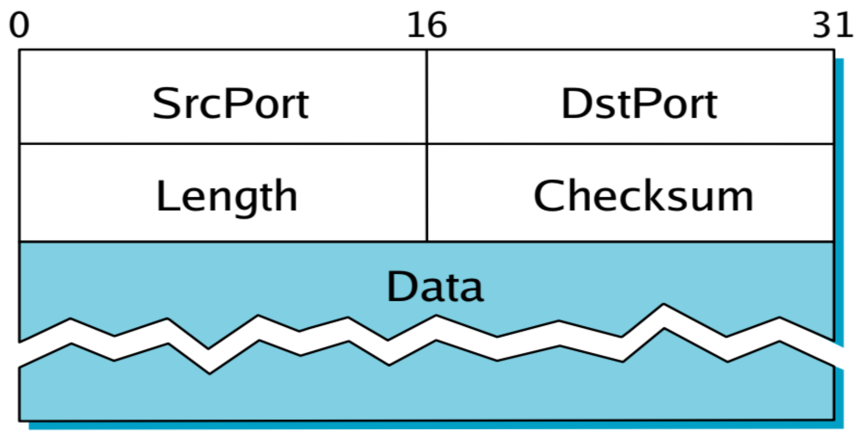
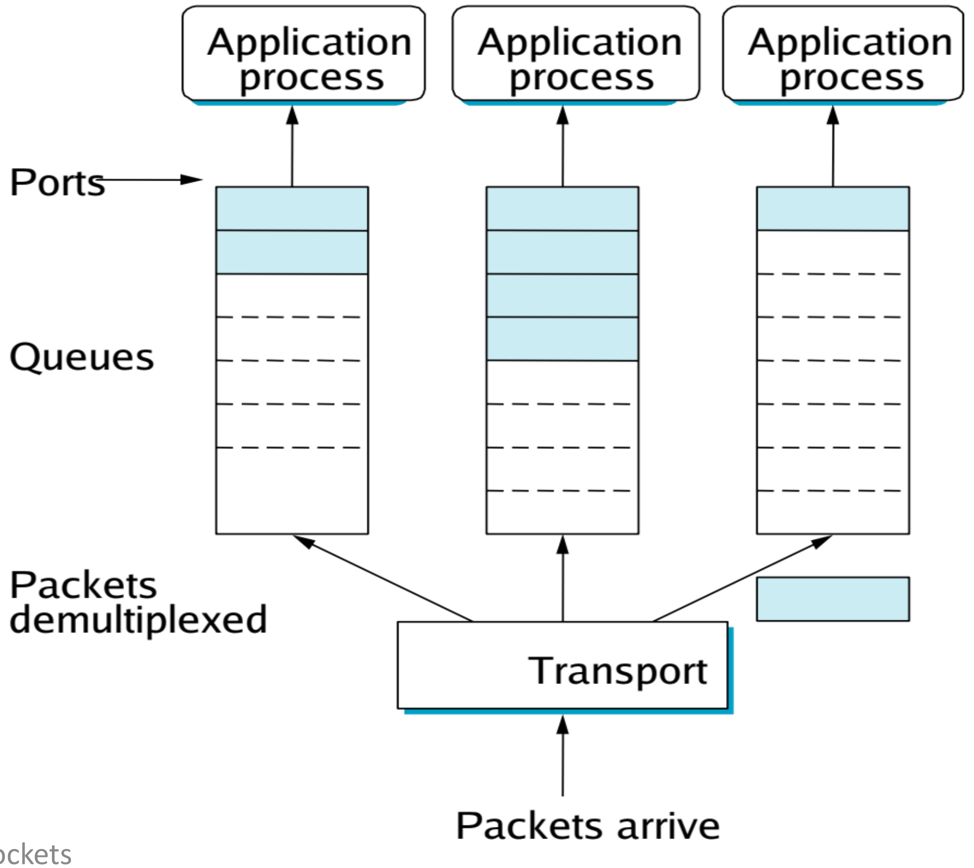
TCP/IP Sockets

Demultiplexing

- Convert host-to-host packet delivery service into a process-to-process communication channel

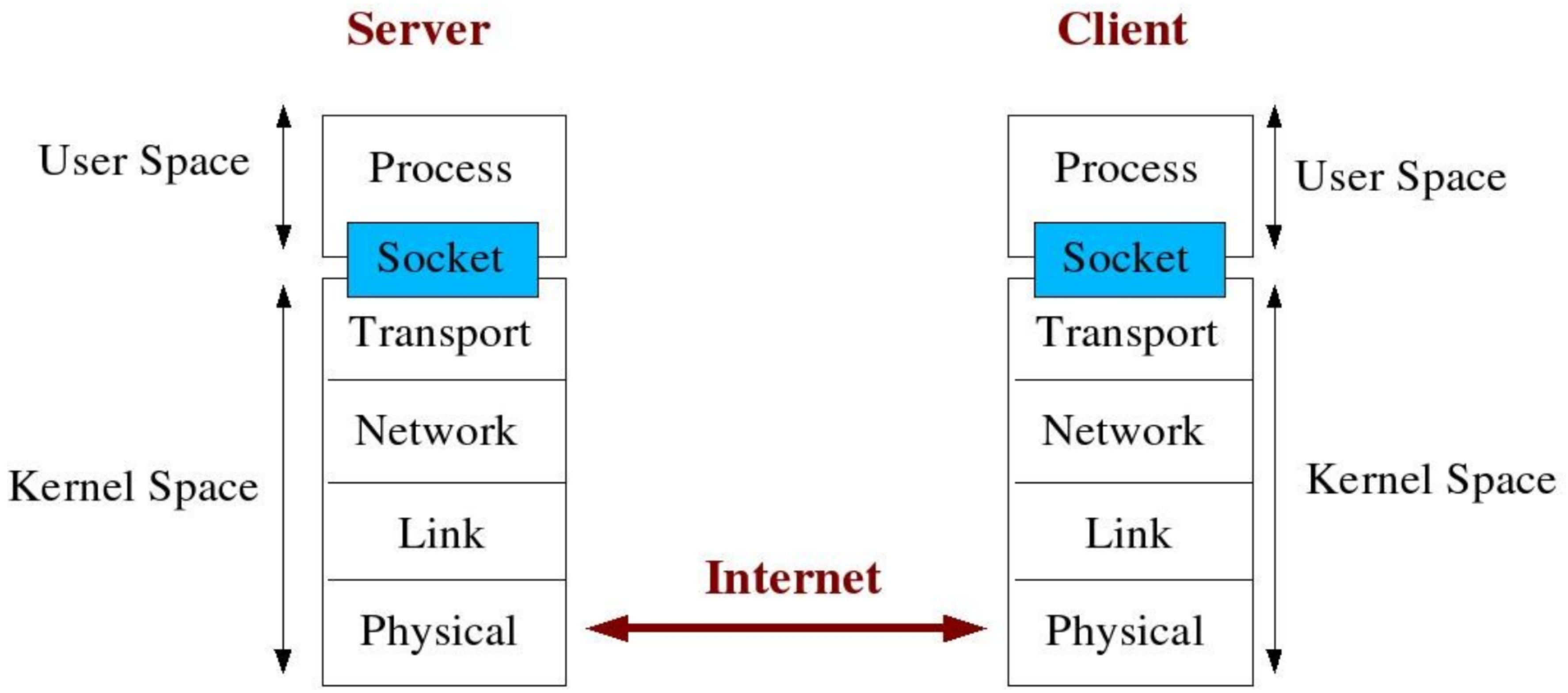




What is a socket?

- Socket: An interface between an application process and transport layer
  - The application process can send/receive messages to/from another application process (local or remote)via a socket
- In Unix jargon, a socket is a file descriptor – an integer associated with an open file
- Types of Sockets: **Internet Sockets**, unix sockets, X.25 sockets etc
  - Internet sockets characterized by IP Address (4 bytes), port number (2 bytes)

Socket Description



Types of Internet Sockets

- Stream Sockets (SOCK_STREAM)
  - Connection oriented
  - Rely on TCP to provide reliable two-way connected communication
- Datagram Sockets (SOCK_DGRAM)
  - Rely on UDP
  - Connection is unreliable

Byte Ordering

- Two types of “Byte ordering”
  - Network Byte Order: High-order byte of the number is stored in memory at the lowest address
  - Host Byte Order: Low-order byte of the number is stored in memory at the lowest address
  - Network stack (TCP/IP) expects Network Byte Order
- Conversions:
  - htons() - Host to Network Short
  - htonl() - Host to Network Long
  - ntohs() - Network to Host Short
  - ntohl() - Network to Host Long

socket() -- Get the file descriptor

- int socket(int domain, int type, int protocol);
  - domain should be set to PF_INET
  - type can be SOCK_STREAM or SOCK_DGRAM
  - set protocol to 0 to have socket choose the correct protocol based on type
  - socket() returns a socket descriptor for use in later system calls or -1 on error

```
int sockfd;
sockfd = socket (PF_INET, SOCK_STREAM, 0);
```

Socket Structures

- struct sockaddr: Holds socket address information for many types of sockets

```
struct sockaddr {
        unsigned short   sa_family;     //address family AF_xxx
        unsigned short   sa_data[14]; //14 bytes of protocol addr
}
```

- struct sockaddr_in: A parallel structure that makes it easy to reference elements of the socket address

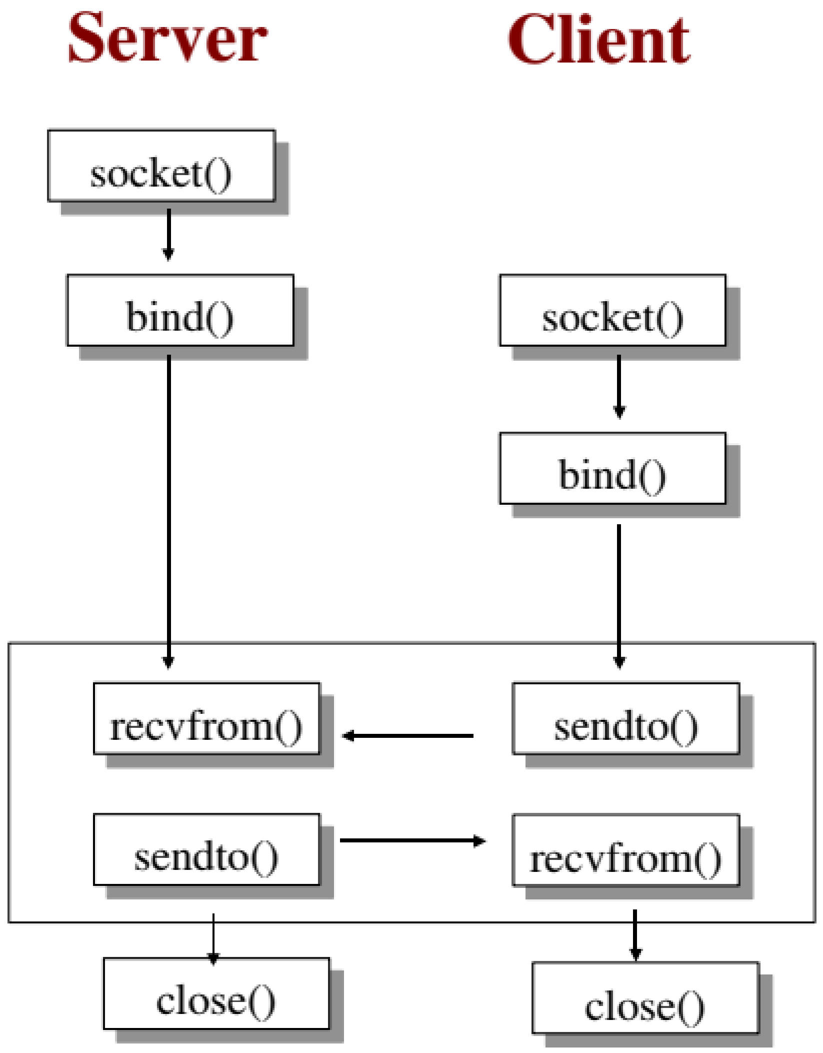
```
struct sockaddr_in {
        short int                  sin_family;    // set to AF_INET
        unsigned short int         sin_port;      // Port number
        struct in_addr             sin_addr;      // Internet address
        unsigned char              sin_zero[8];  //set to all zeros
}
```

- sin_port and sin_addr must be in **Network Byte Order**

bind() - what port am I on?

- Used to associate a socket with a port on the local machine
  - The port number is used by the kernel to match an incoming packet to a process
- int bind(int sockfd, struct sockaddr *my_addr, int addrlen)
  - sockfd is the socket descriptor returned by socket()
  - my_addr is pointer to struct sockaddr that contains information about your IP address and port
  - addrlen is set to sizeof(struct sockaddr)
  - returns -1 on error
  - my_addr.sin_port = 0; //choose an unused port at random
  - my_addr.sin_addr.s_addr = INADDR_ANY; //use my IP adr

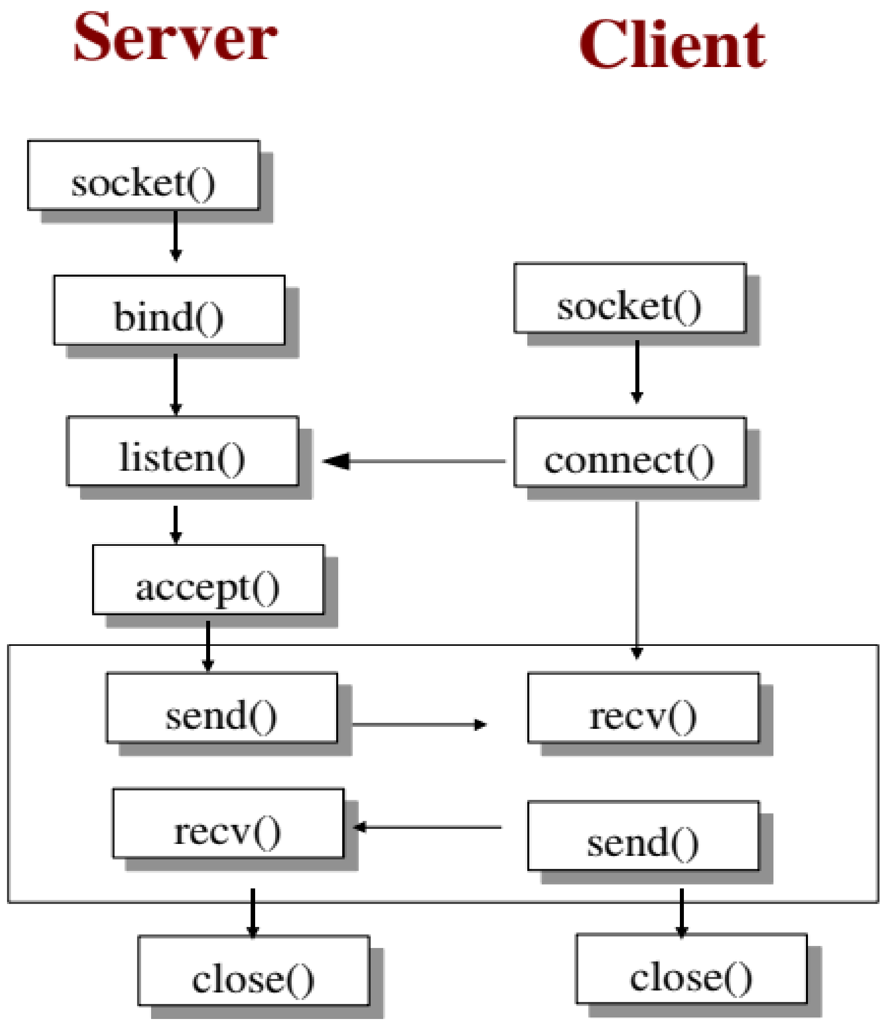
Connectionless Protocol



sendto() and recvfrom() - DGRAM style

- int sendto(int sockfd, const void *msg, int len, int flags, const struct sockaddr *to, int tolen);
  - *to* is a pointer to a struct sockaddr which contains the destination IP and port
  - *tolen* is sizeof(struct sockaddr)
- int recvfrom(int sockfd, void *buf, int len, int flags, struct sockaddr *from, int *fromlen);
  - *from* is a pointer to a local struct sockaddr that will be filled with IP address and port of the originating machine
  - *fromlen* will contain length of address stored in *from*

Connection Oriented Protocol



connect() - Hello!

- Connects to a remote host
- int connect(int sockfd, struct sockaddr *serv_addr, int addrlen)
  - sockfd is the socket descriptor returned by socket()
  - serv_addr is pointer to struct sockaddr that contains information on destination IP address and port
  - addrlen is set to sizeof(struct sockaddr)
  - returns -1 on error
- No need to bind(), kernel will choose a port

listen() - Call me please!

- Waits for incoming connections
- int listen(int sockfd, int backlog);
  - sockfd is the socket file descriptor returned by socket()
  - backlog is the number of connections allowed on the incoming queue
  - listen() returns -1 on error
  - Need to call bind() before you can listen()
    - socket()
    - bind()
    - listen()
    - accept()

accept() - Thank you for calling !

- accept() gets the pending connection on the port you are listen()ing on
- int accept(int sockfd, void *addr, int *addrlen);
  - sockfd is the listening socket descriptor
  - information about incoming connection is stored in addr which is a pointer to a local struct sockaddr_in
  - addrlen is set to sizeof(struct sockaddr_in)
  - accept returns *a new socket file descriptor* to use for this accepted connection and -1 on error

send() and recv() - Let's talk!

- The two functions are for communicating over stream sockets or connected datagram sockets.
- int send(int sockfd, const void *msg, int len, int flags);
  - sockfd is the socket descriptor you want to send data to (returned by socket() or got from accept())
  - msg is a pointer to the data you want to send
  - len is the length of that data in bytes
  - set flags to 0 for now
  - sent() returns the number of bytes actually sent (may be less than the number you told it to send) or -1 on error

send() and recv() - Let's talk!

- int recv(int sockfd, void *buf, int len, int flags);
  - sockfd is the socket descriptor to read from
  - buf is the buffer to read the information into
  - len is the maximum length of the buffer
  - set flags to 0 for now
  - recv() returns the number of bytes actually read into the buffer or -1 on error
  - If recv() returns 0, the remote side has closed connection on you

close() - Bye Bye!

- int close(int sockfd);
  - Closes connection corresponding to the socket descriptor and frees the socket descriptor
  - Will prevent any more sends and recvs