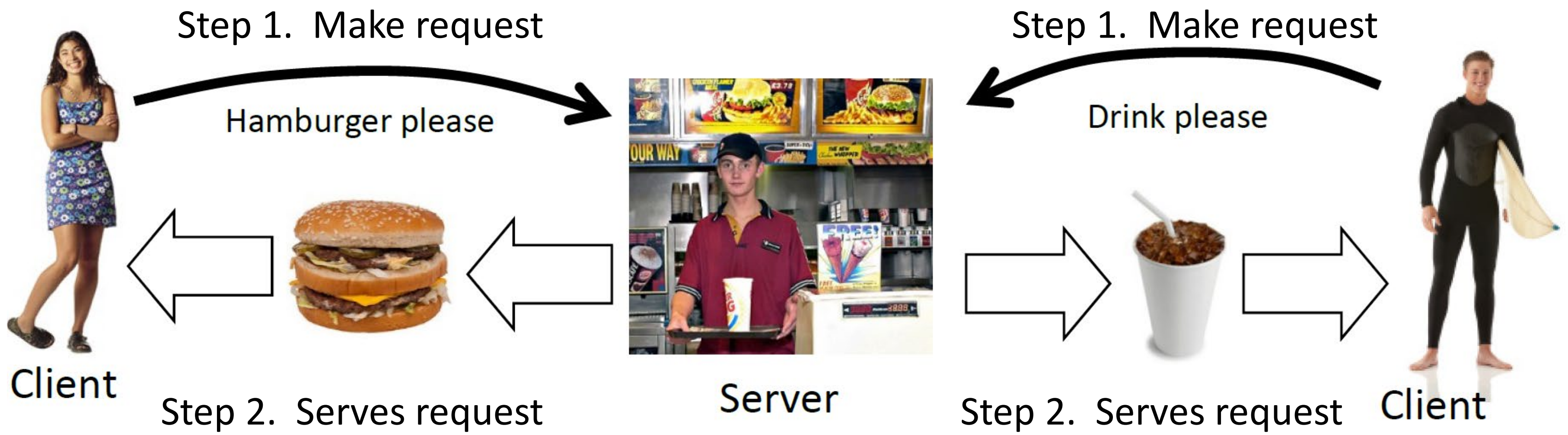
Client-Server Lab
Part 2 Internet

Outline

- Client server paradigm
- Internet
- Sockets
- Simple client-server
- Zombie processes
- TCP port assignments
- Simple exercises for the lab
- The assignment

Client Server Paradigm



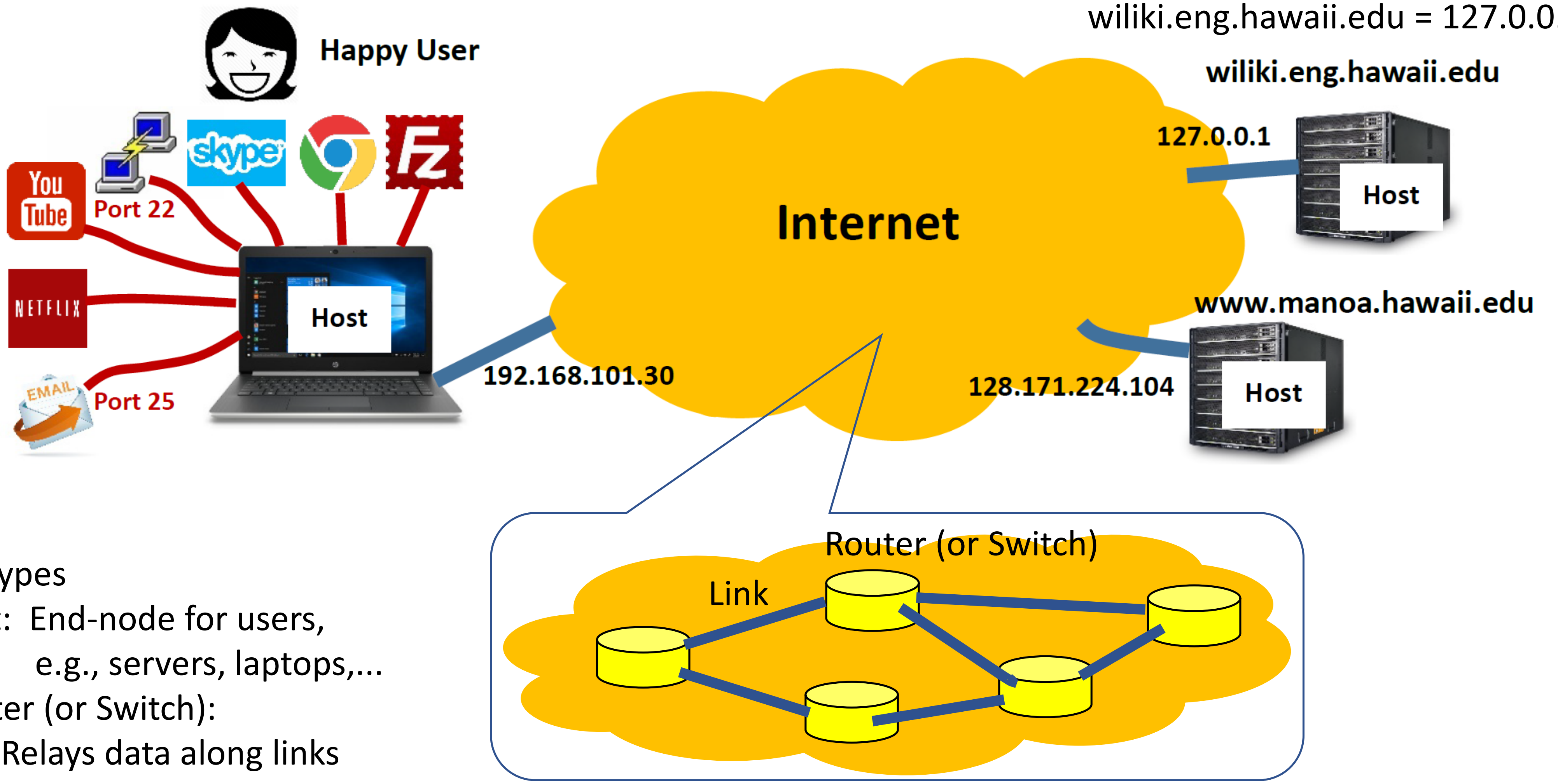
Example: client.c

Example: server.c

Internet: User point of view

IP address = 32 bit number
Written decimal-dot notation
127.0.0.1, what machines use
Domain name: wiliki.eng.hawaii.edu, what humans use

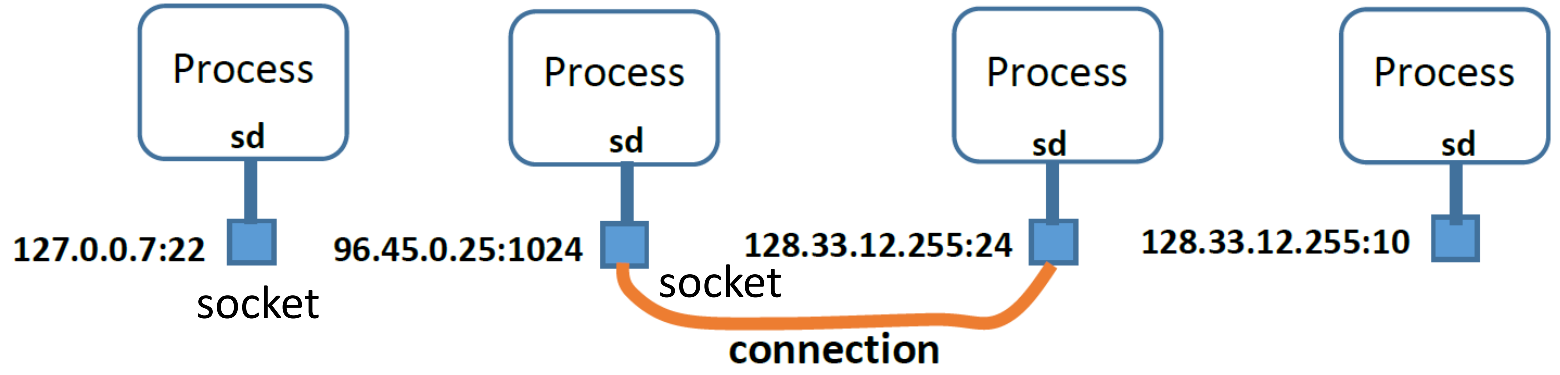
wiliki.eng.hawaii.edu = 127.0.0.1



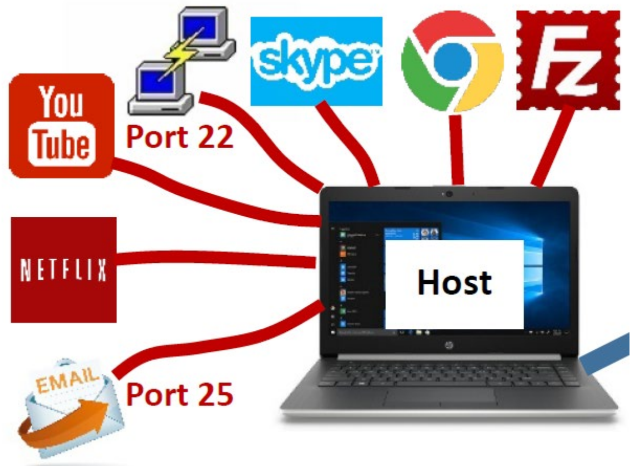
Node Types
Host: End-node for users,
e.g., servers, laptops,...
Router (or Switch):
Relays data along links

Internet: Application software

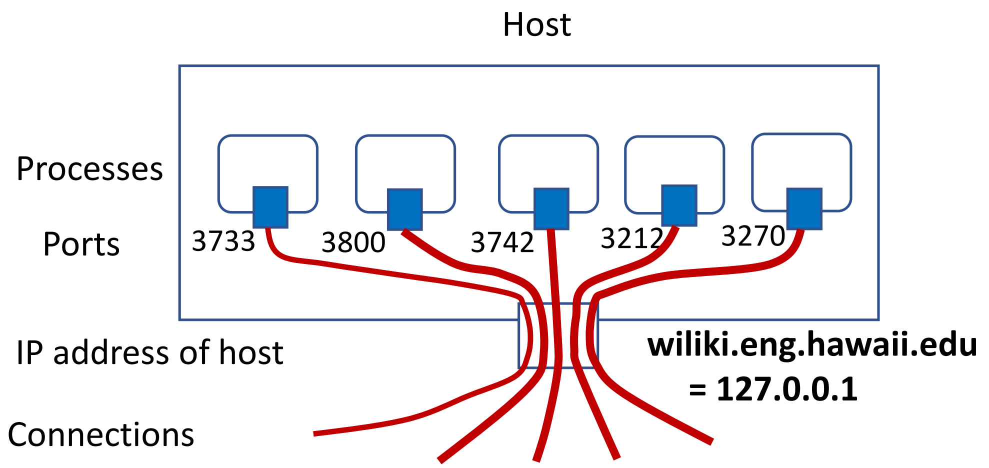
sd = socket file descriptor



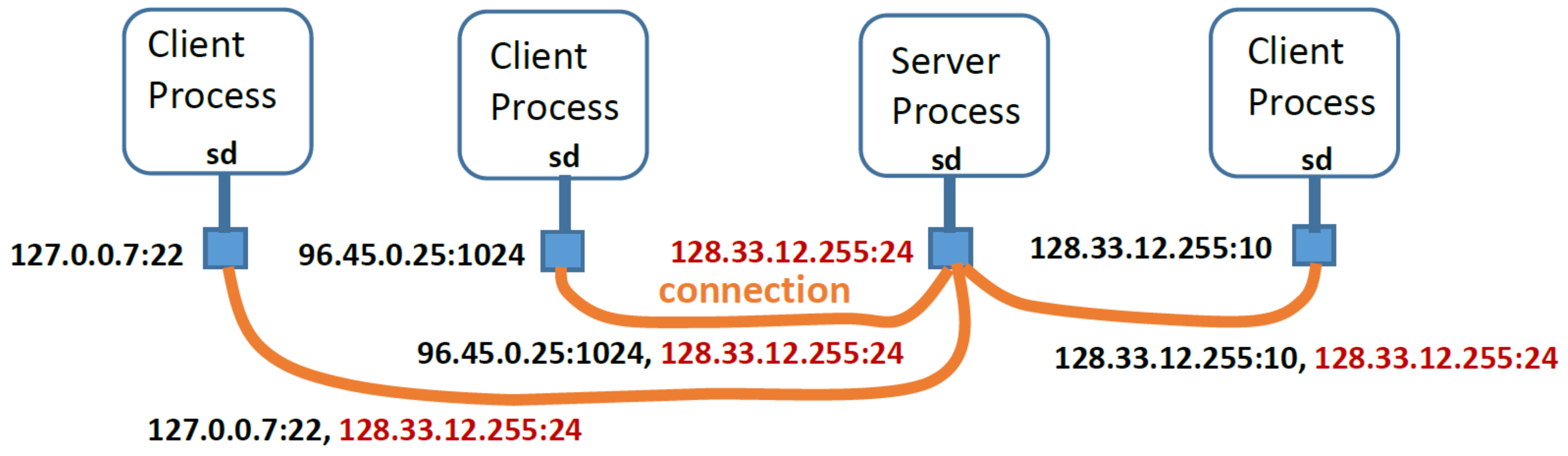
Multiple applications/processes on one host



Port numbers distinguish between connections to different processes on a host



Sockets

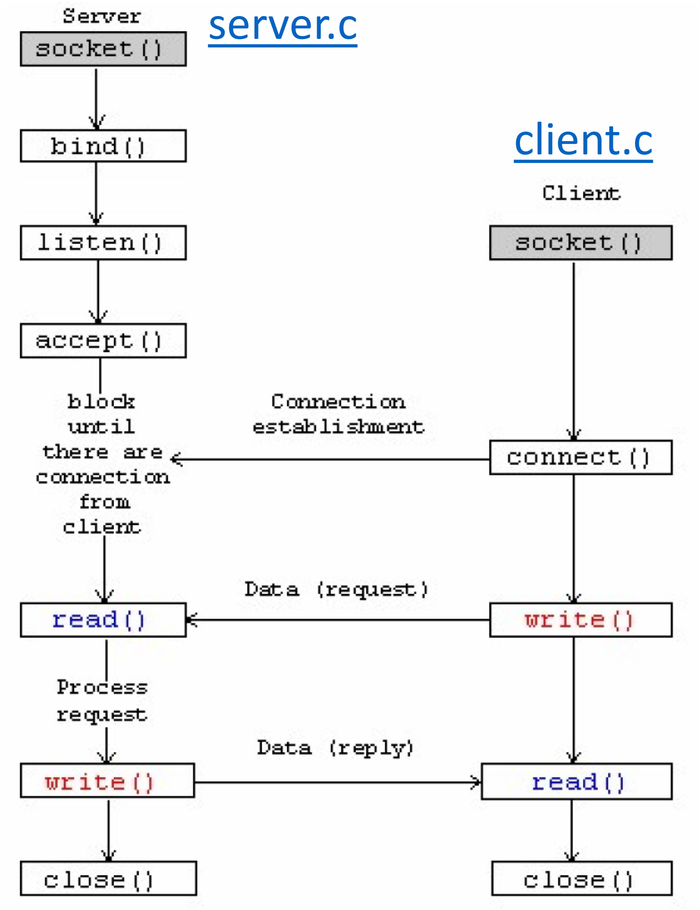

Client Process
sd
Client Process
sd
Server Process
sd
Client Process
sd
127.0.0.7:22
96.45.0.25:1024
128.33.12.255:24
128.33.12.255:10
connection
96.45.0.25:1024, 128.33.12.255:24
128.33.12.255:10, 128.33.12.255:24
127.0.0.7:22, 128.33.12.255:24

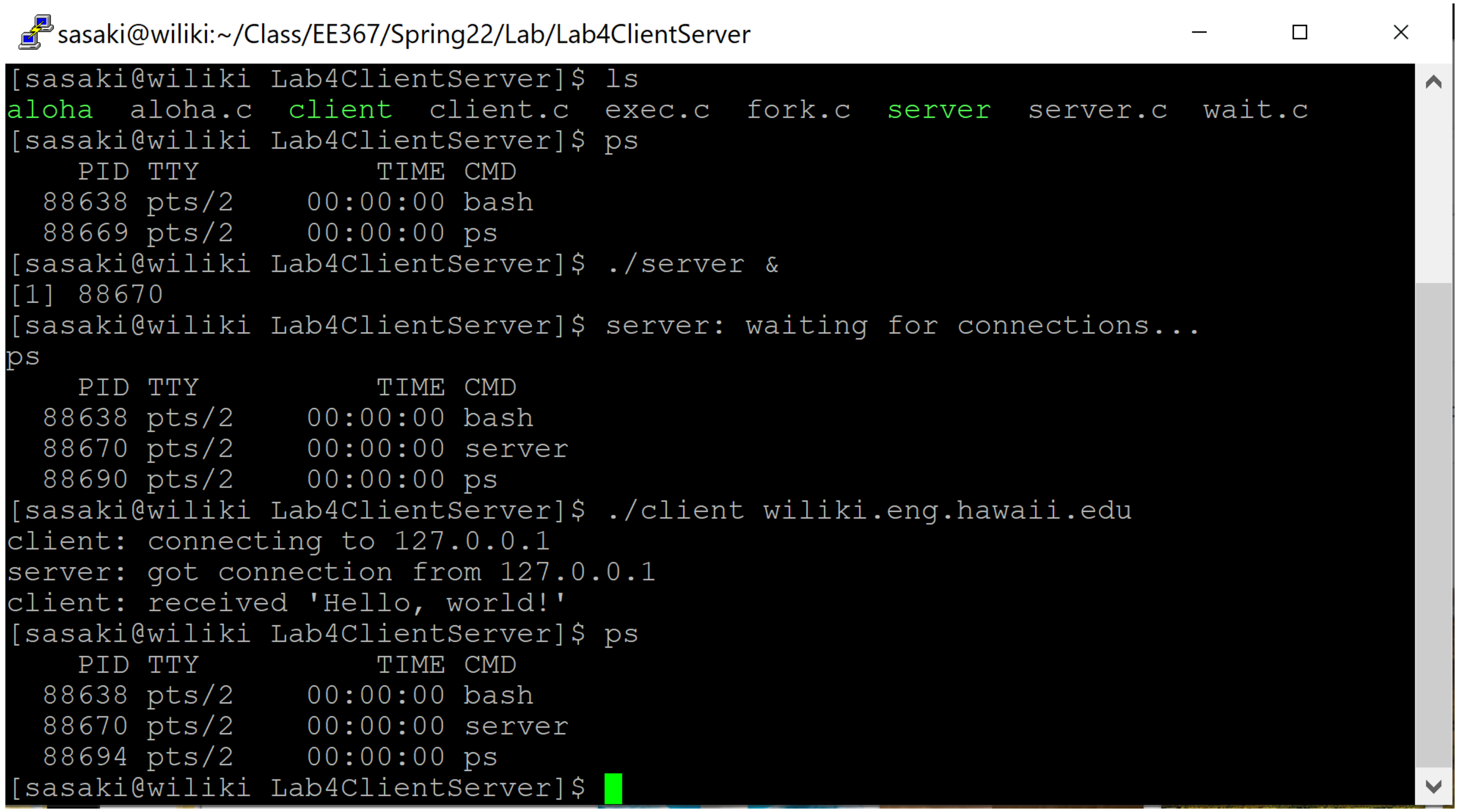
Simple Client-Server From Beej's Guide

Beej's Guide to Network Programming

server.c

client.c




sasaki@wiliki:~/Class/EE367/Spring22/Lab/Lab4ClientServer

```
[sasaki@wiliki Lab4ClientServer]$ ls
aloha   aloha.c   client   client.c   exec.c   fork.c   server   server.c   wait.c
[sasaki@wiliki Lab4ClientServer]$ ps
    PID TTY          TIME CMD
  88638 pts/2    00:00:00 bash
  88669 pts/2    00:00:00 ps
[sasaki@wiliki Lab4ClientServer]$ ./server &
[1] 88670
[sasaki@wiliki Lab4ClientServer]$ server: waiting for connections...
ps
    PID TTY          TIME CMD
  88638 pts/2    00:00:00 bash
  88670 pts/2    00:00:00 server
  88690 pts/2    00:00:00 ps
[sasaki@wiliki Lab4ClientServer]$ ./client wiliki.eng.hawaii.edu
client: connecting to 127.0.0.1
server: got connection from 127.0.0.1
client: received 'Hello, world!'
[sasaki@wiliki Lab4ClientServer]$ ps
    PID TTY          TIME CMD
  88638 pts/2    00:00:00 bash
  88670 pts/2    00:00:00 server
  88694 pts/2    00:00:00 ps
[sasaki@wiliki Lab4ClientServer]$
```

client.c

```
#define PORT "3490"
#define MAXDATASIZE 100
```

the port client will be connecting to, i.e., port of the server

max number of bytes we can get at once

```
// get sockaddr, IPv4 or IPv6:
void *get_in_addr(struct sockaddr *sa){
        if (sa->sa_family == AF_INET) {
                return &(((struct sockaddr_in*)sa)->sin_addr);
        }
        return &(((struct sockaddr_in6*)sa)->sin6_addr);}
}
```

Two versions of IP (Internet Protocol):
- AF_INET = IPv4 (version 4)
- AF_INET6 = IPv6 (version 6)

The IP address is located in the data structure 'sa' depending on the address family (AF) it's using

The appropriate internet address is returned

client.c – continued

```
struct addrinfo {
    int              ai_flags;
    int              ai_family;
    int              ai_socktype;
    int              ai_protocol;
    socklen_t        ai_addrlen;
    struct sockaddr *ai_addr;
    char            *ai_canonname;
    struct addrinfo *ai_next;
};
```

Node in a linked list

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

        < Variable declarations >

        if (argc != 2) {
           fprintf(stderr,"usage: client hostname\n");
           exit(1);
        }
```

Client connects to the server

Usage: ./client wiliki.eng.hawaii.edu
Here './client' is argv[0] and
'wiliki.eng.hawaii.edu' is argv[1]

Initializes **struct addrinfo 'hints'**, which sets up the socket

```
        memset(&hints, 0, sizeof hints);
        hints.ai_family = AF_UNSPEC;
        hints.ai_socktype = SOCK_STREAM;
```

Clear **struct addrinfo 'hints'** with bytes 0

```
        if ((rv = getaddrinfo(argv[1], PORT, &hints, &servinfo)) != 0) {
                fprintf(stderr, "getaddrinfo: %s\n", gai_strerror(rv));
                return 1;
        }
```

Get IP address information from the domain name in argv[1],
e.g., 'wiliki.eng.hawaii.edu'
and port # PORT
Puts information in 'hints' and 'servinfo'
servinfo is a pointer to a struct addrinfo node
servinfo is a pointer to a linked list of possible connections
Returns rv = 0 if it works, and nonzero if there is an error

client.c – continued

p → linked list of struct addrinfo nodes that has connection possibilities
Loop through all the results (linked list) and connect to the first we can

```
for(p = servinfo; p != NULL; p = p->ai_next) {
```

socket() creates and returns an end-point for a connection

```
        if ((sockfd = socket(p->ai_family, p->ai_socktype, p->ai_protocol)) == -1) {
                perror("client: socket");
                continue;          Didn't work so go to beginning of for-loop
        }
```

connect() attempts to make a connection to server

```
        if (connect(sockfd, p->ai_addr, p->ai_addrlen) == -1) {
                close(sockfd);
                perror("client: connect");
                continue;          Didn't work so go to to beginning of for-loop
        }
        break;
}
if (p == NULL) {
        fprintf(stderr, "client: failed to connect\n");
        return 2;
}
```

```
struct addrinfo {
    int              ai_flags;
    int              ai_family;
    int              ai_socktype;
    int              ai_protocol;
    socklen_t        ai_addrlen;
    struct sockaddr *ai_addr;
    char            *ai_canonname;
    struct addrinfo *ai_next;
};
```

Node in a linked list

Usage: ./client wiliki.eng.hawaii.edu
Here './client' is argv[0] and
'wiliki.eng.hawaii.edu' is argv[1]

Initializes **struct addrinfo 'hints'**, which sets up the socket

Clear **struct addrinfo 'hints'** with bytes 0

client.c – continued

```
        inet_ntop(p->ai_family,    get_in_addr((struct sockaddr *)p->ai_addr),    s,     sizeof s);        Convert IP address to char string
                                                         IP address                  char string
                                                    IP addr is void pointer        s is void pointer

        printf("client: connecting to %s\n", s);

        freeaddrinfo(servinfo);            Free memory of the servinfo linked list

        if (  (numbytes   =   recv(sockfd,   buf,   MAXDATASIZE-1,   0))     == -1  ) {            Similar to read(fd, buf, length);
            perror("recv");
            exit(1);
        }

        buf[numbytes] = '\0’;
        printf("client: received '%s'\n",buf);

        close(sockfd);

        return 0;
}
```

Now let’s do server.c

```
void sigchld_handler(int s){
		while(waitpid(-1, NULL, WNOHANG) > 0);
}
```

SIgnal handler
This deletes zombie processes

```
void *get_in_addr(struct sockaddr *sa){
		if (sa->sa_family == AF_INET) {
				return &(((struct sockaddr_in*)sa)->sin_addr);
		}
		return &(((struct sockaddr_in6*)sa)->sin6_addr);
}
```

Same as in client.c
Return socket IP address, which is IPv4 or IPv6

server.c – continued

Listener:
    Listens for connection requests from clients
    It uses the IP address of its computer
        and its own port number
    When it gets a request, then it creates
        a child process to handle the client

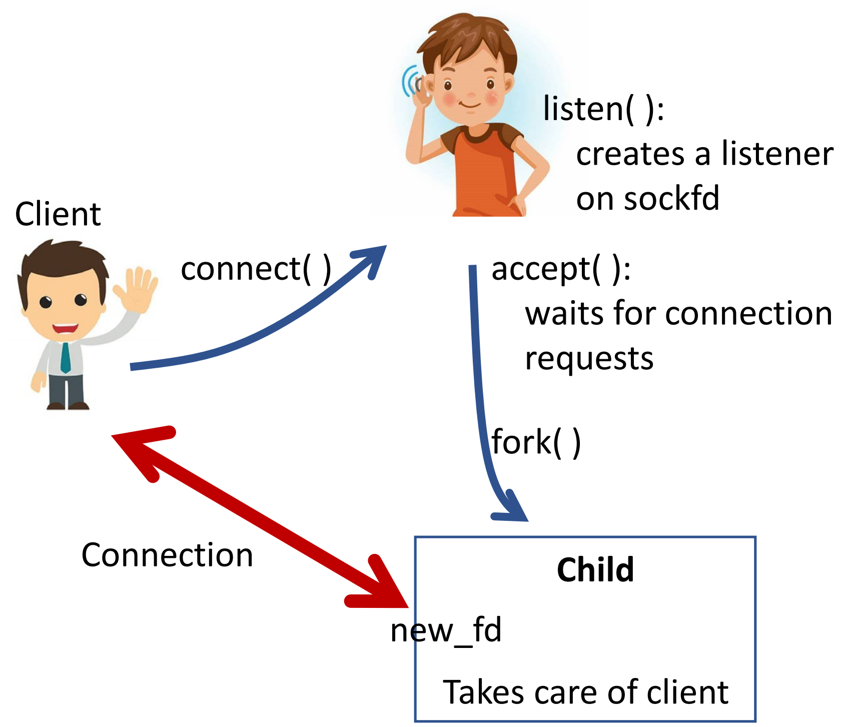
```
int main(void){

        <  Declarations of variables >

        memset(&hints, 0, sizeof hints);            Set up hints for a listener
        hints.ai_family = AF_UNSPEC;                Any address family may apply
        hints.ai_socktype = SOCK_STREAM;
        hints.ai_flags = AI_PASSIVE; // use my IP   Indicates it will be used by the server

        if ((rv = getaddrinfo(NULL, PORT, &hints, &servinfo)) != 0) {  Same as client.c
                fprintf(stderr, "getaddrinfo: %s\n", gai_strerror(rv));
                return 1;
        }
```

Listens for connection requests from clients



server.c – continued

Start a socket

Allows reuse of the socket's IP address

Assigns IP address to sockfd

```
for(p = servinfo; p != NULL; p = p->ai_next) {
        if ((sockfd = socket(p->ai_family, p->ai_socktype, p->ai_protocol)) == -1) {        perror("server: socket");
                                                                                               continue;

        }
        if (setsockopt(sockfd, SOL_SOCKET, SO_REUSEADDR, &yes, sizeof(int)) == -1) {perror("setsockopt");
                                                                                               exit(1);

        }
        if (bind(sockfd, p->ai_addr, p->ai_addrlen) == -1) {                                   close(sockfd);
                                                                                               perror("server: bind");
                                                                                               continue;

        }
        break;
}
if (p == NULL)  {          fprintf(stderr, "server: failed to bind\n");
                           return 2;
}

freeaddrinfo(servinfo);

if (listen(sockfd, BACKLOG) == -1) {            perror("listen");
                                                exit(1);
}
```

Free linked list of nodes

Start listening

server.c – continued

```
sa.sa_handler = sigchld_handler; // reap all dead processes
sigemptyset(&sa.sa_mask);
sa.sa_flags = SA_RESTART;
if (sigaction(SIGCHLD, &sa, NULL) == -1) {
		perror("sigaction");
		exit(1);
}
```

Start a socket

Allows reuse
of the socket's
IP address

Assigns IP address
to sockfd

Free linked list of nodes

Start listening

server.c – continued

Parent:
    Keeps listening for connection requests from clients at sockfd
    Creates children to take care of connections to clients at new_fd
Child:
    Takes care of connections to clients at new_fd

```
    printf("server: waiting for connections...\n");
    while(1) {      // main accept() loop
            sin_size = sizeof their_addr;
            new_fd = accept(sockfd, (struct sockaddr *)&their_addr, &sin_size);
            if (new_fd == -1) {
                    perror("accept");
                    continue;
            }

            inet_ntop(their_addr.ss_family,   get_in_addr((struct sockaddr *)&their_addr),     s,    sizeof s);
            printf("server: got connection from %s\n", s);

            if (!fork()) {
                    close(sockfd);
                    if (send(new_fd, "Hello, world!", 13, 0) == -1)
                            perror("send");
                    close(new_fd);
                    exit(0);
            }
            close(new_fd);
    }
    return 0;
}
```

Waits until listener gets a connection request from a client
newfd = fd for the new connection for the client

Prints out IP address of client, making the request

Child: takes care of request from client

Child doesn't need listener

Child sends "hello world!" to client; similar to write(fd, buf, length);

Close the connection

Parent: goes back to waiting for the next client, i.e., keeps listening

Close the connection of the client, since the child takes care of it
Listener is still alive in the parent