Introduction to Sockets

What is a socket?

• The ***socket*** is the BSD method for accomplishing inter-process communication (IPC).

• It is used to allow one process to speak to another (on same or different machine).

– ***Analogy***: Like the telephone is used to allow one person to speak to another.

• Works very similar to files.

– Socket descriptor _very similar to file descriptor.

– Read/write on a socket and file are very similar.

Basic Idea

When two processes located on the same or different machines communicate, we define association and socket.

– ***Association***: basically a 5-tuple

- Protocol
- Local IP address
- Local port number
- Remote IP address
- Remote port number

– ***Socket***: also called half-association (a 3-tuple)

- Protocol, local IP address, local port number
- Protocol, remote IP address, remote port number

More about sockets

Creating a socket is the first step in network programming using BSD socket interface.

– Using the *socket()* system call.

• Two main addressing formats of a socket:

– ***AF_UNIX***: uses Unix pathnames to identify sockets, and are very useful for IPC between processes on the same machine.

– ***AF_INET***: uses IP addresses.

• In addition to machine address, there is also a port number that allows more than one *AF_INET* socket on each machine.

Types of socket

Two most common types:

– ***SOCK_STREAM***: Stream sockets, which provide reliable, two-way, connection-oriented communication streams. *<Uses TCP>*

– ***SOCK_DGRAM***: Datagram sockets, which provide connectionless, unreliable service, used for packet-by-packet transfer of information. *<Uses UDP>*

- Other types like SOCK_RAW also exist.

– Beyond the scope of the present discussion.

Systems calls for using sockets

- socket()
- bind()
- connect()
- listen()
- accept()
- send() & recv()
- sendto() & recvfrom()
- close() & shutdown()
- getpeername()
- gethostname()
- gethostbyname()

socket() :: Get the Socket Descriptor

- ***General syntax:***

– *domain*: should be set to AF_INET (typically)

– *type*: should be set to SOCK_STREAM or SOCK_DGRAM

– *protocol*: set to zero (typically)

- ***Returns***: socket descriptor; -1 on error

#include <sys/types.h>

#include <sys/socket.h>

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

bind():: What Port am I on?

Used to associate the socket with an address

- ***General syntax***:

– *sockfd*: socket file descriptor returned by *socket()*

– *my_addr*: pointer to a structure that contains information about the local IP address and port number.

– *addrlen*: typically set to *sizeof(struct sockaddr)*

- ***Returns***: -1 on error

```
#include <sys/types.h>
#include <sys/socket.h>
int bind (int sockfd, struct sockaddr *my_addr, int addrlen);
```

The *sockaddr* Structure

```
struct sockaddr
{
unsigned short sa_family;
char sa_data[14];
}
struct sockaddr_in
{
short int sin_family;
unsigned short int sin_port;
struct in_addr sin_addr;
unsigned char sin_zero[8];
}
```

sockaddr_in is a parallel structure to ***sockaddr*** which a programmer uses in the program for convenience.

```
struct in_addr
{
unsigned long s_addr;
}
```

connect(): Connect to a Remote Socket

- ***General syntax***:

– *sockfd*: socket file descriptor returned by *socket()*

– *serv_addr*: pointer to a structure that contains the destination IP address and the port number

– *addrlen*: typically set to *sizeof(struct sockaddr)*

- ***Returns***: -1 on error

```
#include <sys/types.h>
#include <sys/socket.h>
int connect (int sockfd, struct sockaddr *serv_addr, int addrlen);
```

listen(): Get Set for Incoming Connections

• Here, we wish to wait for incoming connections and handle them in some way.

– Two steps, first you *listen(),* then you *accept().*

• ***General syntax***:

– *sockfd*: socket file descriptor returned by *socket().*

– *backlog*: used to set the maximum number of requests (up to a maximum of about 20) that will be queued up before requests start being denied.

• ***Returns***: -1 on error

int listen (int sockfd, int backlog);

accept(): Waiting for Incoming Connections

- Basic concept:

– Someone far away will try to *connect()* to your machine on a port that you are *listen()*'ing on.

– Such connections will be queued up waiting to be *accept()*'ed.

– *accept()* returns a ***brand new socket file descriptor*** to use for every single connection.

- Two socket file descriptors!!

– The original one is still listening on your port.

– Newly created one is finally ready to *send()* and *recv().*

accept(): contd..

General syntax:

– *sockfd*: *listen()*'ing socket descriptor

– *addr*: pointer to a local *struct sockaddr_in* (This is where the information about the incoming connection will go)

– *addrlen*: local integer variable that should be set to *sizeof(struct sockaddr_in)* before *accept()* is called.

- ***Returns***: -1 on error

#include <sys/socket.h>

*int accept (int sockfd, void *addr, int *addrlen);*

send() and recv(): Sending/receiving Data

• Used for communicating over stream sockets or connected datagram sockets.

• ***General syntax***:

– *mesg*: a pointer to the data you want to send

– *len*: length of the data in bytes

– *buf*: buffer to read the information into

– *flags*: typically set to 0

• *send()* returns the number of bytes actually sent out, and *recv()* returns the number of bytes actually read into the buffer.

*int send (int sockfd, const void *mesg, int len, int flags);*

*int recv (int sockfd, void *buf, int len, unsigned int flags);*

sendto() and recvfrom()

Used to transmit and receive data packets over unconnected datagram sockets.

- ***General syntax***:

If you *connect()* a datagram socket, you can then simply use *send()* and *recv()* for all your transactions.

*int sendto (int sockfd, const void *msg, int len, unsigned int flags,*

*const struct sockaddr *to, int tolen);*

*int recvfrom (int sockfd, void *buf, int len, unsigned int flags,*

*struct sockaddr *from, int *fromlen);*

close() and shutdown()

Used to close the connection on the socket descriptor.

- This prevents any more reads and writes to the socket.
- how=0 _further receives are disallowed
- how=1 _further sends are disallowed
- how=2 _further sends and receives are disallowed (like *close*())

close (sockfd);

int shutdown (int sockfd, int how);

getpeername()

• This function will tell you who is at the other end of a connection stream socket.

– *sockfd*: descriptor of the connected stream socket

– *addr*: pointer to a structure that will hold the information about the other side of the connection

– *addrlen*: pointer to an *int* that should be initialized to *sizeof(struct sockaddr)*

#include <sys/socket.h>

*int getpeername (int sockfd, struct sockaddr *addr, int *addrlen);*

gethostname()

This function returns the name of the computer that your program is running on.

– This name can be used by *gethostbyname()* to determine the IP address of the local machine.

– *hostname*: pointer to an array of *char*s that will contain the host name upon the function's return.

– *size*: length in bytes of the *hostname* array.

#include <unistd.h>

*int gethostname (char *hostname, size_t size);*

gethostbyname()

Returns the IP address of a host given its name.

– Invokes the *Domain Name Server (DNS).*

– Returns a pointer to a struct hostent:

#include <netdb.h>

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

```
struct hostent
{
char *h_name; /* official name of the host */
char **h_aliases; /* NULL terminate array of alternate names */
int haddrtype; /* Type of address being returned (AF_INET) */
int h_length; /* Length of the address in bytes */
char **h_addr_list; /* Zero terminated array of network addresses */
};
#define h_addr h_adr_list[0];
```

Client-server Model

Standard model for network applications.

– A ***server*** is a process that is waiting to be contacted by a ***client*** process so as to provide some service.

- ***Typical scenario***:

– The server process is started on some computer system.

  - Initializes itself, then goes to sleep waiting for a client request.

– A client process is started, either on the same system or on some other system.

  - Client sends a request (across the network) to the server.

– When the server process has finished providing its service to the client, the server goes back to sleep, waiting for the next client request to arrive.

Client-server Model (contd.)

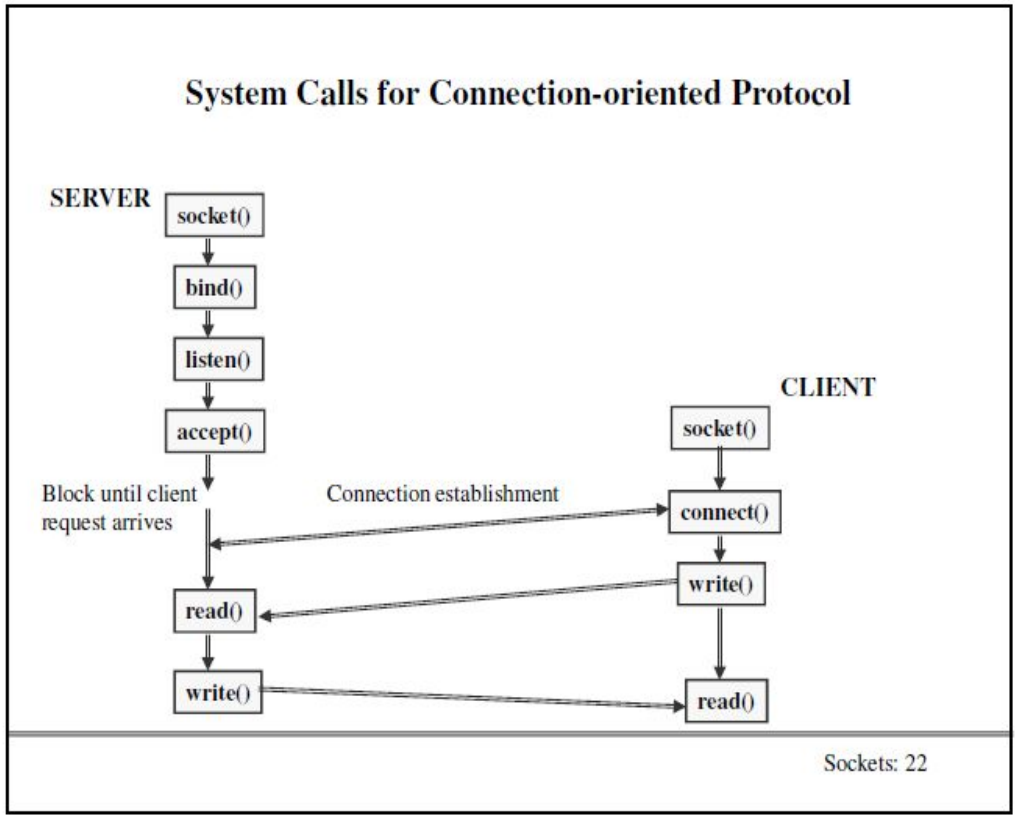
Roles of the client and the server processes are asymmetric.

- Two types of servers:

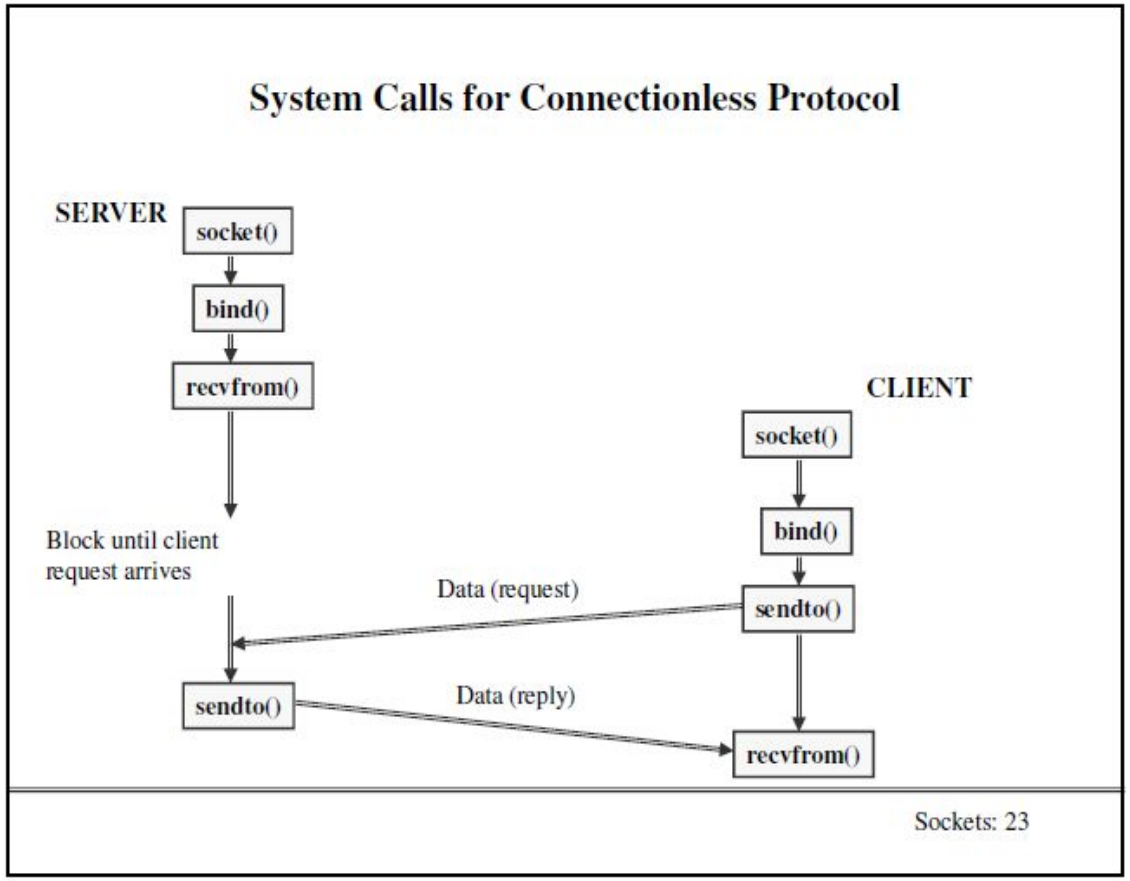
– ***Iterative servers***: Used when the server process knows in advance how long it takes to handle each request and it handles each request itself.

– ***Concurrent servers***: Used when the amount of work required to handle a request is unknown; the server starts another process to handle each request.

System calls for Connection-oriented Protocol



System calls for Connectionless Protocol



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