Introduction to Socket Programming Part-I

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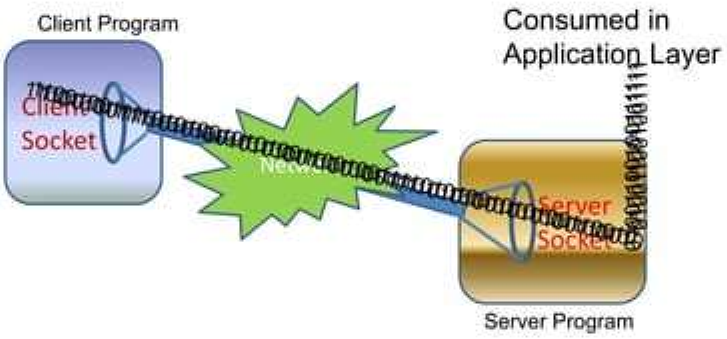
Sockets!!!

- Is it like this ???

- Electrical Sockets, used to transfer Electrical power

Sockets in Network Programs



Network Sockets

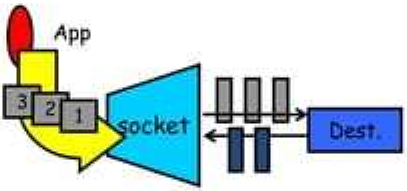
- The *socket* is the method for accomplishing communication among processes in a network.
- An interface between application and the network
- i.e. The application can send/receive data to/from the network via sockets
- In UNIX terminology you can say that it is also a file,
  - As a file is understood by a *file descriptor*
  - *Socket* is also recognized by a *socket descriptor* (a 16 bit integer)
- Sockets are always created in pairs and they are used to communicate with other sockets
- There are many kinds of sockets like Internet sockets, UNIX sockets, . . .

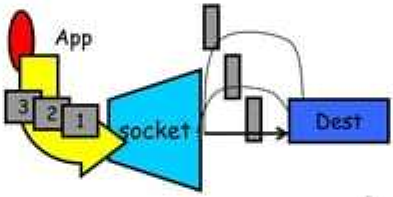
Socket API

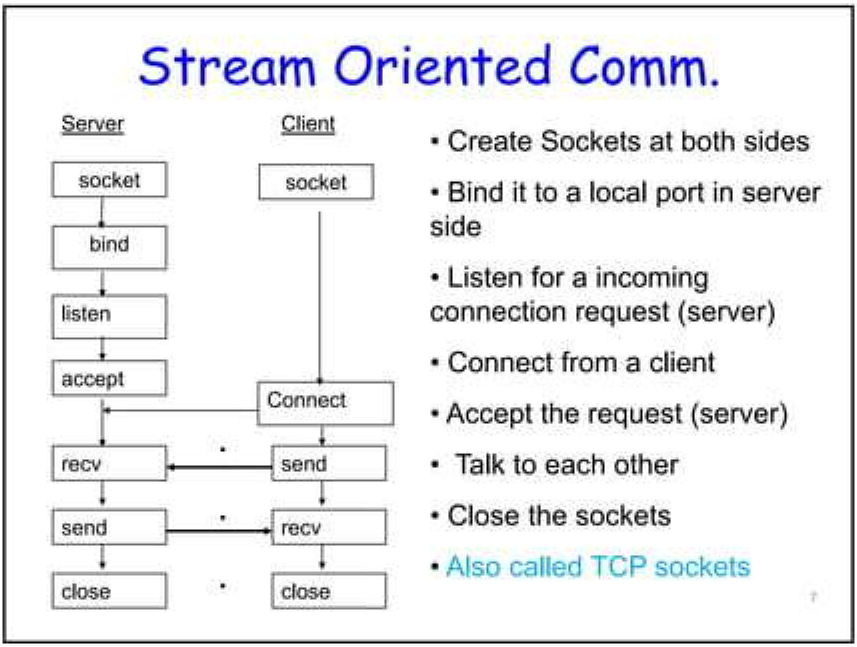
- We will use Socket API with C programming in Linux environment
- Socket API contains many data structures, functions and system calls which will help us to write good and efficient network programs
- Requirement is any PC loaded with Linux, C and Socket API
- It is also possible to program in other environments like windows and other UNIX systems!!! You need to explore

Essential types of Sockets

- SOCK_STREAM
  - TCP
  - reliable delivery
  - in-order guaranteed
  - connection-oriented
  - bidirectional
- SOCK_DGRAM
  - UDP
  - unreliable delivery
  - no order guarantee
  - no notion of "connection"
  - can send or receive







Stream Oriented Comm.

Server

socket

bind

listen

accept

recv

send

close

Client

socket

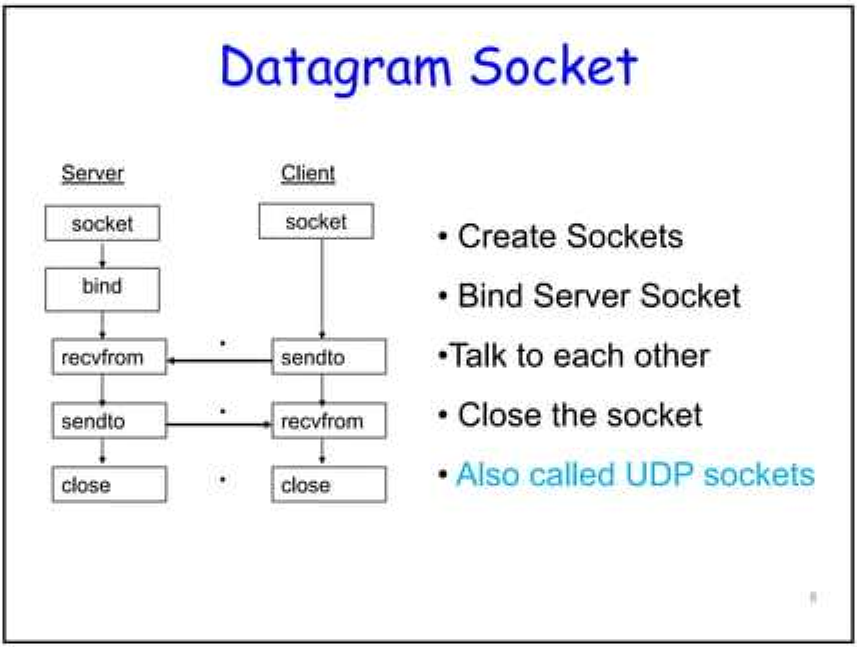
Connect

send

recv

close

- Create Sockets at both sides
- Bind it to a local port in server side
- Listen for a incoming connection request (server)
- Connect from a client
- Accept the request (server)
- Talk to each other
- Close the sockets
- Also called TCP sockets



Datagram Socket

Server

socket

bind

recvfrom

sendto

close

Client

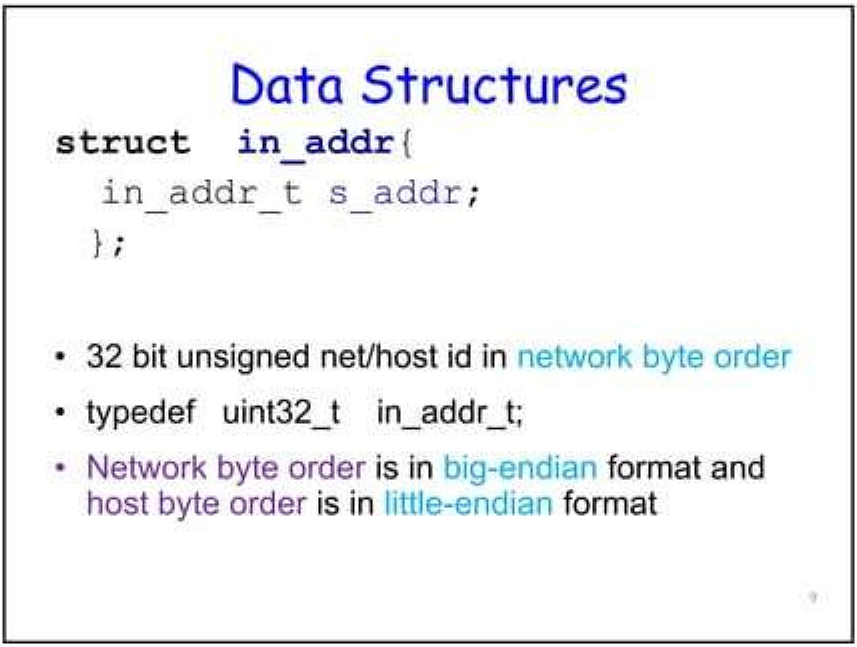
socket

sendto

recvfrom

close

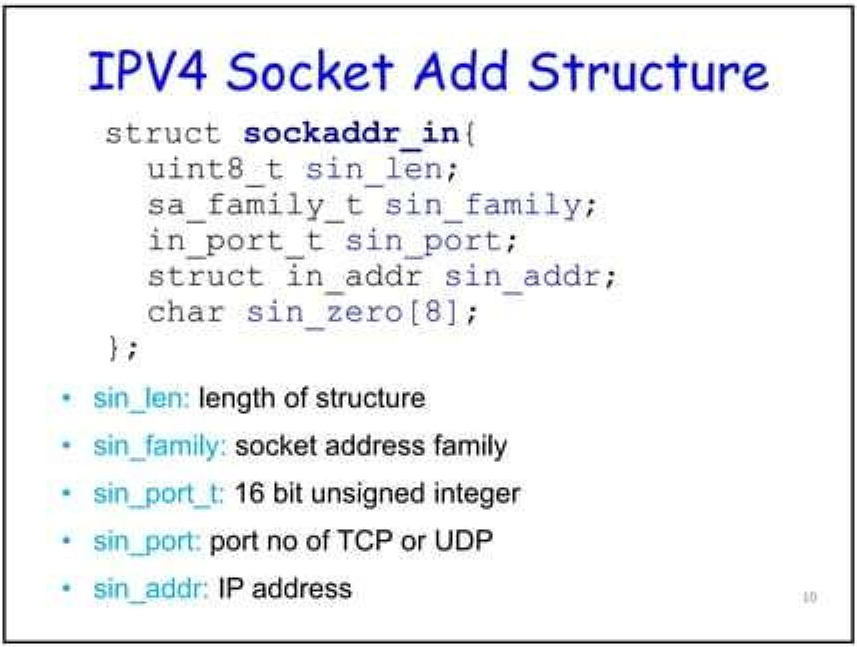
- Create Sockets
- Bind Server Socket
- Talk to each other
- Close the socket
- Also called UDP sockets



Data Structures

```
struct  in_addr{
   in_addr_t s_addr;
  };
```

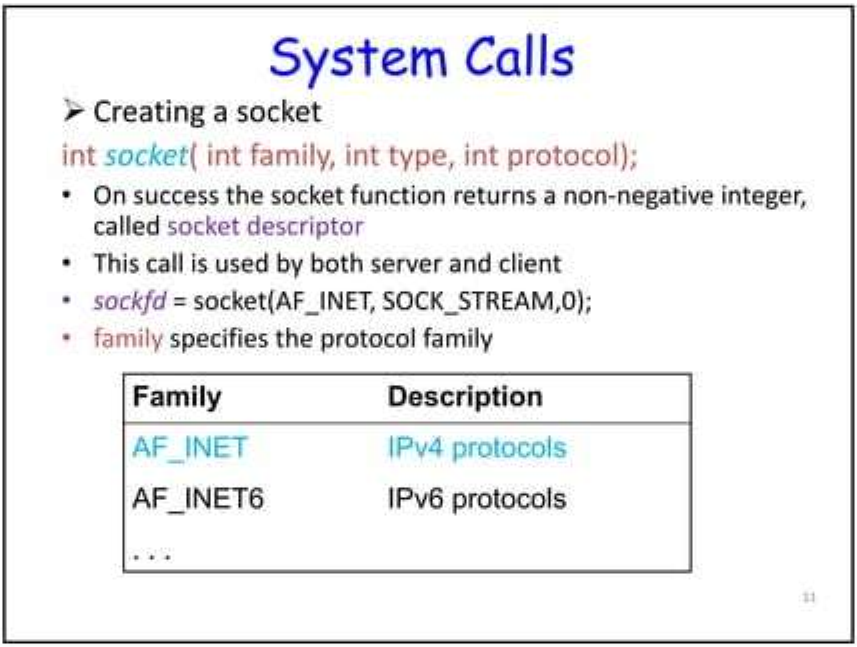
- 32 bit unsigned net/host id in network byte order
- typedef uint32_t in_addr_t;
- Network byte order is in big-endian format and host byte order is in little-endian format



IPV4 Socket Add Structure

```
struct sockaddr_in{
  uint8_t sin_len;
  sa_family_t sin_family;
  in_port_t sin_port;
  struct in_addr sin_addr;
  char sin_zero[8];
};
```

- sin_len: length of structure
- sin_family: socket address family
- sin_port_t: 16 bit unsigned integer
- sin_port: port no of TCP or UDP
- sin_addr: IP address



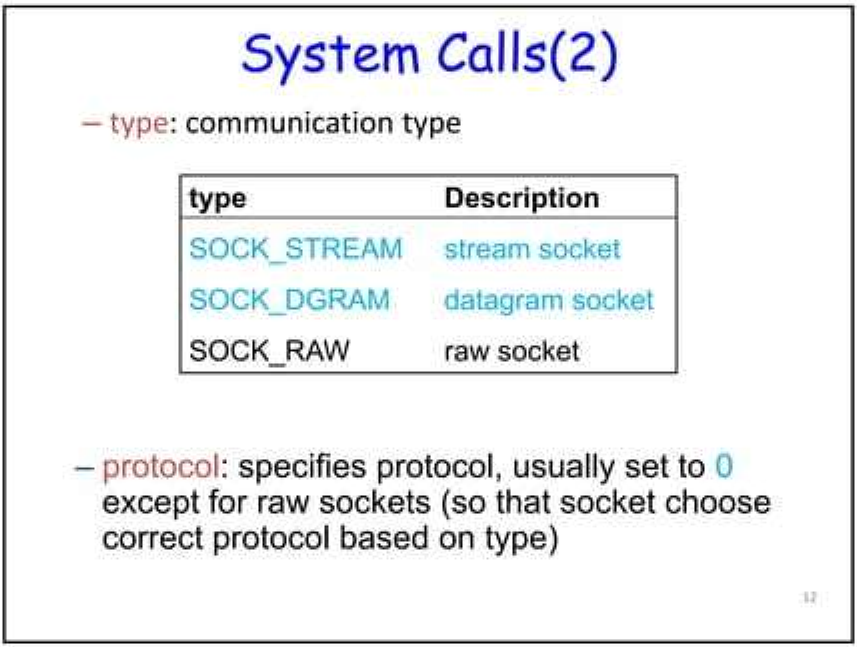
System Calls

➢ Creating a socket

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

- On success the socket function returns a non-negative integer, called socket descriptor
- This call is used by both server and client
- *sockfd* = socket(AF_INET, SOCK_STREAM,0);
- family specifies the protocol family

Family	Description
AF_INET	IPv4 protocols
AF_INET6	IPv6 protocols
. . .	

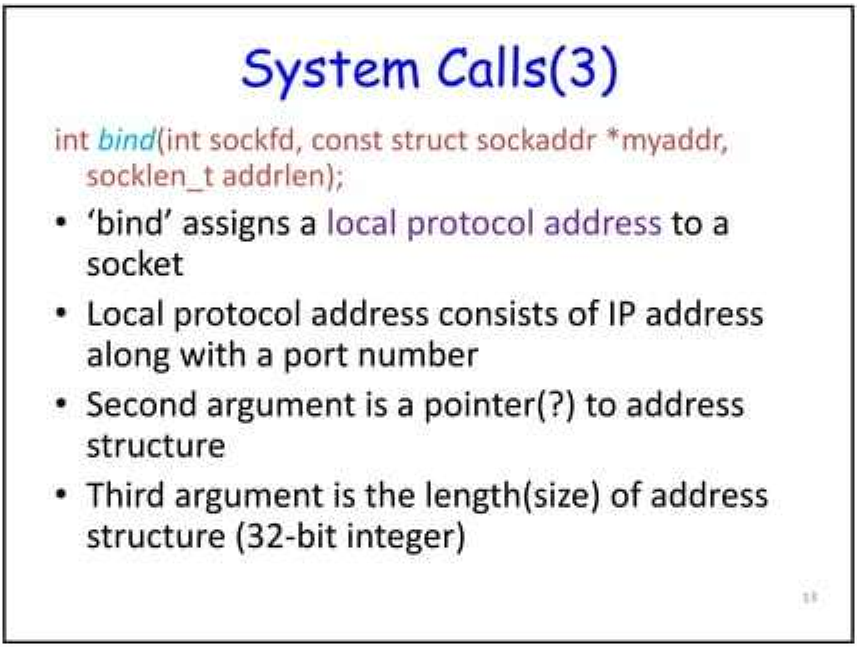


System Calls(2)

– type: communication type

type	Description
SOCK_STREAM	stream socket
SOCK_DGRAM	datagram socket
SOCK_RAW	raw socket

– protocol: specifies protocol, usually set to 0 except for raw sockets (so that socket choose correct protocol based on type)



System Calls(3)

```
int bind(int sockfd, const struct sockaddr *myaddr,
   socklen_t addrlen);
```

- 'bind' assigns a local protocol address to a socket
- Local protocol address consists of IP address along with a port number
- Second argument is a pointer(?) to address structure
- Third argument is the length(size) of address structure (32-bit integer)

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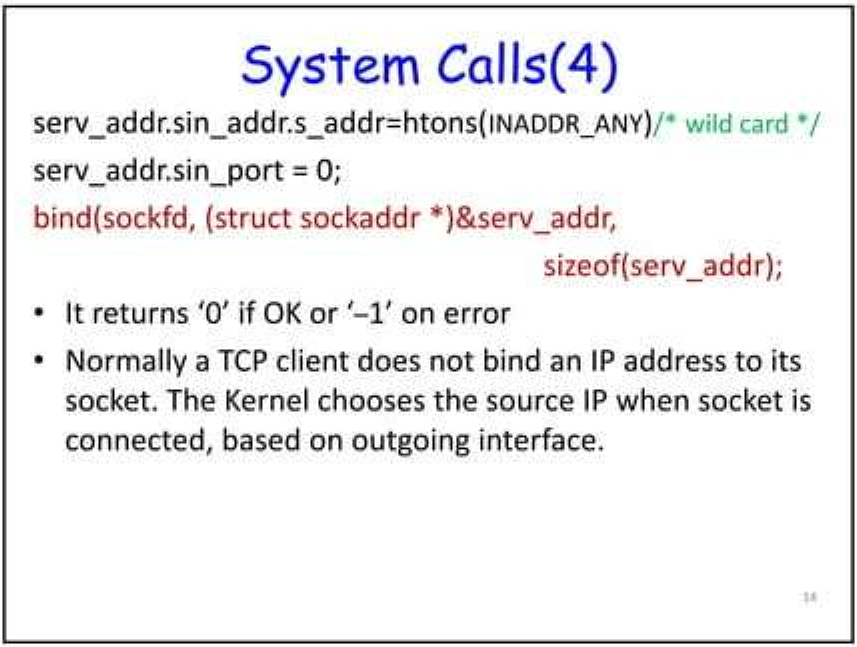

System Calls(4)

```
serv_addr.sin_addr.s_addr=htons(INADDR_ANY)/* wild card */
serv_addr.sin_port = 0;
bind(sockfd, (struct sockaddr *)&serv_addr,
                                        sizeof(serv_addr);
```

- It returns '0' if OK or '–1' on error
- Normally a TCP client does not bind an IP address to its socket. The Kernel chooses the source IP when socket is connected, based on outgoing interface.

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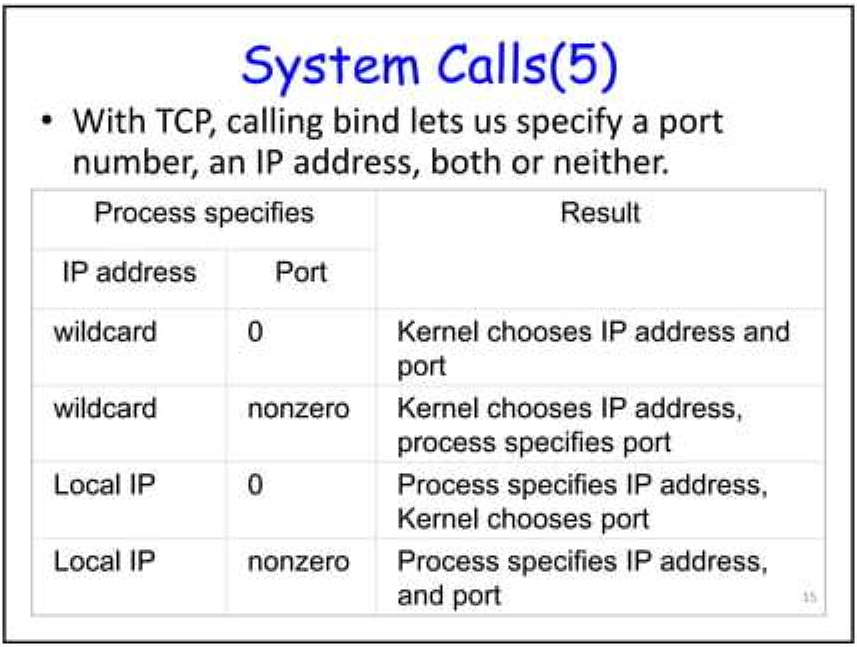
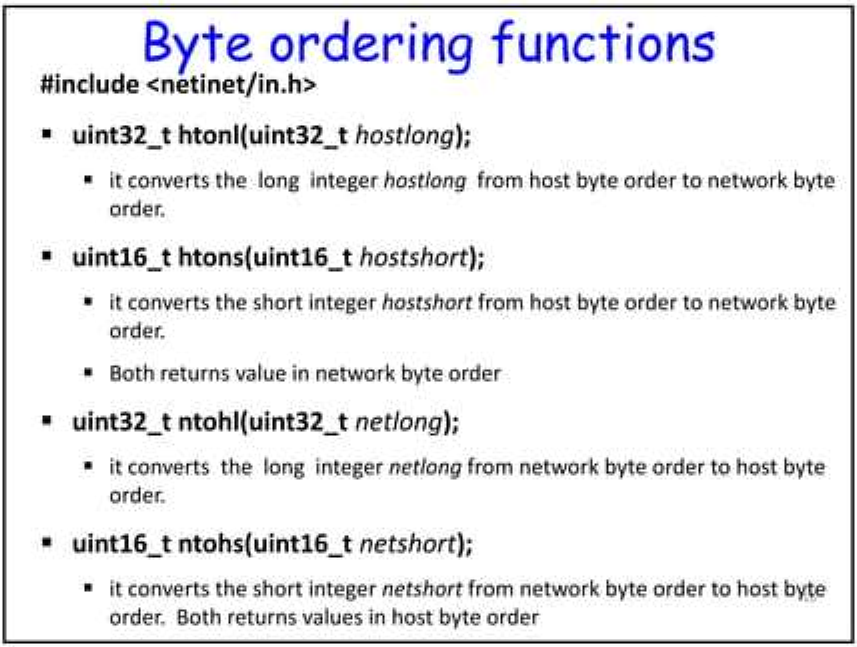


System Calls(5)

- With TCP, calling bind lets us specify a port number, an IP address, both or neither.

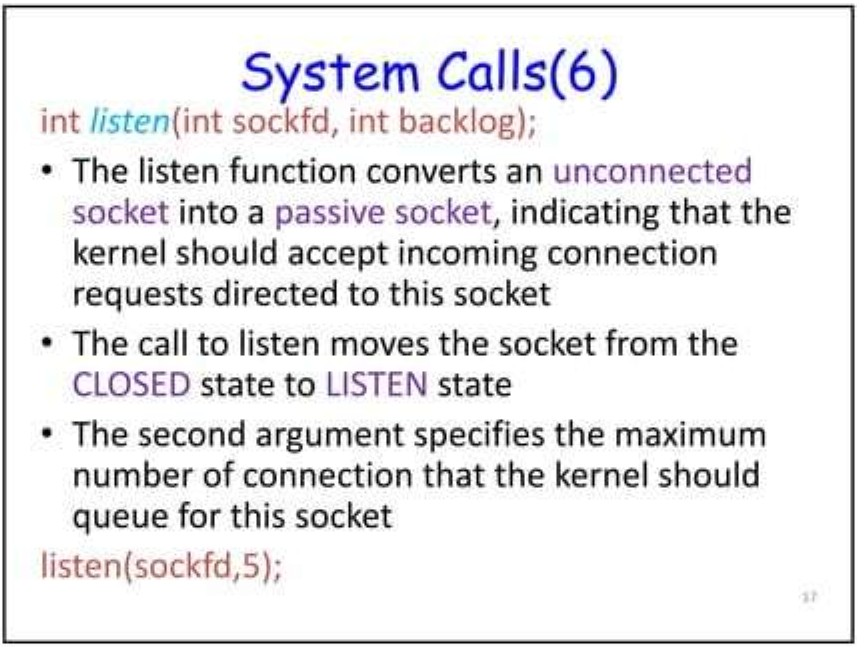
Process specifies		Result
IP address	Port	
wildcard	0	Kernel chooses IP address and port
wildcard	nonzero	Kernel chooses IP address, process specifies port
Local IP	0	Process specifies IP address, Kernel chooses port
Local IP	nonzero	Process specifies IP address, and port



Byte ordering functions

#include <netinet/in.h>

- **uint32_t htonl(uint32_t *hostlong*);**
  - it converts the long integer *hostlong* from host byte order to network byte order.
- **uint16_t htons(uint16_t *hostshort*);**
  - it converts the short integer *hostshort* from host byte order to network byte order.
  - Both returns value in network byte order
- **uint32_t ntohl(uint32_t *netlong*);**
  - it converts the long integer *netlong* from network byte order to host byte order.
- **uint16_t ntohs(uint16_t *netshort*);**
  - it converts the short integer *netshort* from network byte order to host byte order. Both returns values in host byte order



System Calls(6)

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

- The listen function converts an unconnected socket into a passive socket, indicating that the kernel should accept incoming connection requests directed to this socket
- The call to listen moves the socket from the CLOSED state to LISTEN state
- The second argument specifies the maximum number of connection that the kernel should queue for this socket

listen(sockfd,5);

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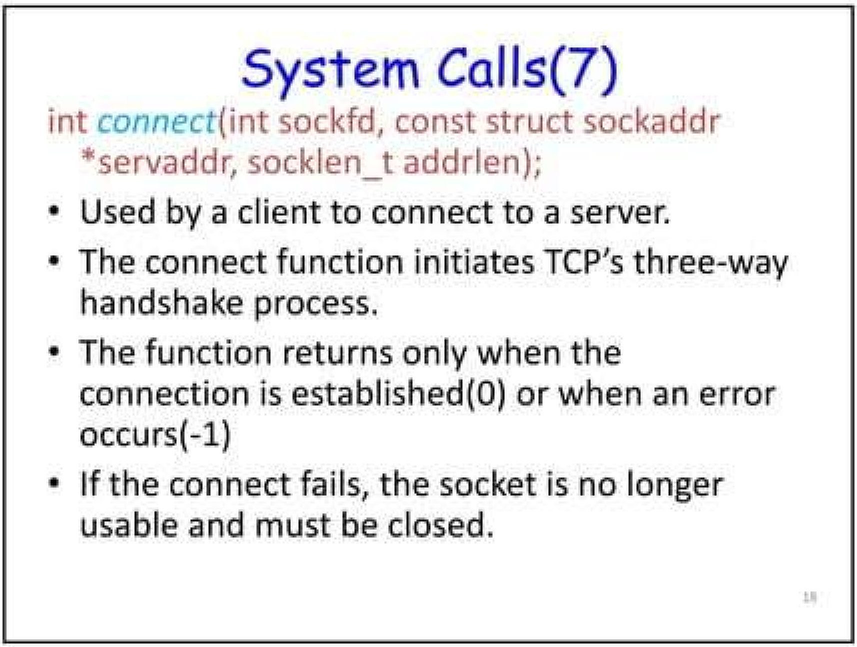

System Calls(7)

int *connect*(int sockfd, const struct sockaddr *servaddr, socklen_t addrlen);

- Used by a client to connect to a server.
- The connect function initiates TCP's three-way handshake process.
- The function returns only when the connection is established(0) or when an error occurs(-1)
- If the connect fails, the socket is no longer usable and must be closed.

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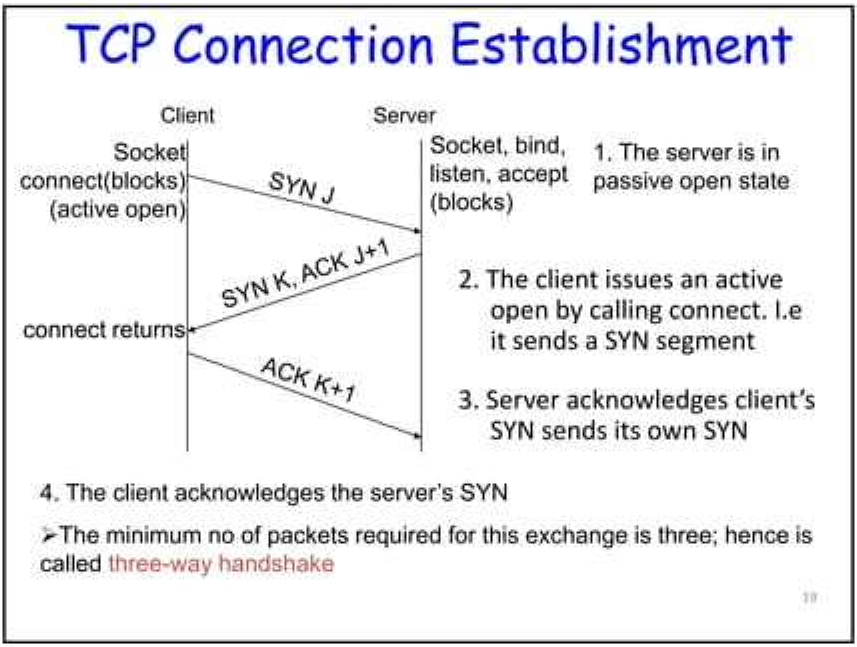

TCP Connection Establishment

1. The server is in passive open state

2. The client issues an active open by calling connect. I.e it sends a SYN segment

3. Server acknowledges client's SYN sends its own SYN

4. The client acknowledges the server's SYN

➢The minimum no of packets required for this exchange is three; hence is called three-way handshake

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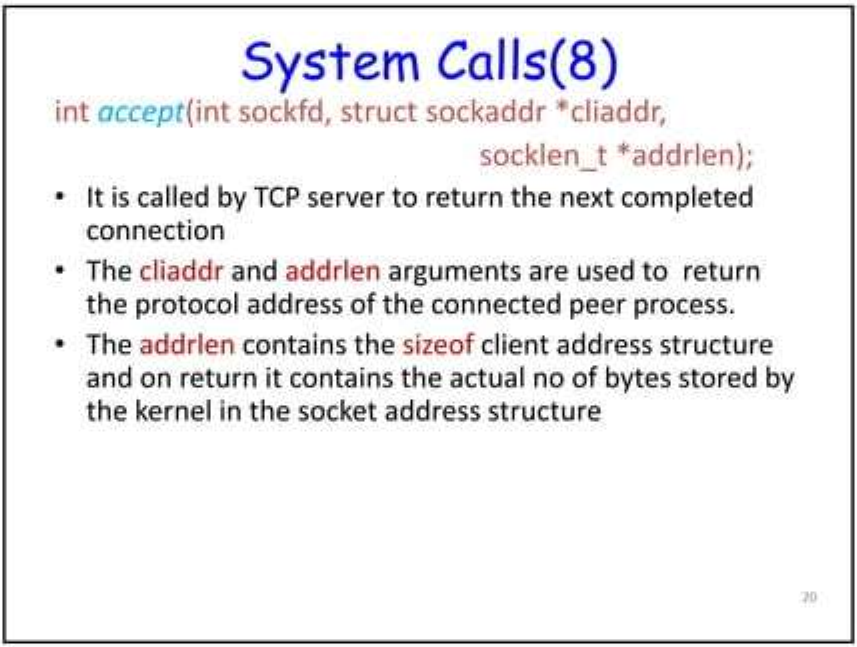

System Calls(8)

int *accept*(int sockfd, struct sockaddr *cliaddr,
socklen_t *addrlen);

- It is called by TCP server to return the next completed connection
- The cliaddr and addrlen arguments are used to return the protocol address of the connected peer process.
- The addrlen contains the sizeof client address structure and on return it contains the actual no of bytes stored by the kernel in the socket address structure

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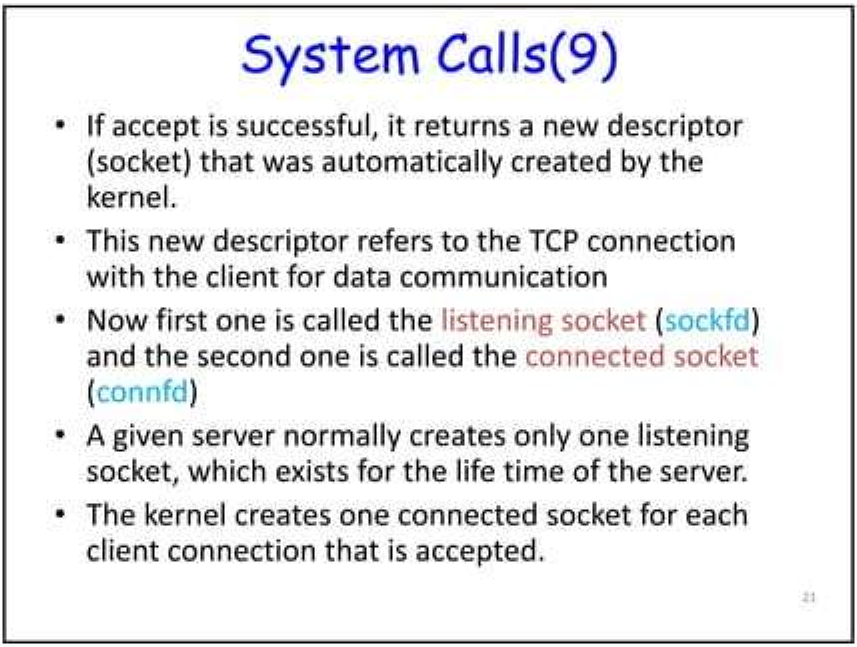

System Calls(9)

- If accept is successful, it returns a new descriptor (socket) that was automatically created by the kernel.
- This new descriptor refers to the TCP connection with the client for data communication
- Now first one is called the listening socket (sockfd) and the second one is called the connected socket (connfd)
- A given server normally creates only one listening socket, which exists for the life time of the server.
- The kernel creates one connected socket for each client connection that is accepted.

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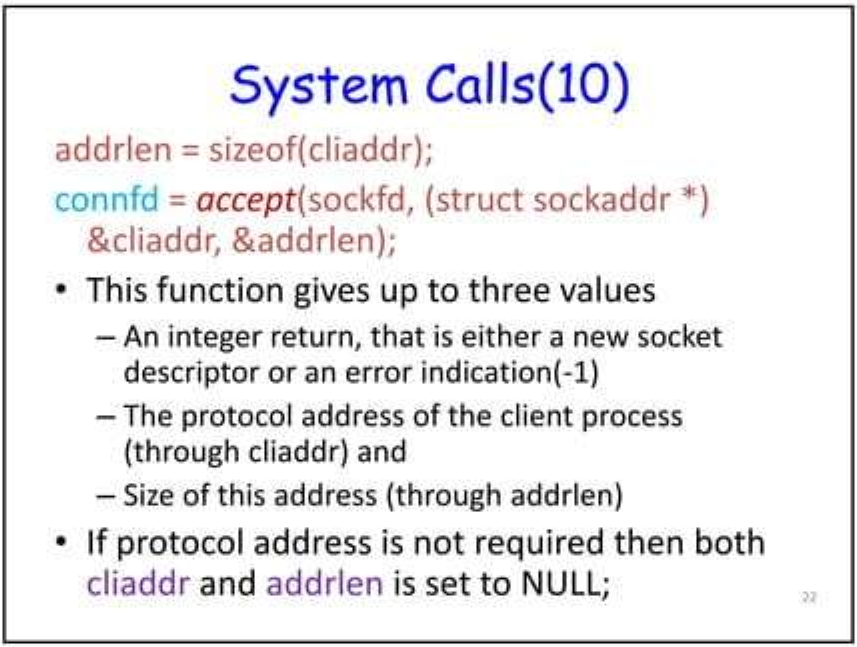

System Calls(10)

```
addrlen = sizeof(cliaddr);
connfd = accept(sockfd, (struct sockaddr *)
  &cliaddr, &addrlen);
```

- This function gives up to three values
  - An integer return, that is either a new socket descriptor or an error indication(-1)
  - The protocol address of the client process (through cliaddr) and
  - Size of this address (through addrlen)
- If protocol address is not required then both cliaddr and addrlen is set to NULL;

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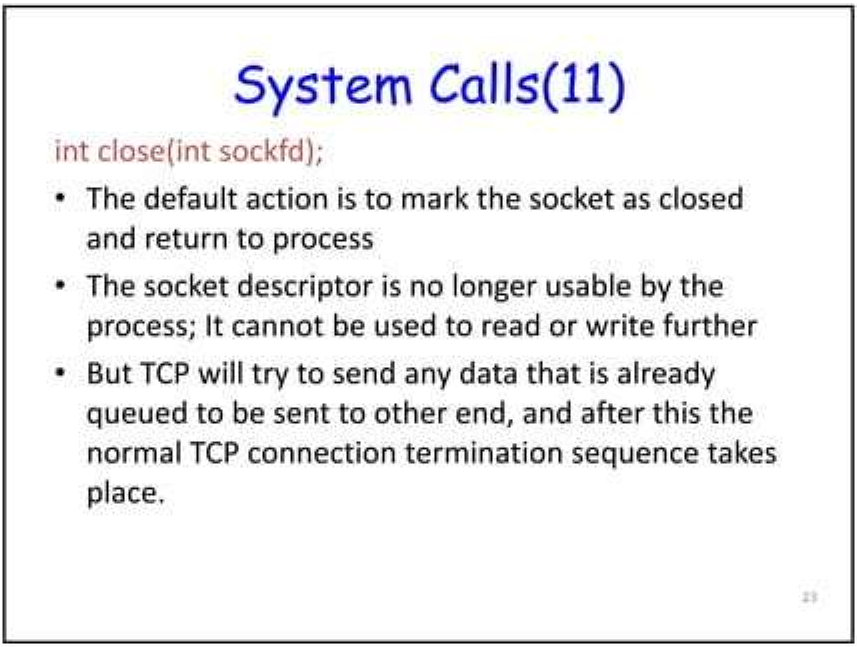

System Calls(11)

int close(int sockfd);

- The default action is to mark the socket as closed and return to process
- The socket descriptor is no longer usable by the process; It cannot be used to read or write further
- But TCP will try to send any data that is already queued to be sent to other end, and after this the normal TCP connection termination sequence takes place.

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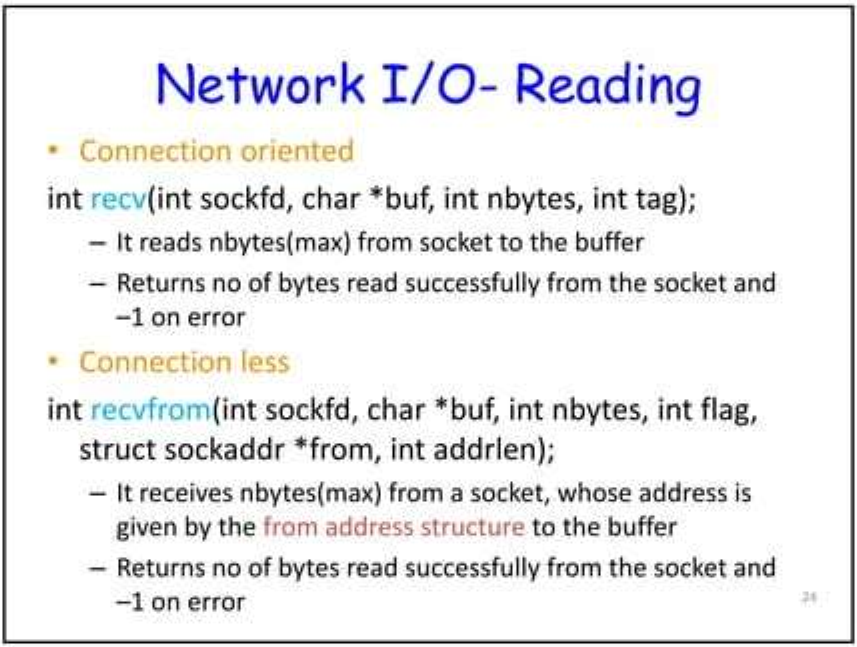

Network I/O- Reading

- Connection oriented

int recv(int sockfd, char *buf, int nbytes, int tag);

- It reads nbytes(max) from socket to the buffer
- Returns no of bytes read successfully from the socket and –1 on error

- Connection less

int recvfrom(int sockfd, char *buf, int nbytes, int flag, struct sockaddr *from, int addrlen);

- It receives nbytes(max) from a socket, whose address is given by the from address structure to the buffer
- Returns no of bytes read successfully from the socket and –1 on error

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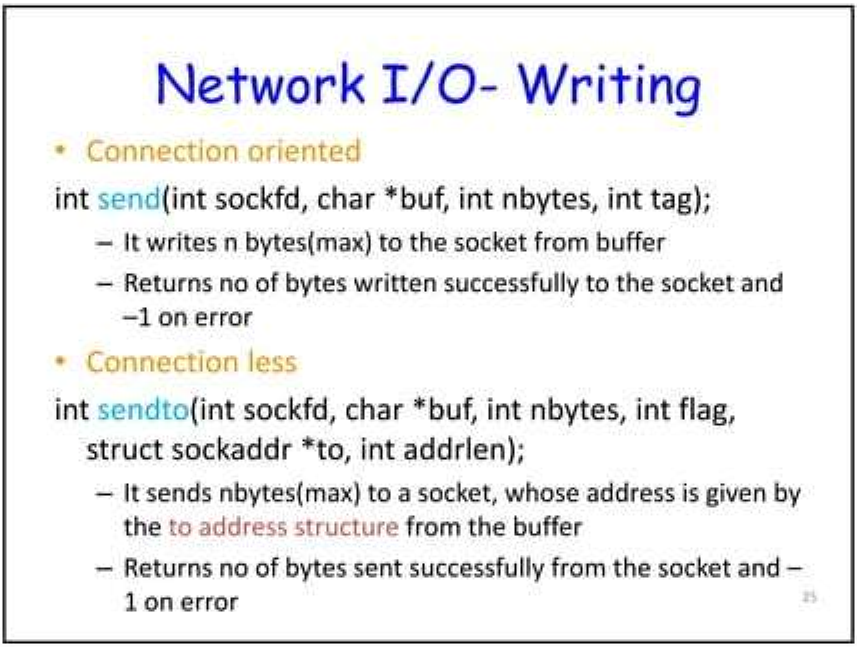

Network I/O- Writing

- Connection oriented

int send(int sockfd, char *buf, int nbytes, int tag);

  - It writes n bytes(max) to the socket from buffer
  - Returns no of bytes written successfully to the socket and –1 on error

- Connection less

int sendto(int sockfd, char *buf, int nbytes, int flag, struct sockaddr *to, int addrlen);

  - It sends nbytes(max) to a socket, whose address is given by the to address structure from the buffer
  - Returns no of bytes sent successfully from the socket and –1 on error

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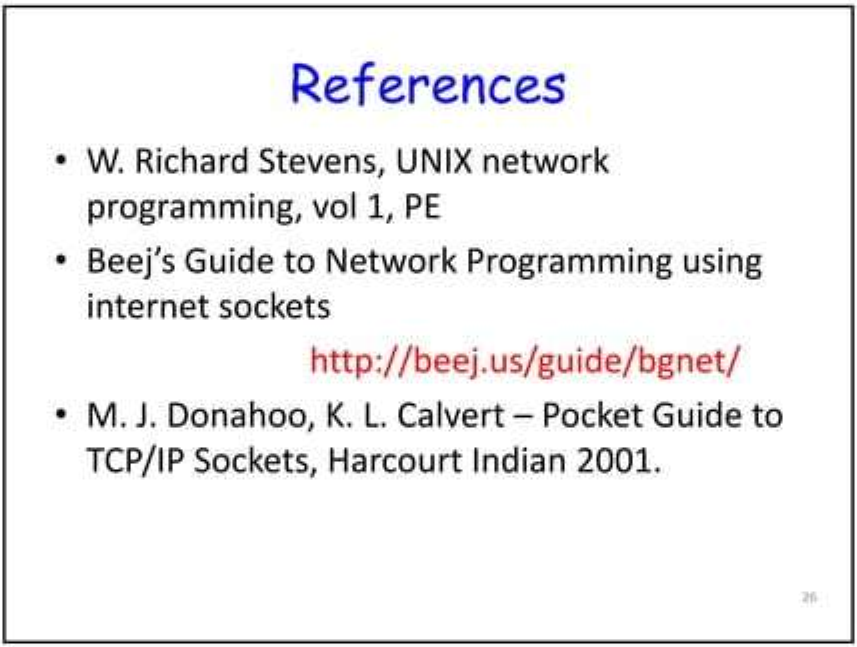

References

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  http://beej.us/guide/bgnet/
- M. J. Donahoo, K. L. Calvert – Pocket Guide to TCP/IP Sockets, Harcourt Indian 2001.

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Thank You

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