Socket Programming

Srinidhi Varadarajan

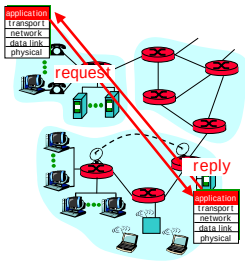
Client-server paradigm

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



Application Layer Programming

API: application programming interface

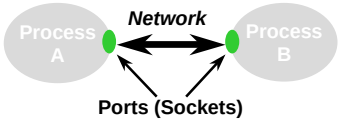
- defines interface between application and transport layer
- sockets: Internet API
  - two processes communicate by sending data into socket, reading data out of socket

Socket Interface. What is it?

- Gives a file system like abstraction to the capabilities of the network.
- Each transport protocol offers a set of services. The socket API provides the abstraction to access these services
- The API defines function calls to create, close, read and write to/from a socket.

Socket Abstraction

- The *socket* is the basic abstraction for network communication in the socket API
  - Defines an endpoint of communication for a process
  - Operating system maintains information about the socket and its connection
  - Application references the socket for sends, receives, etc.

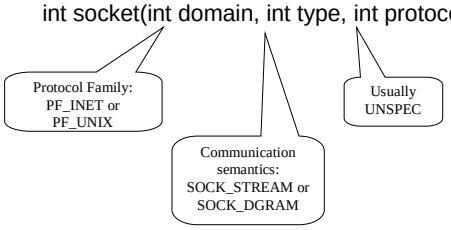


What do you need for socket communication ?

- Basically 4 parameters
  - Source Identifier (IP address)
  - Source Port
  - Destination Identifier
  - Destination Port
- In the socket API, this information is communicated by binding the socket.

Creating a socket

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



The call returns a integer identifier called a *handle*

Binding a socket

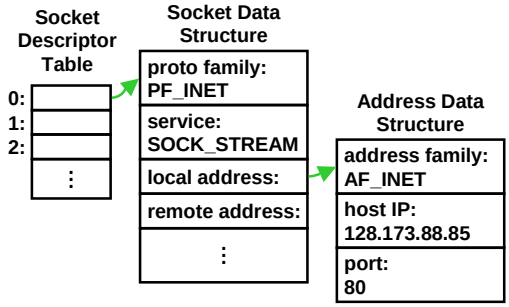
int bind (int socket, struct sockaddr *address, int addr_len)

- **This call is executed by:**
  - **Server in TCP and UDP**
- **It binds the socket to the specified address. The address parameter specifies the local component of the address, e.g. IP address and UDP/TCP port**

Socket Descriptors

- **Operating system maintains a set of socket descriptors for each process**
  - **Note that socket descriptors are shared by threads**
- **Three data structures**
  - **Socket descriptor table**
  - **Socket data structure**
  - **Address data structure**

Socket Descriptors



TCP Server Side: Listen

int listen (int socket, int backlog)

- **This server side call specifies the number of pending connections on the given socket.**
- **When the server is processing a connection, "backlog" number of connections may be pending in a queue.**

TCP Server Side: Passive Open

int accept (int socket, struct sockaddr *address, int *addr_len)

- **This call is executed by the server.**
- **The call does not return until a remote client has established a connection.**
- **When it completes, it returns a new socket handle corresponding to the just-established connection**

TCP Client Side: Active Open

int connect (int socket, struct sockaddr *address, int *addr_len)

- **This call is executed by the client. *address contains the remote address.**
- **The call attempts to connect the socket to a server. It does not return until a connection has been established.**
- **When the call completes, the socket "socket" is connected and ready for communication.**

Sockets: Summary

- **Client:**

int socket(int domain, int type, int protocol)
int connect (int socket, struct sockaddr *address, int addr_len)

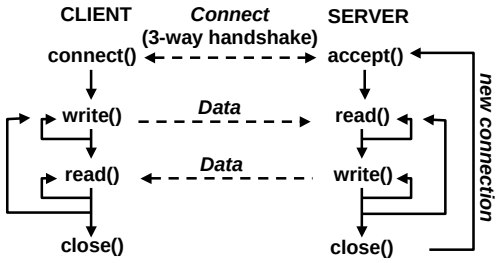
- **Server:**

int socket(int domain, int type, int protocol)
int bind (int socket, struct sockaddr *address, int addr_len)
int listen (int socket, int backlog)
int accept (int socket, struct sockaddr *address, int *addr_len)

Message Passing

- `int send (int socket, char *message, int msg_len, int flags) (TCP)`
- `int sendto (int socket, void *msg, int len, int flags, struct sockaddr * to, int tolen ); (UDP)`
- `int write(int socket, void *msg, int len); /* TCP */`
- `int recv (int socket, char *buffer, int buf_len, int flags) (TCP)`
- `int recvfrom(int socket, void *msg, int len, int flags, struct sockaddr *from, int *fromlen); (UDP)`
- `int read(int socket, void *msg, int len); (TCP)`

Summary of Basic Socket Calls



Network Byte Order

- **Network byte order is most-significant byte first**
- **Byte ordering at a host may differ**
- **Utility functions**
  - **htons(): Host-to-network byte order for a short word (2 bytes)**
  - **htonl(): Host-to-network byte order for a long word (4 bytes)**
  - **ntohs(): Network-to-host byte order for a short word**
  - **ntohl(): Network-to-host byte order for a long word**

Some Other "Utility" Functions

- **gethostname() -- get name of local host**
- **getpeername() -- get address of remote host**
- **getsockname() -- get local address of socket**
- **get*X*by*Y*() -- get protocol, host, or service number using known number, address, or port, respectively**
- **getsockopt() -- get current socket options**
- **setsockopt() -- set socket options**
- **ioctl() -- retrieve or set socket information**

Some Other "Utility" Functions

- **inet_addr() -- convert "dotted" character string form of IP address to internal binary form**
- **inet_ntoa() -- convert internal binary form of IP address to "dotted" character string form**

Address Data Structures

```
struct sockaddr {
   u_short     sa_family;      // type of address
   char        sa_data[14];    // value of address
}
```

- **sockaddr is a generic address structure**

```
struct sockaddr_in {
   u_short     sa_family;      // type of address (AF_INET)
   u_short     sa_port;        // protocol port number
   struct      in_addr sin_addr;       // IP address
   char        sin_zero[8];    // unused (set to zero)
}
```

- **sockaddr_in is specific instance for the Internet address family**