Elementary TCP Sockets

UNIX Network Programming

Vol. 1, Second Ed. Stevens

Chapter 4

IPv4 Socket Address Structure

The Internet socket address structure is named **sockaddr_in** *and is defined by including <netinet/in.h> header.*

```
struct in_addr {
  in_addr_t   s_addr                  /* 32-bit IP address */
};                                    /* network byte ordered */
struct sockaddr_in {
  uint8_t          sin_len;           /* length of  structure (16) */
  sa_family_t      sin_family;        /* AF_INET */
  in_port_t        sin_port;          /* 16-bit TCP or UDP port number */
                                      /* network byte ordered */
  struct in_addr   sin_addr;          /* 32-bit IPv4 address */
                                      /* network byte ordered */
  char             sin_zero[8];       /* unused */
};
```

The Socket Interface

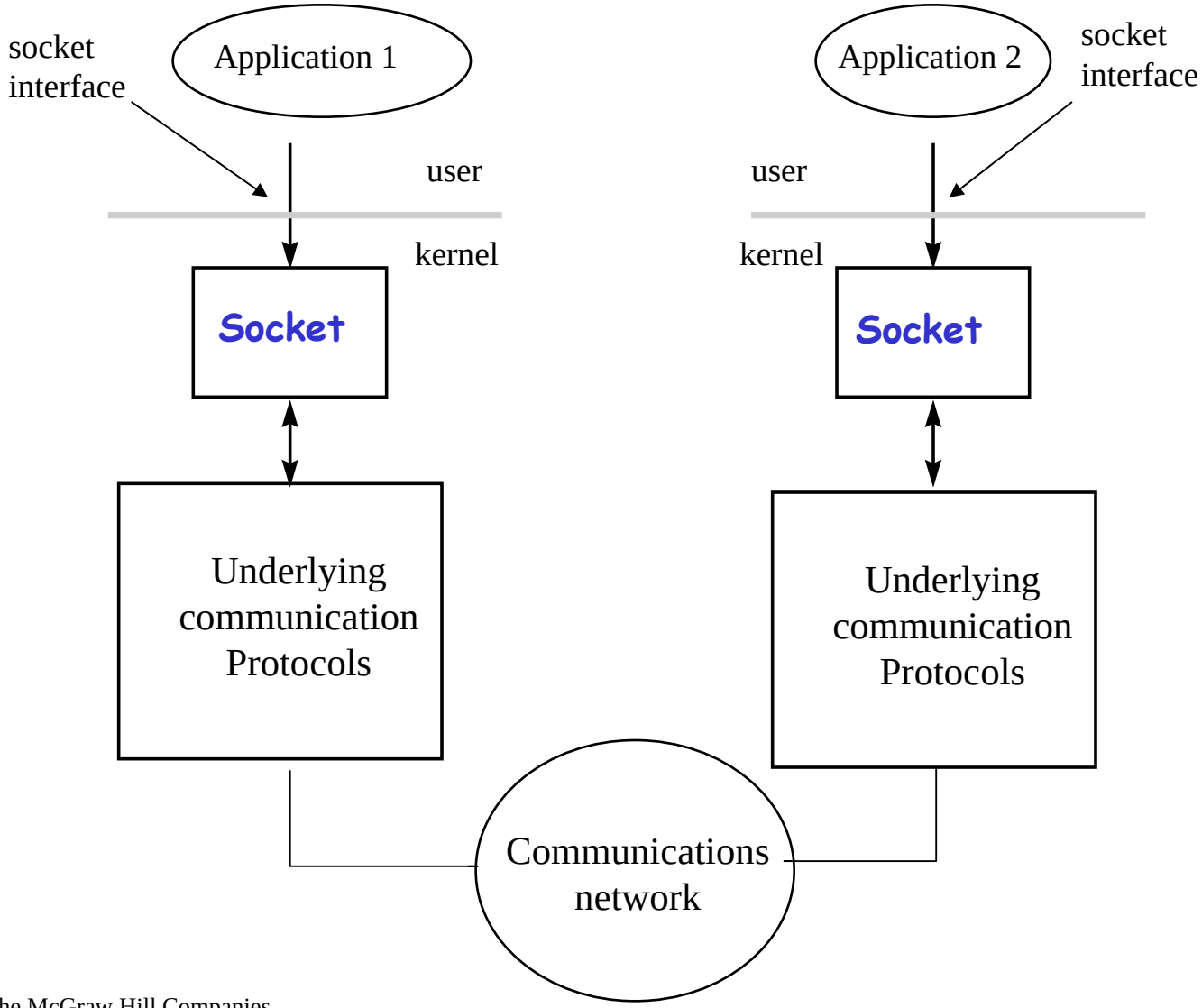

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Figure 2.16

TCP Socket Calls

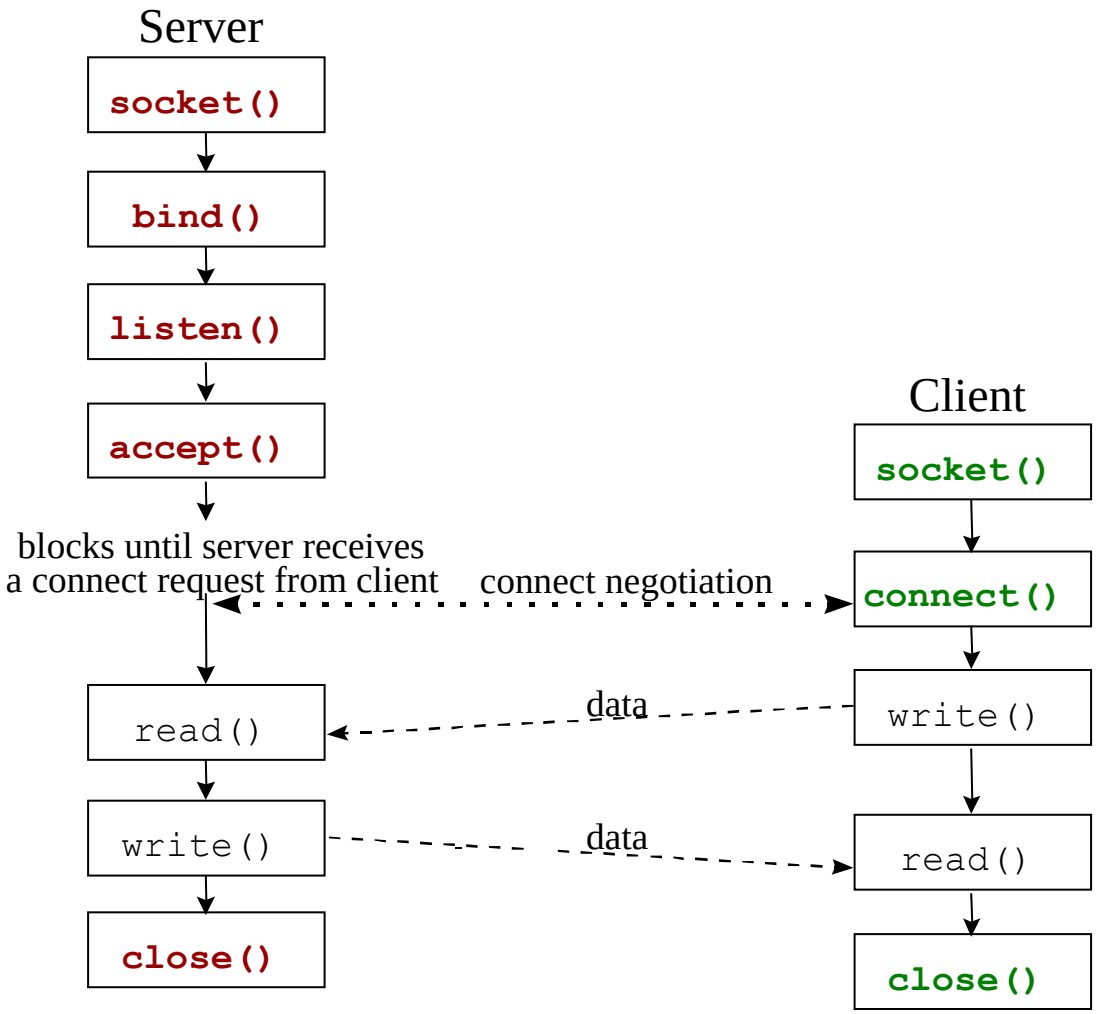

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Figure 2.17

UDP Socket Calls

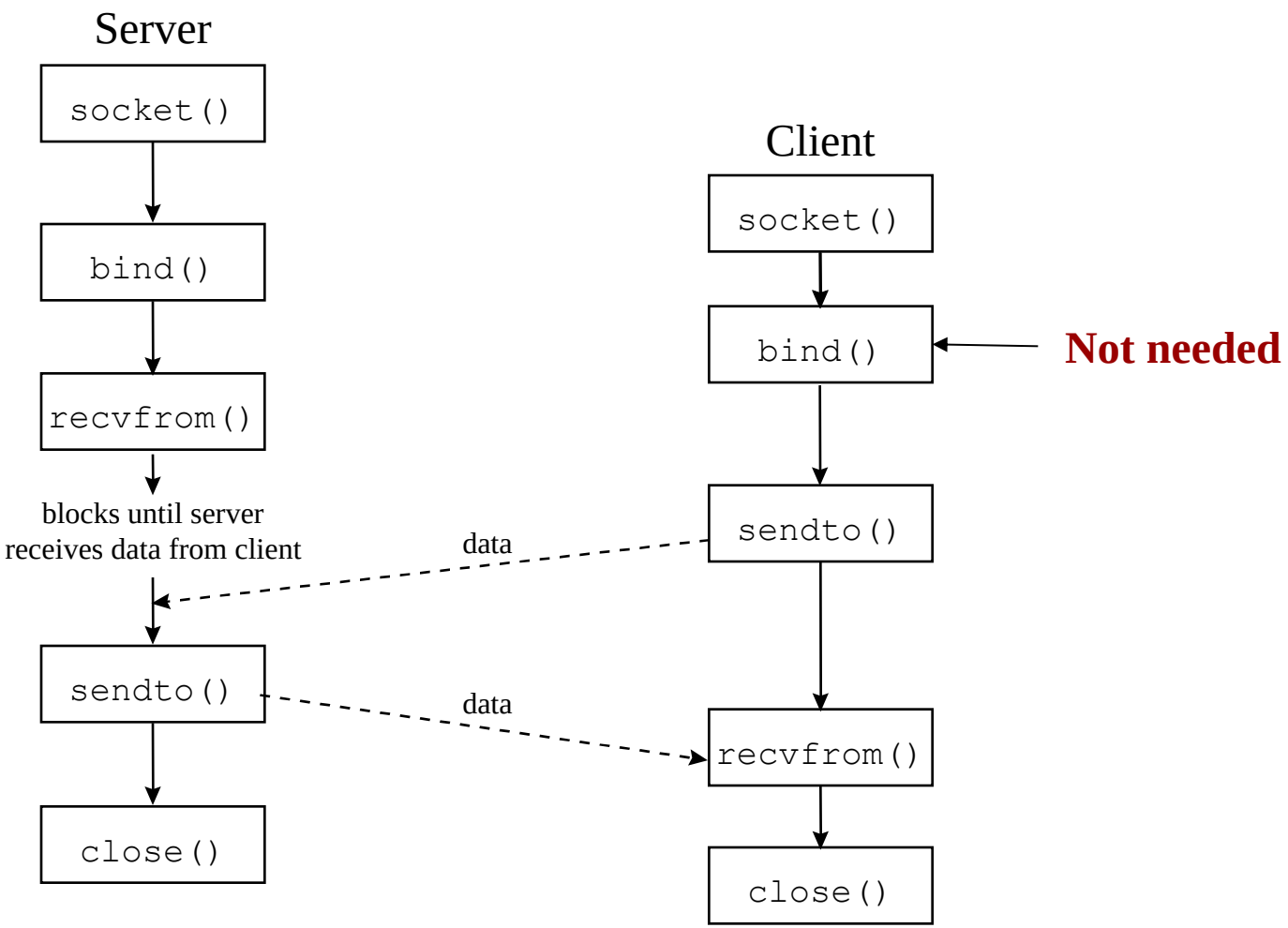

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Figure 2.18

System Calls for Elementary TCP Sockets

```
#include  <sys/types.h>
#include  <sys/socket.h>
```

socket Function

```
int  socket ( int family, int type, int protocol );
```

family: specifies the protocol family {AF_INET for TCP/IP}

type: indicates communications semantics

SOCK_STREAM	stream socket	TCP
SOCK_DGRAM	datagram socket	UDP
SOCK_RAW	raw socket	

protocol: set to 0 except for raw sockets

returns on success: socket descriptor {a small nonnegative integer}

on error: -1

Example:

```
if (( sd = socket (AF_INET, SOCK_STREAM, 0)) < 0)
    err_sys ("socket call error");
```

connect Function

```
int  connect (int  sockfd, const struct sockaddr  *servaddr,
socklen_t  addrlen);
```

sockfd: a socket descriptor returned by the socket function

**servaddr*: a pointer to a socket address structure

addrlen: the size of the socket address structure

The socket address structure must contain the **IP address** and the **port number** for the connection wanted.

In TCP **connect** initiates a three-way handshake. **connect** returns only when the connection is established or when an error occurs.

returns on success: 0

on error: -1

Example:

```
if ( connect (sd, (struct sockaddr *) &servaddr, sizeof (servaddr)) != 0)
    err_sys("connect call error");
```

TCP Socket Calls

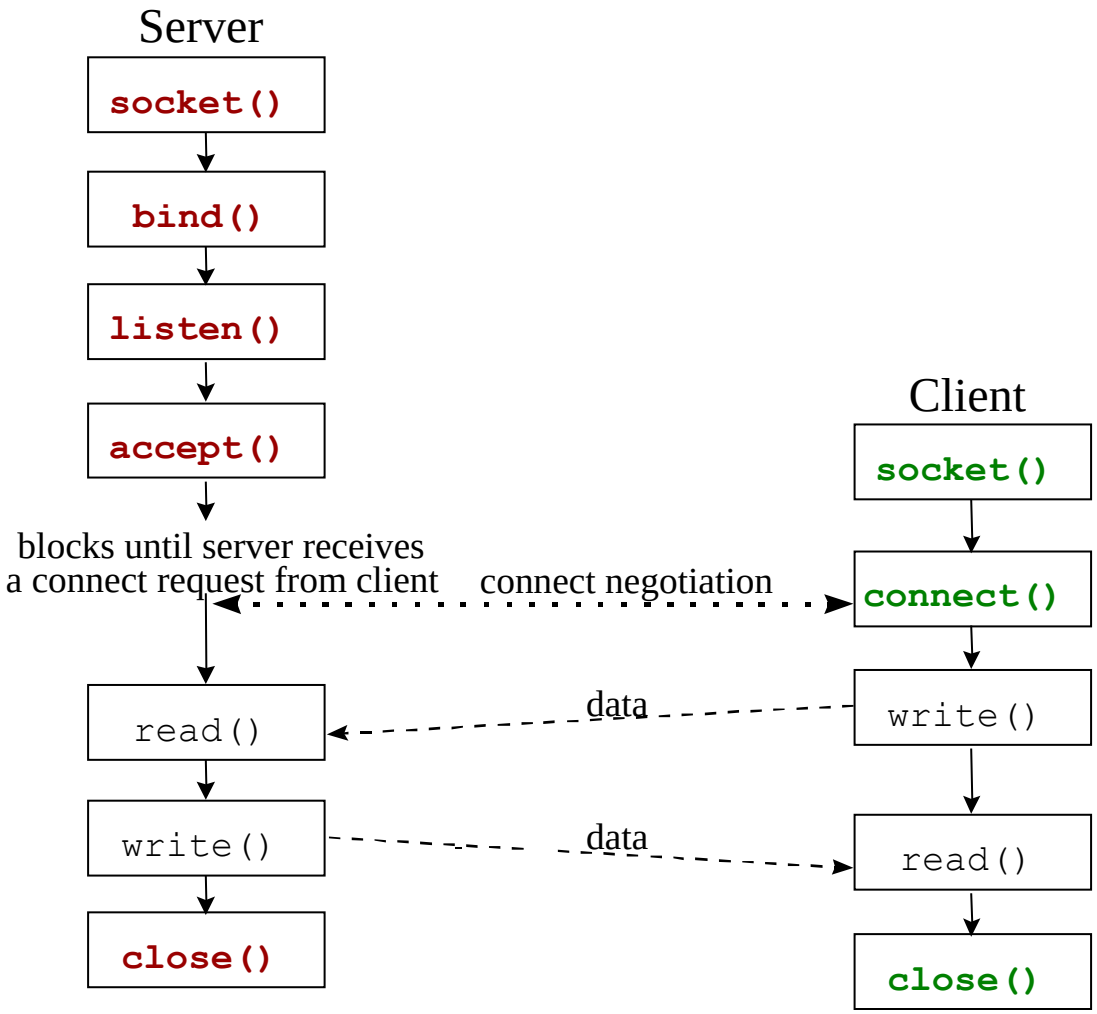

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Figure 2.17

bind Function

int bind (int *sockfd*, const struct sockaddr **myaddr*, socklen_t *addrlen*);

bind assigns a local protocol address to a socket.

protocol address: a 32 bit IPv4 address and a 16 bit TCP or UDP port number.

sockfd: a socket descriptor returned by the socket function.

****myaddr***: a pointer to a protocol-specific address.

addrlen: the size of the socket address structure.

Servers **bind** their "well-known port" when they start.

<u>returns</u> on success: 0

on error: -1

Example:

```
if (bind (sd, (struct sockaddr *) &servaddr, sizeof (servaddr)) != 0)
    errsys ("bind call error");
```

listen Function

int listen (int *sockfd*, int *backlog*);

listen is called **only** by a TCP server and performs two actions:

1. Converts an unconnected socket (*sockfd*) into a passive socket.
2. Specifies the maximum number of connections (*backlog*) that the kernel should queue for this socket.

listen is normally called before the **accept** function.

returns on success: 0

on error: -1

Example:

```
if (listen (sd, 2) != 0)
    errsys ("listen call error");
```

accept Function

```
int  accept (int  sockfd, struct sockaddr  *cliaddr, socklen_t *addrlen);
```

accept is called by the TCP server to return the next completed connection from the front of the completed connection queue.

sockfd: This is the same socket descriptor as in **listen** call.

****cliaddr***: used to return the protocol address of the connected peer process (i.e., the client process).

****addrlen***: {this is a value-result argument}

before the accept call: We set the integer value pointed to by *addrlen to the size of the socket address structure pointed to by *cliaddr;

on return from the accept call: This integer value contains the actual number of bytes stored in the socket address structure.

<u>returns</u> on success: a **new** socket descriptor

on error: -1

accept Function (cont.)

```
int accept (int sockfd, struct sockaddr *cliaddr, socklen_t *addrlen);
```

For **accept** the first argument ***sockfd*** is the listening socket and the returned value is the connected socket.

The server will have one connected socket for each client connection accepted.

When the server is finished with a client, the connected socket must be closed.

Example:

connected socket

```
sfd = accept (sd, NULL, NULL);
if (sfd == -1) err_sys ("accept error");
```

close Function

int close (int *sockfd*);

close marks the socket as closed and returns to the process immediately.

sockfd: This socket descriptor is no longer useable.

Note – TCP will try to send any data already queued to the other end before the normal connection termination sequence.

Returns on success: 0

on error: -1

Example:

```
close (sfd);
```

TCP Echo Server

```
#include <stdio.h>          /* for printf() and fprintf() */
#include <sys/socket.h> /* for socket(), bind(), and connect() */
#include <arpa/inet.h>   /* for sockaddr_in and inet_ntoa() */
#include <stdlib.h>       /* for atoi() and exit() */
#include <string.h>       /* for memset() */
#include <unistd.h>       /* for close() */

#define MAXPENDING 5    /* Maximum outstanding connection requests */
void DieWithError(char *errorMessage);  /* Error handling function */
void HandleTCPClient(int clntSocket);   /* TCP client handling function */
```

D&C

```
int main(int argc, char *argv[])
{   int servSock;                  /*Socket descriptor for server */
    int clntSock;                  /* Socket descriptor for client */
    struct sockaddr_in echoServAddr; /* Local address */
    struct sockaddr_in echoClntAddr; /* Client address */
    unsigned short echoServPort;     /* Server port */
    unsigned int clntLen;            /* Length of client address data structure */

    if (argc != 2)     /* Test for correct number of arguments */
    {
        fprintf(stderr, "Usage:  %s <Server Port>\n", argv[0]);
        exit(1);
    }
    echoServPort = atoi(argv[1]);  /* First arg:  local port */

    /* Create socket for incoming connections */
    if ((servSock = socket (PF_INET, SOCK_STREAM, IPPROTO_TCP)) < 0)
        DieWithError("socket() failed");
```

D&C

TCP Echo Server

```
 /* Construct local address structure */
memset(&echoServAddr, 0, sizeof(echoServAddr));        /* Zero out structure */
echoServAddr.sin_family = AF_INET;                     /* Internet address family */
echoServAddr.sin_addr.s_addr = htonl(INADDR_ANY); /* Any incoming interface */
echoServAddr.sin_port = htons(echoServPort);           /* Local port */

/* Bind to the local address */
if (bind (servSock, (struct sockaddr *) &echoServAddr, sizeof(echoServAddr)) < 0)
        DieWithError("bind() failed");

/* Mark the socket so it will listen for incoming connections */
if (listen (servSock, MAXPENDING) < 0)
        DieWithError("listen() failed");
```

D&C

TCP Echo Server

```
for (;;) /* Run forever */
{
   /* Set the size of the in-out parameter */
   clntLen = sizeof(echoClntAddr);        /* Wait for a client to connect */
   if ((clntSock = accept (servSock, (struct sockaddr *) &echoClntAddr, &clntLen)) < 0)
         DieWithError("accept() failed");

   /* clntSock is connected to a client! */
   printf("Handling client %s\n", inet_ntoa(echoClntAddr.sin_addr));
   HandleTCPClient(clntSock);
 }
 /* NOT REACHED */
}
```

D&C

TCP Echo Client

```
#include <stdio.h>          /* for printf() and fprintf() */
#include <sys/socket.h> /* for socket(), connect(), send(), and recv() */
#include <arpa/inet.h>   /* for sockaddr_in and inet_addr() */
#include <stdlib.h>        /* for atoi() and exit() */
#include <string.h>       /* for memset() */
#include <unistd.h>      /* for close() */

#define RCVBUFSIZE 32   /* Size of receive buffer */

void DieWithError(char *errorMessage);  /* Error handling function */
```

D&C

```
int main(int argc, char *argv[])

{
    int sock;                          /* Socket descriptor */
    struct sockaddr_in echoServAddr;   /* Echo server address */
    unsigned short echoServPort;       /* Echo server port */
    char *servIP;                      /* Server IP address (dotted quad) */
    char *echoString;                  /* String to send to echo server */
    char echoBuffer[RCVBUFSIZE];       /* Buffer for echo string */
    unsigned int echoStringLen;        /* Length of string to echo */
    int bytesRcvd, totalBytesRcvd;     /* Bytes read in single recv()
                                          and total bytes read */

    if ((argc < 3) || (argc > 4))    /* Test for correct number of arguments */
    {
      fprintf(stderr, "Usage: %s <Server IP> <Echo Word> [<Echo Port>]\n",
              argv[0]);
     exit(1);
    }
```

D&C

```
servIP = argv[1];            /* First arg: server IP address (dotted quad) */
echoString = argv[2];        /* Second arg: string to echo */

if (argc == 4)
    echoServPort = atoi(argv[3]); /* Use given port, if any */
else
    echoServPort = 7;  /* 7 is the well-known port for the echo service */

/* Create a reliable, stream socket using TCP */
if ((sock = socket (PF_INET, SOCK_STREAM, IPPROTO_TCP)) < 0)
     DieWithError("socket() failed");

/* Construct the server address structure */
memset(&echoServAddr, 0, sizeof(echoServAddr));     /* Zero out structure */
echoServAddr.sin_family      = AF_INET;             /* Internet address family */
echoServAddr.sin_addr.s_addr = inet_addr(servIP);   /* Server IP address */
echoServAddr.sin_port        = htons(echoServPort); /* Server port */
```

D&C

TCP Echo Client

```
/* Establish the connection to the echo server */
if (connect (sock, (struct sockaddr *) &echoServAddr, sizeof(echoServAddr)) < 0)
        DieWithError("connect() failed");

echoStringLen = strlen(echoString);          /* Determine input length */

/* Send the string to the server */
if (send (sock, echoString, echoStringLen, 0) != echoStringLen)
        DieWithError("send() sent a different number of bytes than expected");

/* Receive the same string back from the server */
totalBytesRcvd = 0;
printf("Received: ");                /* Setup to print the echoed string */
```

D&C

TCP Echo Client

```
while (totalBytesRcvd < echoStringLen)
{
      /* Receive up to the buffer size (minus 1 to leave space for
                                a null terminator) bytes from the sender */
      if ((bytesRcvd = recv(sock, echoBuffer, RCVBUFSIZE - 1, 0)) <= 0)
        DieWithError("recv() failed or connection closed prematurely");
      totalBytesRcvd += bytesRcvd;   /* Keep tally of total bytes */
      echoBuffer[bytesRcvd] = '\0';  /* Terminate the string! */
      printf("%s", echoBuffer);      /* Print the echo buffer */
}
printf("\n");    /* Print a final linefeed */
close (sock);
exit(0);
}
```

D&C