CSC 4304 - Systems Programming
Fall 2008

LECTURE - XVI
SOCKETS

Tevfik Koşar

Louisiana State University
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Project 2: Simple Web Server

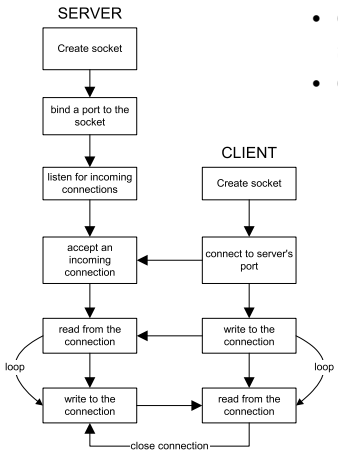
Basics of a Web Server

- Listen to a Network port
- Interpret incoming messages (requests)
- Serve requests
  - Read requested files
  - Send them over network
- Run consistently in the background

Creating a Socket

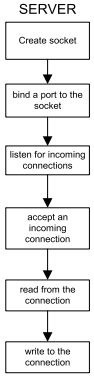
```
#include <sys/types.h>
#include <sys/socket.h>
int socket(int domain, int type, int protocol);
```

- domain is one of the *Address Families* (AF_INET, AF_UNIX, etc.)
- type defines the communication protocol semantics, usually defines either:
  - SOCK_STREAM: connection-oriented stream (TCP)
  - SOCK_DGRAM: connectionless, unreliable (UDP)
- protocol specifies a particular protocol, just set this to 0 to accept the default (PF_INET, PF_UNIX) based on the domain



- Connection-oriented socket connections
- Client-Server view

Server Side Socket Details



int socket(int domain, int type, int protocol)
sockfd = socket(PF_INET, SOCK_STREAM, 0);

int bind(int sockfd, struct sockaddr *server_addr, socklen_t length)
bind(sockfd, &server, sizeof(server));

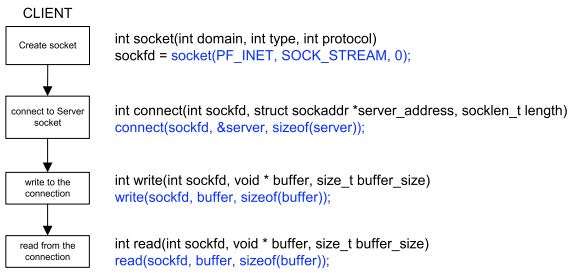
int listen(int sockfd, int num_queued_requests)
listen(sockfd, 5);

int accept(int sockfd, struct sockaddr *incoming_address, socklen_t length)
newfd = accept(sockfd, &client, sizeof(client)); /* BLOCKS */

int read(int sockfd, void * buffer, size_t buffer_size)
read(newfd, buffer, sizeof(buffer));

int write(int sockfd, void * buffer, size_t buffer_size)
write(newfd, buffer, sizeof(buffer));

Client Side Socket Details



Setup for an Internet Domain Socket

```
struct sockaddr_in {
  sa_family_t sin_family;
  unsigned short int sin_port;
  struct in_addr sin_addr;
  unsigned char pad[…];
};
```

- sin_family is set to *Address Family* AF_INET
- sin_port is set to the port number you want to *bind* to
- sin_addr is set to the IP address of the machine you are binding to (struct in_addr is a wrapper struct for an unsigned long). INADDR_ANY supports all interfaces (since a given machine may have multiple interface cards)
- ignore padding

Reading/Writing to/from Sockets

- Sockets, like everything else, are like *files*:
  - low level IO:
    - read() system call
    - write() system call
  - higher level IO:
    - int recv(int socket, char *buf, int len, int flags);
      - blocks on read
      - returns 0 when other connection has terminated
    - int send(int socket, char *buf, int len, int flags);
      - returns the number of bytes *actually sent*
    - where flags may be one of:
      - MSG_DONTROUTE (don't route out of localnet)
      - MSG_OOB (out of band data (think *interruption*))
      - MSG_PEEK (examine, but don't remove from stream)

Closing a Socket Session

- int close(int socket);
  - closes read/write IO, closes socket file descriptor
- int shutdown(int socketfd, int how);
  - where how is:
    - 0: no more receives allowed
    - 1: no more sends are allowed
    - 2: disables both receives and sends (but doesn't close the socket, use close() for that)
- *Example*: hangserver.c (hangman game)

Select()

int select(int numfiledescs, fd_set readfdsset, fd_set writefdsset, fd_set errorfdsset, struct timeval * timeout);

- The select() system call provides a way for a single server to wait until a set of network connections has data available for reading
- The advantage over fork() here is that no multiple processes are spawned
- The downside is that the single server must handle state management on its own for all its new clients

Select() cont..

- select() will return if *any* of the descriptors in readfdsset and writefdsset of file descriptors are ready for reading or writing, respectively, or, if any of the descriptors in errorfdsset are in an error condition
- The FD_SET(int fd, fd_set *set) function will add the file descriptor *fd* to the set *set*
- The FD_ISSET(int fd, fd_set *set) function will tell you if filedesc *fd* is in the modified set *set*
- select() returns the total number of descriptors in the modified sets
- If a client closes a socket whose file descriptor is in one of your watched sets, select() will return, and your next recv() will return 0, indicating the socket has been closed

More Socket Functions

- int getpeername(int sockfd, struct sockaddr * addr, int *addrlen);
  - this tells you the *hostname* of the REMOTE connection
- int gethostname(char * hostname, size_t size);
  - this tells you the *hostname* of your LOCAL connection
- int inet_aton(const char * string_address, &(addr.sin_addr));
  - converts the const ip *string_address* ("192.168.3.1") into an acceptable numeric form
- addr.sin_addr = inet_addr("192.168.3.1");
  - does the same thing

More Socket Functions *(cont.)*

- struct hostent *gethostbyname(const char *hostname);
  - Does a DNS lookup and returns a pointer to a hostent structure that contains the host name, aliases, address type (AF_INET, etc.), length, and an array of IP addresses for this host (hostent.h_addr_list[0] is usually the one)
    (cf. /etc/nsswitch.conf)

```
struct hostent {
       char *h_name; /*DNS host name*/
       char **h_aliases; /*alias list*/
 int h_addrtype; /* "AF_INET", etc*/
       int h_length; /* length of addr*/
       char **h_addr_list; /*list of IP
adds*/
       };
```


Example: A Time Server

```
#include  <stdio.h>
#include  <sys/types.h>
#include  <sys/socket.h>
#include  <netinet/in.h>
#include  <netdb.h>

#define   PORTNUM  8824
#define   oops(msg)      { perror(msg) ; exit(1) ; }
```



```
   void main(int ac, char **av)
{
    struct  sockaddr_in   saddr;   /* build our address here */
    struct   hostent       *hp;   /* this is part of our    */
    char hostname[256];          /* address                */
    int  slen,sock_id,sock_fd;  /* line id, file desc     */
    FILE *sock_fp;              /* use socket as stream   */
    char    *ctime();            /* convert secs to string */
    long    time(), thetime;       /* time and the val       */


      gethostname( hostname , 256);          /* where am I ?          */
      hp = gethostbyname( hostname );        /* get info about host  */
      bzero( &saddr, sizeof(saddr) );        /* zero struct          */
                                            /* fill in hostaddr     */
      bcopy( hp->h_addr, &saddr.sin_addr, hp->h_length);
      saddr.sin_family = AF_INET ;           /* fill in socket type  */
      saddr.sin_port = htons(PORTNUM);       /* fill in socket port  */

      sock_id = socket( AF_INET, SOCK_STREAM, 0 );    /* get a socket */
      if ( sock_id == -1 ) oops( "socket" );

      if ( bind(sock_id, &saddr, sizeof(saddr)) != 0 )/* bind it to   */
             oops( "bind" );                          /* an address   */

      if ( listen(sock_id, 1) != 0 ) oops( "listen" );
```



```
    while ( 1 ){
            sock_fd = accept(sock_id, NULL, NULL); /* wait for call */
        printf("** Server: A new client connected!");
            if ( sock_fd == -1 )
                    oops( "accept" );       /* error getting calls  */

          show_my_port(sock_fd);
            sock_fp = fdopen(sock_fd,"w");  /* we'll write to the   */
            if ( sock_fp == NULL )          /* socket as a stream   */
                    oops( "fdopen" );       /* unless we can't      */

            thetime = time(NULL);           /* get time             */
                                            /* and convert to strng */
            fprintf( sock_fp, "************************************\n");
            fprintf( sock_fp, "** From Server: The current time is: ");
            fprintf( sock_fp, "%s", ctime(&thetime) );
            fprintf( sock_fp, "************************************\n");

            fclose( sock_fp );              /* release connection   */
            fflush(stdout);           /* force output  */
      }
}
```


Acknowledgments

- Advanced Programming in the Unix Environment by R. Stevens
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