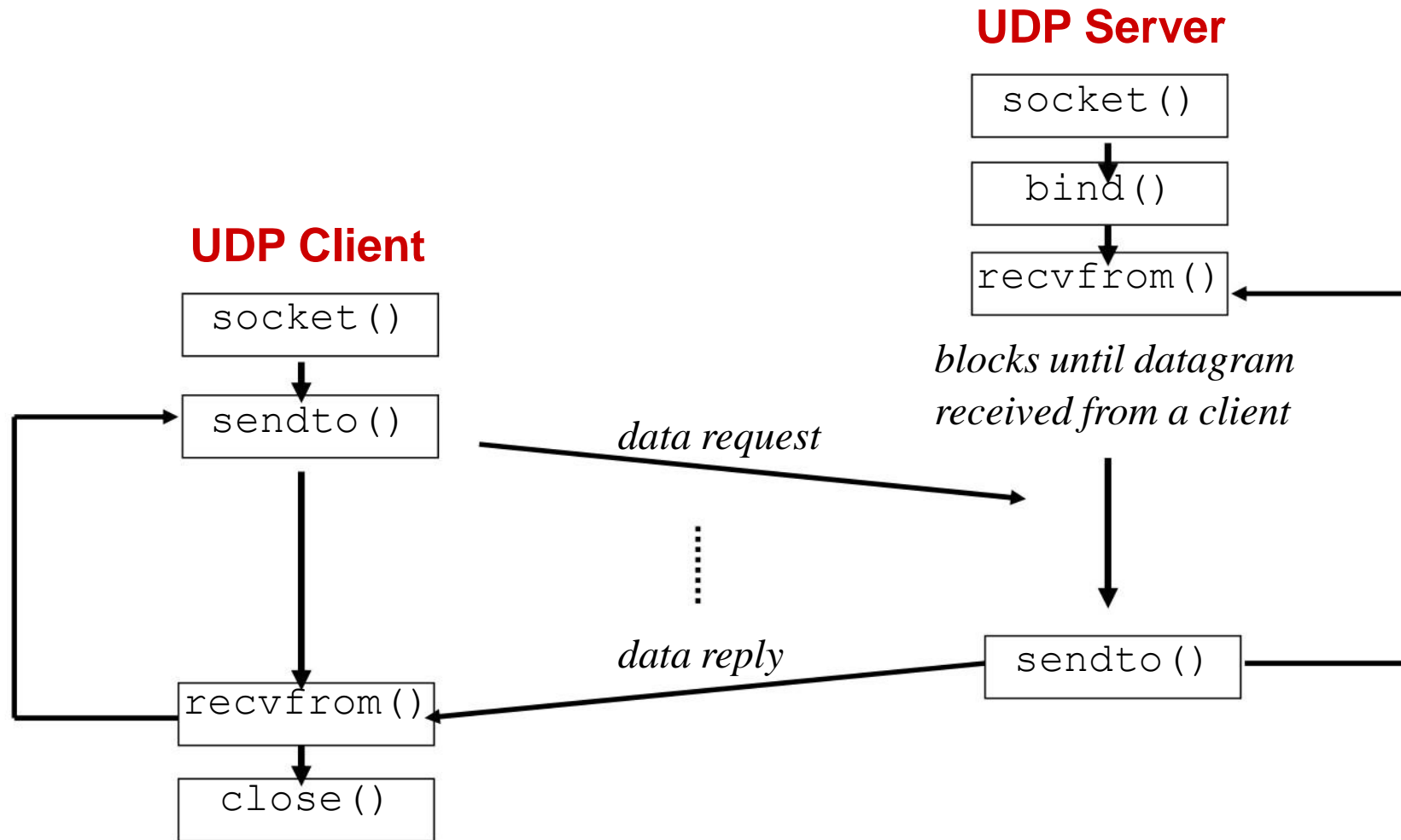
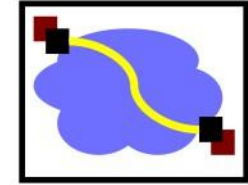
- **read** can be used with a socket

```
int sd;                /* socket descriptor */
char buf[512];         /* used by read() */
int nbytes;            /* used by read() */

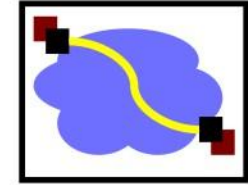
/* 1) create the socket */
/* 2) bind the socket to a port */
/* 3) listen on the socket */
/* 4) accept the incoming connection */

if((nbytes = read(sd, buf, sizeof(buf))) < 0) {
    perror("read"); exit(1);
}
```

# UDP Client-Server Interaction



# Simple Server Program

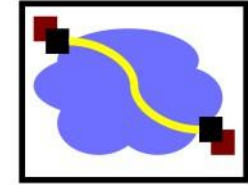


```
#include<stdio.h>
#include<sys/types.h>
#include<sys/socket.h>
#include<netinet/in.h>
#include<string.h>

int main(int argc,char **argv)
{

    int len;
    int sockfd,newfd,n;
    struct sockaddr_in servaddr,cliaddr;
    char buff[1024];
    char str[1000];
```

# Simple Server Program



```
sockfd=socket(AF_INET,SOCK_STREAM,0);
```

```
if(sockfd<0)
```

```
    perror("cannot create socket");
```

```
bzero(&servaddr,sizeof(servaddr));
```

```
servaddr.sin_family=AF_INET;
```

```
servaddr.sin_addr.s_addr=INADDR_ANY;
```

```
servaddr.sin_port=htons(7228);
```

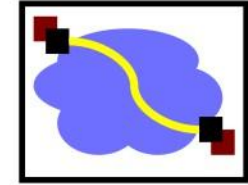
```
if(bind(sockfd,(struct sockaddr*)&servaddr,sizeof(servaddr))<0)
```

```
    perror("Bind error");
```

```
listen(sockfd,2);
```



# Simple Server Program

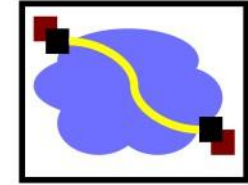


```
len=sizeof(cliaddr);
newfd=accept(sockfd,(struct sockaddr*)&cliaddr,&len);
// printf("hi");
//Receiving the message

n=read(newfd,buff,sizeof(buff));
printf("\nReceived Message is \t%s",buff);

close(sockfd);
close(newfd);
return 0;
}
```

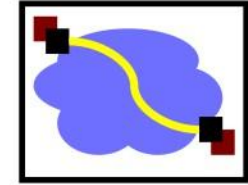
# Simple Client Program



```
#include<stdio.h>
#include<sys/types.h>
#include<sys/socket.h>
#include<netinet/in.h>
#include<string.h>

int main(int argc,char **argv)
{
    int len;
    int sockfd,n;
    struct sockaddr_in servaddr,cliaddr;
```

# Simple Client Program



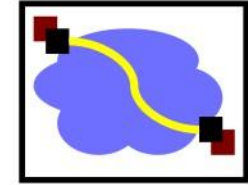
```
char str[1000];
char buff[1024];

sockfd=socket(AF_INET,SOCK_STREAM,0);
if(sockfd<0)
    perror("cannot create socket");

bzero(&servaddr,sizeof(servaddr));

servaddr.sin_family=AF_INET;
servaddr.sin_addr.s_addr=inet_addr(argv[1]);
servaddr.sin_port=htons(7228);
```

# Simple Client Program



```
connect(sockfd,(struct sockaddr*)&servaddr,sizeof(servaddr));
```

```
//Sending Message
```

```
printf("Enter the message");
```

```
scanf("%s",buff);
```

```
n=write(sockfd,buff,sizeof(buff));
```

```
close(sockfd);
```

```
return 0;
```

```
}
```