

# Interprocess communication in C in Operating Systems

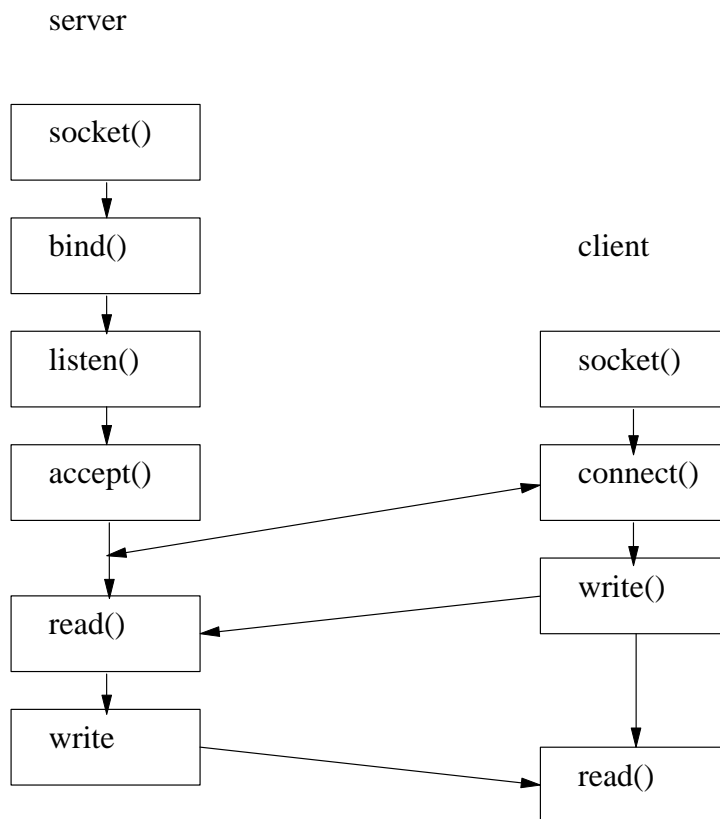
- the C language says nothing about IPC
  - the operating system offers various mechanism for IPC
  - there normally exist a set of library headers and library archives which are provided by the operating system and system C library
  
- common methods of IPC are:
  - sockets (Berkeley and System V Transport Layer Interface)
  - shared memory (normally used in conjunction with semaphores)
  - semaphores

# Berkeley Sockets

- the C interface to sockets ultimately gives the programmer a file descriptor on both client and server which can be both read from and written to
- elegant as the user application can map the code onto a socket or a file

Process	Description	Function
server	create end point	socket ()
	bind address	bind ()
	specify queue	listen ()
	wait for connection	accept ()
client	create end point	socket ()
	bind address	bind ()
	connect to server	connect ()
	transfer data	read () write () recv () send ()
	datagrams	recvfrom () sendto ()
	terminate	close () shutdown ()

# Connection oriented sockets



## Consider Python Code for a Server

```
#!/usr/bin/python

from socket import *
myHost = ""
myPort = 2000

s = socket(AF_INET, SOCK_STREAM)
# bind it to the server port number
s.bind((myHost, myPort))
# allow 5 pending connections
s.listen(5)

while True:
    # wait for next client to connect
    connection, address = s.accept()
    while True:
        data = connection.recv(1024)
        if data:
            connection.send("echo -> " + data)
        else:
            break
    connection.close()
```

## Consider Python Code for a client

```
#!/usr/bin/python

import sys
from socket import *
serverHost = "localhost"
serverPort = 2000

# create a TCP socket
s = socket(AF_INET, SOCK_STREAM)

s.connect((serverHost, serverPort))
s.send("Hello world")
data = s.recv(1024)
print data
```

## Now the equivalent client C code

```
#include <stdio.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <netdb.h>
#include <unistd.h>
#include <signal.h>
#include <errno.h>
#include <malloc.h>
#include <signal.h>
#include <string.h>
#include <stdlib.h>
```

## Now the equivalent client C code

```
#if !defined(TRUE)
# define TRUE (1==1)
#endif
#if !defined(FALSE)
# define FALSE (1==0)
#endif

#define ERROR(X) { printf("%s:%d:%s\n", __FILE__, __LINE__, X); \
                  exit(1); }

#define ASSERT(X) { if (! (X)) \
                   { printf("%s:%d: assert(%s) failed\n", \
                             __FILE__, __LINE__, #X ); exit(1); }}

#define MAXBUFFER 4096

const char *serverName = "localhost";
const int portNo = 2000;
```



## Now the equivalent client C code

```
main ()
{
    struct hostent      *hp;
    struct sockaddr_in  sa;
    int                 socketFd;
    char                inBuffer[MAXBUFFER];

    hp = gethostbyname(serverName);
    if (hp == NULL) {
        fprintf(stderr, "cannot find host: %s\n", serverName);
        exit(1);
    }

    memset((void *)&sa, 0, sizeof(sa));
    sa.sin_family = AF_INET;

    /* memcpy(dest, src, length) */
    memcpy((void *)&sa.sin_addr, (void *)hp->h_addr, hp->h_length);
    sa.sin_port = htons(portNo);
}
```

## Now the equivalent client C code

```
/*  
 * Open a TCP socket (an Internet stream socket)  
 */  
  
socketFd = socket(hp->h_addrtype, SOCK_STREAM, 0);  
if (socketFd < 0)  
    ERROR("failed to connect to the TCP server");  
  
if (connect(socketFd, (struct sockaddr *)&sa, sizeof(sa)) < 0)  
    ERROR("failed to connect to the TCP server");  
  
write(socketFd, "hello world\n", 12);  
read(socketFd, inBuffer, sizeof(inBuffer));  
printf("result from server = %s", inBuffer);  
close(socketFd);  
}
```

## Now the equivalent server C code

```
#include <stdio.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <netdb.h>
#include <unistd.h>
#include <signal.h>
#include <errno.h>
#include <malloc.h>
#include <signal.h>
#include <string.h>
#include <stdlib.h>
```

## Now the equivalent server C code

```
#if !defined(TRUE)
# define TRUE (1==1)
#endif
#if !defined(FALSE)
# define FALSE (1==0)
#endif

#define ERROR(X) { printf("%s:%d:%s\n", __FILE__, __LINE__, X); \
                  exit(1); }

#define ASSERT(X) { if (! (X)) \
                   { printf("%s:%d: assert(%s) failed\n", \
                             __FILE__, __LINE__, #X ); exit(1); }}

#define MAXBUFFER 4096

const int portNo = 2000;
const char *serverName = "localhost";
```

## Now the equivalent server C code

```
main ()
{
    struct hostent      *hp;
    struct sockaddr_in sa;
    struct sockaddr_in isa;
    int socketFd;
    int a, b, r, i;
    char  inBuffer[MAXBUFFER];

    hp = gethostbyname(serverName);

    /*
     * Open a TCP socket (an Internet stream socket)
     */

    socketFd = socket(hp->h_addrtype, SOCK_STREAM, 0);
    if (socketFd < 0)
        ERROR("socket");
}
```

## Now the equivalent server C code

```
memset(&sa, 0, sizeof(sa));  
ASSERT((hp->h_addrtype == AF_INET));  
sa.sin_family      = hp->h_addrtype;  
sa.sin_addr.s_addr = htonl(INADDR_ANY);  
sa.sin_port        = htons(portNo);  
  
b = bind(socketFd, (struct sockaddr *)&sa, sizeof(sa));  
if (b < 0)  
    ERROR("bind");  
  
listen(socketFd, 1);
```

## Now the equivalent server C code

```
while (TRUE) {  
    i = sizeof(isa);  
    a = accept(socketFd, (struct sockaddr *)&isa, &i);  
    if (a < 0)  
        ERROR("accept");  
    r = read(a, inBuffer, MAXBUFFER);  
    r = write(a, "echo -> ", 8);  
    r = write(a, inBuffer, strlen(inBuffer));  
    close(a);  
}  
}
```

## Coursework clientlib for C

- given that the Python client code was so simple it would be good to create a simple client side library which can be used to connect to a server
- for example



## Coursework test code

```
#include <stdio.h>
#include "clientlib.h"

main()
{
    cli *c;
    char buffer[50];

    c = clientlib_socket ();
    c = clientlib_connect (c, "localhost", 2000);
    write(clientlib_getfd(c), "hello world", 12);
    read(clientlib_getfd(c), buffer, 50);
    printf("server sent: %s\n", buffer);
    c = clientlib_close(c);
}
```

## clientlib.h

```
#if !defined(clientlibH)
#  define clientlibH
#  if defined(clientlibC)
#    define EXTERN
#  else
#    define EXTERN extern
#  endif

typedef void cli;

/*
 * clientlib_socket - returns a newly malloced cli.
 *                   We dont actually call socket here.
 */

EXTERN cli *clientlib_socket (void);
```

## clientlib.h

```
/*  
 * clientlib_connect - creates the socket and  
 *                   connects to server, port.  
 *                   It returns the cli passed.  
 */  
  
EXTERN cli *clientlib_connect (cli *c,  
                               const char *server, int port);  
  
/*  
 * clientlib_getfd - returns the file descriptor associated  
 *                 with the socket.  
 */  
  
EXTERN int clientlib_getfd (cli *c);
```

## clientlib.h

```
/*  
 * clientlib_close - closes the socket and frees up  
 *                  any allocated space.  
 */  
  
EXTERN cli *clientlib_close (cli *c);
```

## clientlib.c

```
#include <stdio.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <netdb.h>
#include <unistd.h>
#include <signal.h>
#include <errno.h>
#include <malloc.h>
#include <signal.h>
#include <string.h>
#include <stdlib.h>

#if !defined(TRUE)
# define TRUE (1==1)
#endif
#if !defined(FALSE)
# define FALSE (1==0)
#endif
```

## clientlib.c

```
#define ERROR(X)    { printf("%s:%d:%s\n", __FILE__, __LINE__, X); \
                    exit(1); }

#define ASSERT(X)  { if (! (X))
                    { printf("%s:%d: assert(%s) failed\n", \
                              __FILE__, __LINE__, #X ); exit(1); }}

#define clientlibC
#include "clientlib.h"

typedef struct {
    struct hostent *hp;
    struct sockaddr_in sa;
    int socketFd;
} real_cli;
```

## clientlib.c

```
/*  
 * clientlib_socket - returns a newly malloced cli.  
 *                   We dont actually call socket here.  
 */  
  
cli *clientlib_socket (void)  
{  
    real_cli *c = (real_cli *)malloc (sizeof(real_cli));  
  
    return (cli *)c;  
}
```

## clientlib.c

```
/*  
 * clientlib_connect - connects to server, port.  
 *                   It returns the cli passed.  
 */  
  
cli *clientlib_connect (cli *c, const char *server, int port)  
{  
    real_cli *rc = (real_cli *)c;  
  
    /* you need to complete this */  
}
```



## clientlib.c

```
/*  
 * clientlib_getfd - returns the file descriptor associated  
 *                  with the socket.  
 */  
  
int clientlib_getfd (cli *c)  
{  
    real_cli *rc = (real_cli *)c;  
  
    /* you need to complete this */  
}
```

## clientlib.c

```
/*  
 * clientlib_close - closes the socket and frees up  
 *                  any allocated space.  
 */  
  
cli *clientlib_close (cli *c)  
{  
    /* you need to complete this */  
}
```