Socket Programming

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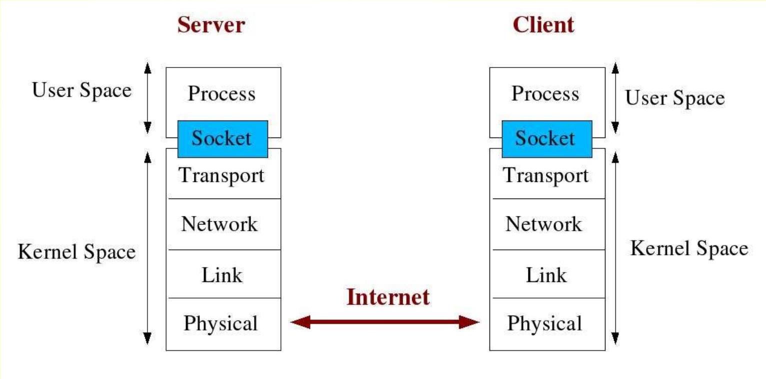
What is a socket?

- 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) and port number (2 bytes)

Socket Description



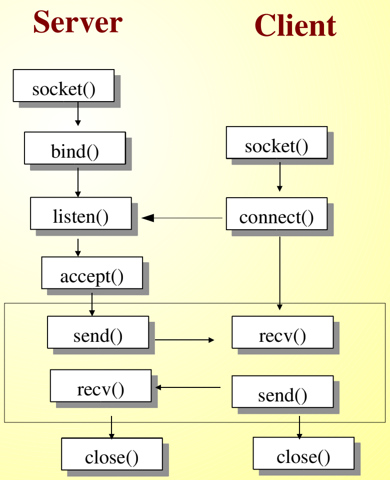
Types of Internet Sockets

- 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

Background

- 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

Connection Oriented Protocol



Server

Client

socket()

bind()

listen()

accept()

send()

recv()

close()

socket()

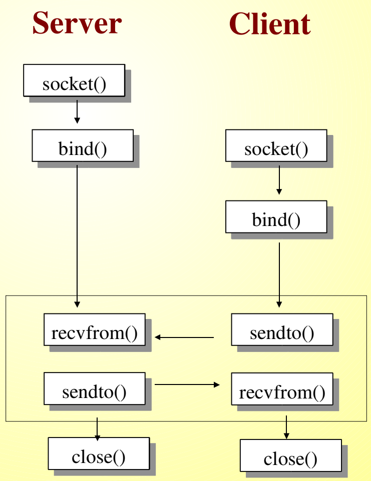
connect()

recv()

send()

close()

Connectionless Protocol



Server

Client

socket()

bind()

recvfrom()

sendto()

close()

socket()

bind()

sendto()

recvfrom()

close()

socket() -- Get the file descriptor

- int socket(int domain, int type, int protocol);
  - domain should be set to AF_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

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
}
```

Dealing with IP Addresses

- int inet_aton(const char *cp, struct in_addr *inp);
- Example usage:

```
struct sockaddr_in     my_addr;
my_addr.sin_family = AF_INET;
my_addr.sin_port = htons(MYPORT);
inet_aton(“10.0.0.5”,&(my_addr.sin_addr));
memset(&(my_addr.sin_zero),'\0',8);
```

- inet_aton() gives non-zero on success and zero on failure
- To convert binary IP to string: inet_noa()

```
printf(“%s”,inet_ntoa(my_addr.sin_addr));
```

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 addr

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
- At times, you don't have to bind() when you are using connect()

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()

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 with 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

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*

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

Miscellaneous Routines

- int getpeername(int sockfd, struct sockaddr *addr, int *addrlen);
  - Will tell who is at the other end of a connected stream socket and store that info in *addr*
- int gethostname(char *hostname, size_t size);
  - Will get the name of the computer your program is running on and store that info in hostname

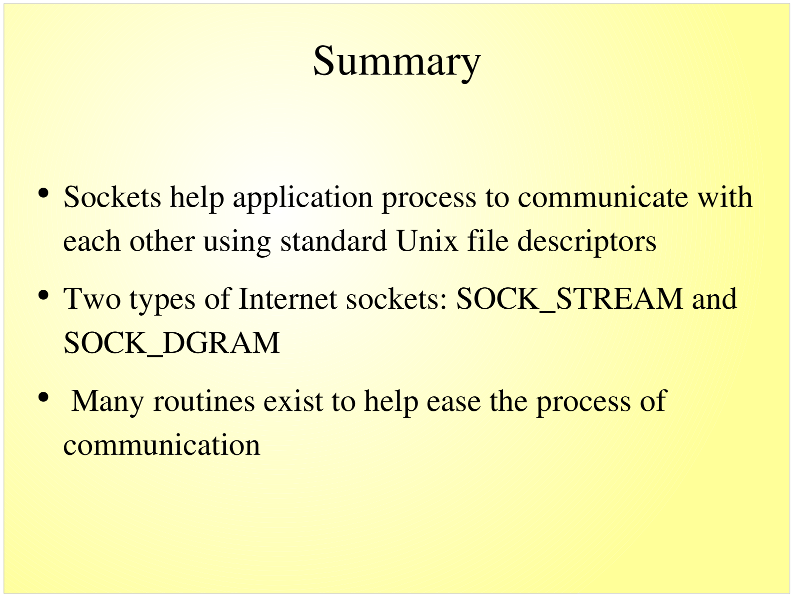
Miscellaneous Routines

- struct hostent *gethostbyname(const char *name);

```
struct hostent {
    char    *h_name;        //official name of host
    char    **h_aliases;  //alternate names for the host
    int     h_addrtype;   //usually AF_NET
    int     h_length;       //length of the address in bytes
    char    **h_addr_list; //array of network addresses for the host
}
#define h_addr h_addr_list[0]
```

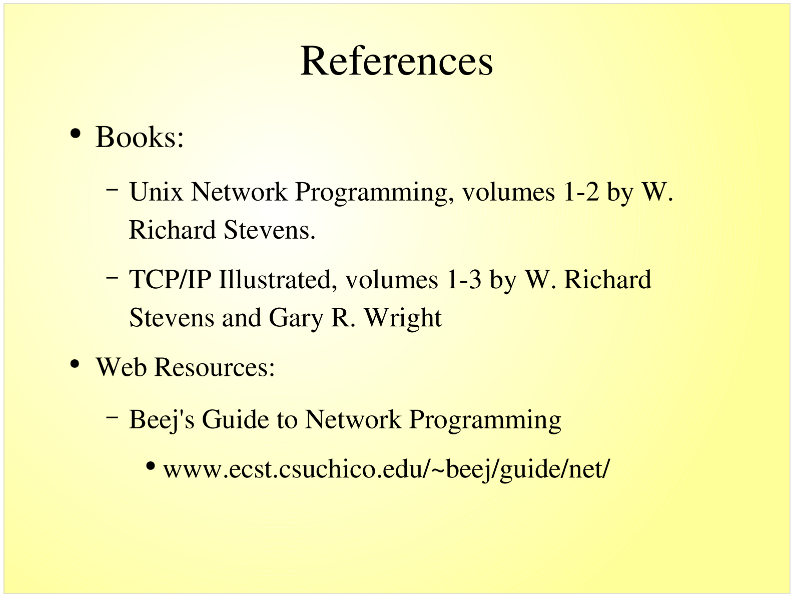
- Example Usage:

```
struct hostent *h;
h = gethostbyname(“www.iitk.ac.in”);
printf(“Host name : %s \n”, h->h_name);
printf(“IP Address: %s\n”,inet_ntoa(*((struct in_addr *)h->h_addr)));
```



Summary

- Sockets help application process to communicate with each other using standard Unix file descriptors
- Two types of Internet sockets: SOCK_STREAM and SOCK_DGRAM
- Many routines exist to help ease the process of communication



References

- Books:
  - Unix Network Programming, volumes 1-2 by W. Richard Stevens.
  - TCP/IP Illustrated, volumes 1-3 by W. Richard Stevens and Gary R. Wright
- Web Resources:
  - Beej's Guide to Network Programming
    - www.ecst.csuchico.edu/~beej/guide/net/