# Client software design

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## A TCP CLIENT

1. Get the IP address and port number of the peer
2. Allocate a socket
3. Choose a local IP address
4. Allow TCP to choose an arbitrary, unused port number
5. Connect the socket to the server
6. Communicate with the server
   - Exchange messages
   - Often the client sends requests and the server replies, but this is not always the case
   - The message exchange happens according to the application-level protocol
7. Close connection



## PEER IDENTIFICATION

- Depending on the actual application, the IP address of the peer (i.e., server) can be specified in more than one ways, including:
  - Hardcoded (rarely)
    - We specify it directly as an integer
  - As command-line argument (read from configuration file, etc.)
    - We use `gethostbyname` to get the actual address (i.e., number)
  - Use a separate protocol (broadcast or multicast) to find a server
- Ports can also be specified in many ways, including:
  - It is a well-known port
    - We use `getservbyname` to obtain the actual port number
  - Hardcoded
    - Possibly suitable for custom client-server applications
  - As command-line argument (read from configuration file, etc.)
    - Especially useful for parameterized clients

```
telnet linux.ubishops.ca 22
my-client linux.ubishops.ca ssh
```



## ALLOCATE A SOCKET

- We need to specify at allocation time:
  - The protocol family
  - The socket type (TCP for the time being)

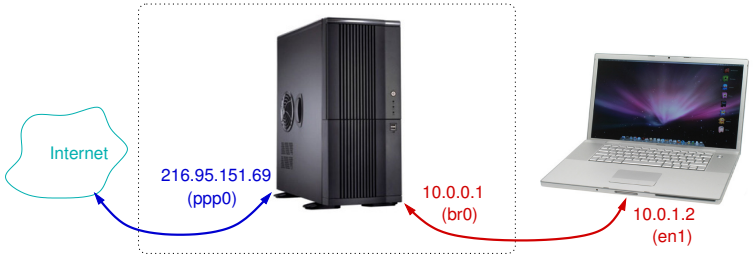
```
#include <sys/types.h>
#include <sys/socket.h>

int sd = socket(PF_INET, SOCK_STREAM, 0);
```

- We end up with a socket descriptor

## Choosing a local IP address

- Why do we need the local IP address?
  - Because a connection is specified by two endpoints
- Why is it a problem to choose a local IP address?
  - Because a machine might have multiple adresses




  - The appropriate address must be chosen so that IP is able to route packets in the right direction
  - Choosing the right IP address is done after a dialogue with IP
  - The system call `connect` does it for us



## Choose a port

- We must specify a local port number for the same reasons we have to specify a local address
- The choice of port number does not matter as long as:
  - It does not conflict with the port assigned to a well-know service
  - It is not in use by another process
- We could try at random until we get a free port...
  - ...However, the system keeps track of port usage anyway, so this would be overkill
  - Thus the port number choice is again taken care of by the call to `connect`



## Connect to the server

- In all, we obtain the local coordinates (IP address, port) and we connect in one step:

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

- Something like this:

```
struct sockaddr_in sin;
int rc = connect(sd, (struct sockaddr *)&sin, sizeof(sin));
if (rc < 0) {
    perror("connect");
    exit(1);
}
```



## Filling in the server address

```
int connectbyportint(const char* host, const unsigned short port) {
    struct hostent *hinfo;
    struct sockaddr_in sin;
    const int type = SOCK_STREAM;
    int sd;

    memset(&sin, 0, sizeof(sin));
    sin.sin_family = AF_INET;
    hinfo = gethostbyname(host);
    if (hinfo == NULL) return err_host;
    sin.sin_addr=(unsigned int)hinfo->h_addr;

    sin.sin_port = port;

    sd = socket(PF_INET, type, 0);
    if ( sd < 0 ) return err_sock;

    int rc = connect(sd, (struct sockaddr *)&sin, sizeof(sin));
    if (rc < 0) {
        close(sd);
        return err_connect;
    }
    return sd;
}
```

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    memset(&sin, 0, sizeof(sin));
    sin.sin_family = AF_INET;
    hinfo = gethostbyname(host);
    if (hinfo == NULL) return err_host;
    sin.sin_addr=(unsigned int)hinfo->h_addr;  // only if you are lucky

    sin.sin_port = port;                       // only if you are lucky

    sd = socket(PF_INET, type, 0);
    if ( sd < 0 ) return err_sock;

    int rc = connect(sd, (struct sockaddr *)&sin, sizeof(sin));
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    memset(&sin, 0, sizeof(sin));
    sin.sin_family = AF_INET;
    hinfo = gethostbyname(host);
    if (hinfo == NULL) return err_host;
    sin.sin_addr=(unsigned int)htonl(hinfo->h_addr); // assumes a bit too much

    sin.sin_port = (unsigned short)htons(port);

    sd = socket(PF_INET, type, 0);
    if ( sd < 0 ) return err_sock;

    int rc = connect(sd, (struct sockaddr *)&sin, sizeof(sin));
    if (rc < 0) {
        close(sd);
        return err_connect;
    }
    return sd;
}
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    struct sockaddr_in sin;
    const int type = SOCK_STREAM;
    int sd;

    memset(&sin, 0, sizeof(sin));
    sin.sin_family = AF_INET;
    hinfo = gethostbyname(host);
    if (hinfo == NULL) return err_host;
    memcpy(&sin.sin_addr, hinfo->h_addr, hinfo->h_length);

    sin.sin_port = (unsigned short)htons(port);

    sd = socket(PF_INET, type, 0);
    if ( sd < 0 ) return err_sock;

    int rc = connect(sd, (struct sockaddr *)&sin, sizeof(sin));
    if (rc < 0) {
        close(sd);
        return err_connect;
    }
    return sd;
}
```



## Communicate with the server

- We send data using `send` (or `write`)
- We receive responses using `recv` (or `read`)
  - Note that the response could come in pieces, even if the server answers back in large chunks
  - You should be prepared to accept data a few bytes at a time

```
const int ALEN = 128;
char* req = "some sort of request";
char ans[ALEN];
char* ans_ptr = ans;
int ans_to_go = ALEN, n = 0;

send(sd,req,strlen(req),0);

while ( ( n = recv(sd,ans_ptr,ans_to_go,0) ) > 0 ) {
  ans_ptr += n;
  ans_to_go -= n;
}
```

## Communicate with the server (cont'd)

- We do not necessarily know how long is the response
- The shape of the response varies according to the application-level protocol and may be:
  - One line of text (terminated by `'\n'`)
    - We use `readline` (or equivalent) to read the answer
  - One line of text determines what comes after it
    - Again, we use `readline` to read one line at a time, and then decide what to do next based on what we just read
  - As much as the server cares to send, with no special end marker
    - We read until there is no more data
    - But how?



## Communicate with the server (cont'd)

- We check whether we have any more data coming on our way
- Communication is not instantaneous, so we have to give some time for the data to arrive

```
const int recv_nodata = -2;

int recv_nonblock (int sd, char* buf, size_t max, int timeout) {
  struct pollfd pollrec;
  pollrec.fd = sd;
  pollrec.events = POLLIN;

  int polled = poll(&pollrec,1,timeout);
  if (polled == 0) return recv_nodata;
  if (polled == -1) return -1;
  return recv(sd,buf,max,0);
}
```

- Outcomes:
  - -2: no more data available within the given `timeout`
  - 0: end of file (when the server closes connection on us)
  - $n > 0$: $n$ characters have been read.



## Closing the connection

- `close` closes the connection and destroys the socket
- Sometimes we want to shut down communication in one direction only
  - Reason: the server receive a request and responds to it
  - But what does it do now with the connection?
    - If the client has in fact more requests, the connection should stay open
    - If this is the last request, the connection should be closed
- A client (or server) can partially close a connection, to let the server know that it is finished.

```
int err = shutdown(sd,SHUT_WR);
```

  - The server (client) will then receive and end of file
- The second argument of `shutdown` can be
  - `SHUT_RD` (0): further receives will be disallowed
  - `SHUT_WR` (1): further sends will be disallowed
  - `SHUT_RDWR` (2): neither receives, nor sends will be allowed