# Discussion 1:

# TCP Sockets and Mininet VM

By Joey Buiteweg

(slide idea credits to Yiwen Zhang and Ben Reeves)

# Greetings!

I took 489 in F18, this is my second year teaching the course

Graduated in Computer Engineering at Umich, CSE SUGS Masters

I played Tenor Sax in the Marching Band for 4 years

Industry experience in network security

^By no means an expert, but I know some things

# DEI and Imposter Syndrome

I care very much about making you all feel included and welcomed here

Some of you may have prior knowledge of the concepts learned in this class

- Please use this to help, not intimidate your peers

**None of you are imposters, you all belong here**

- Much of networking and software in general isn’t intuitive
- We’re here to help
- You can do this!

# Learning Objectives

By the end of this discussion we will:

- Know how to write TCP socket programs
- Be able to use the Mininet VM

# TCP Socket Background

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What is a syscall? What’s an example?

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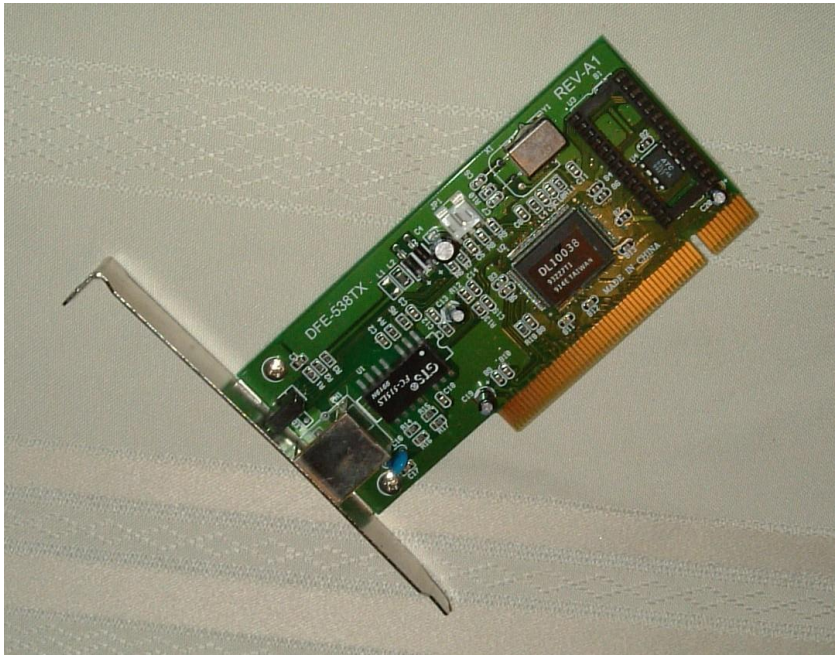
- Allows us to ask the kernel/OS to do things (related to hardware)

What hardware are we interacting with for networking/the internet?

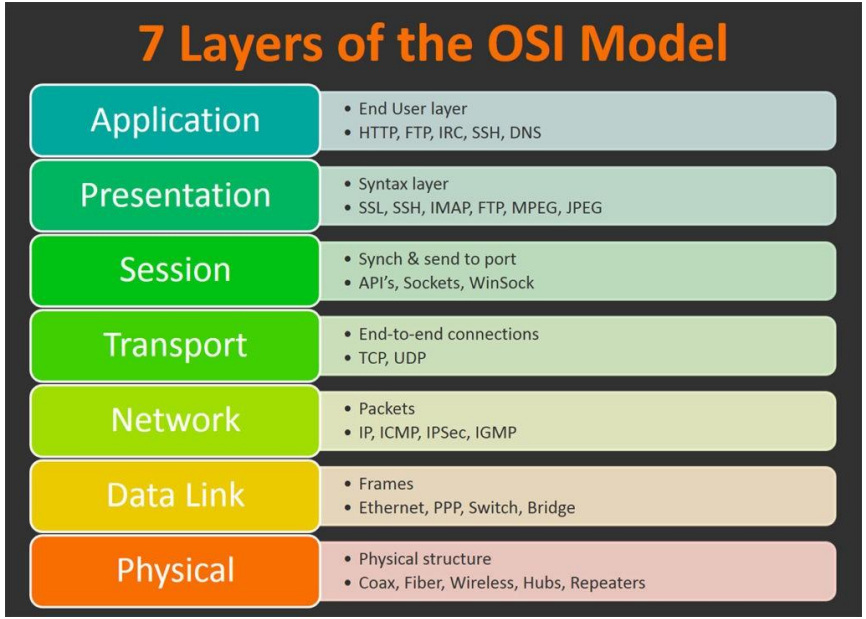
# The NIC (Network Interface Controller)




https://www.tbray.org/ongoing/When/200x/2003/02/18/-big/NIC.jpg.html

# OSI (Open System Interconnect) Model

Abstracted by (for socket programming)




The NIC/Motherboard/CPU/Hardware

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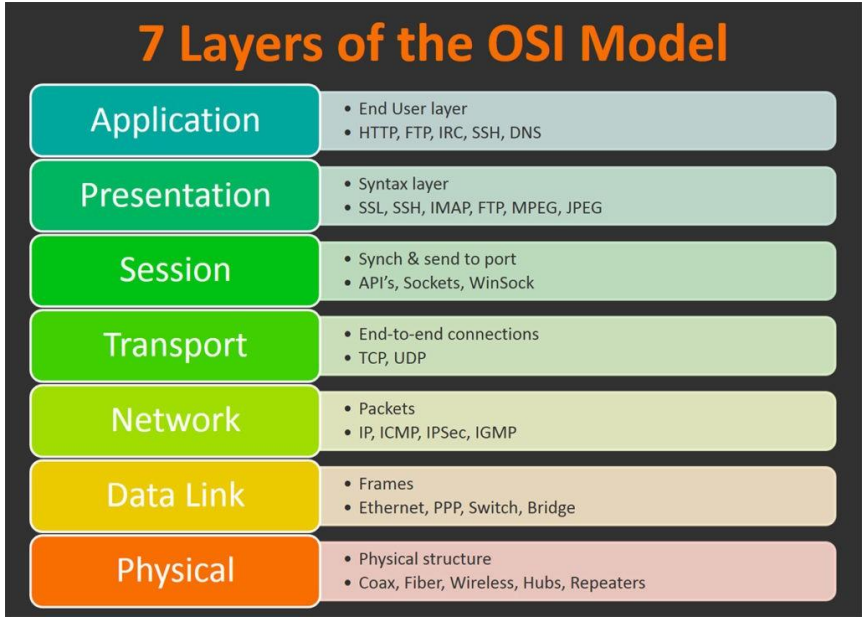


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Kernel

The NIC/Motherboard/CPU/Hardware

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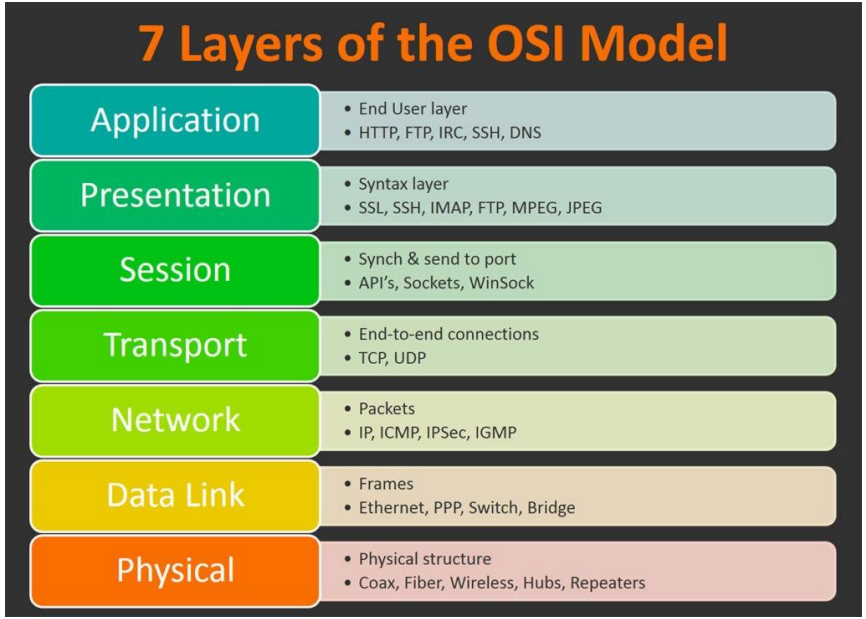


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Kernel or use of raw sockets

Kernel

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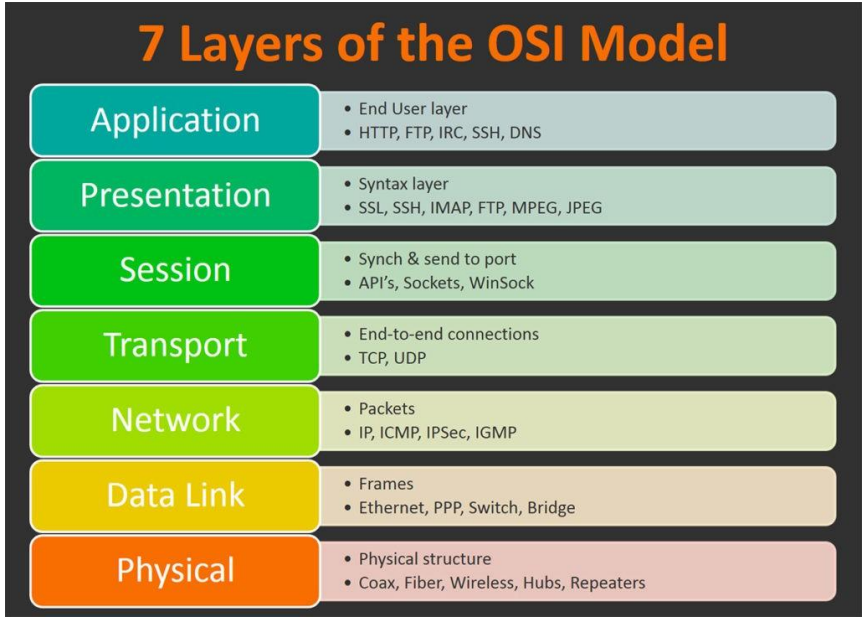


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TCP/UDP Sockets C style API (to the kernel)

Kernel or use of raw sockets

Kernel

The NIC/Motherboard/CPU/Hardware

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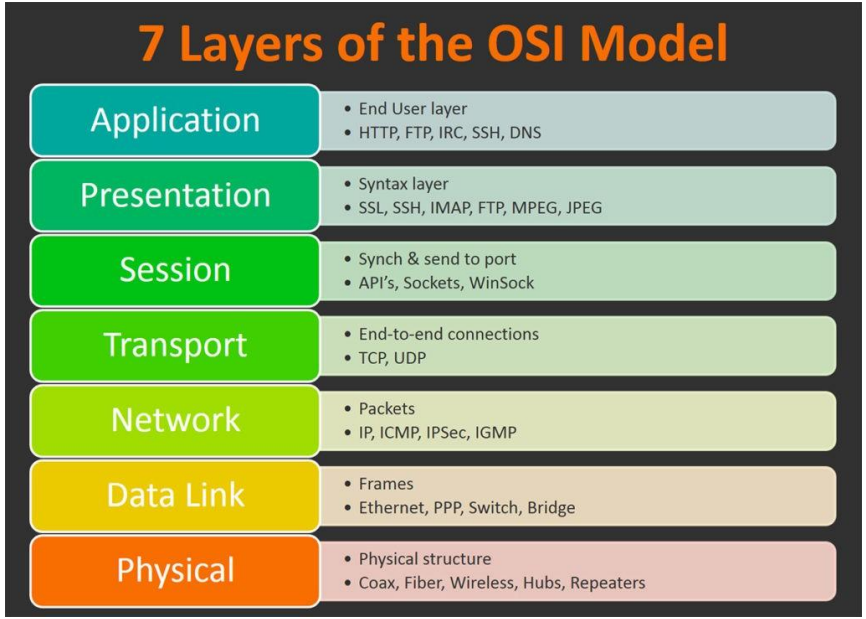


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US!

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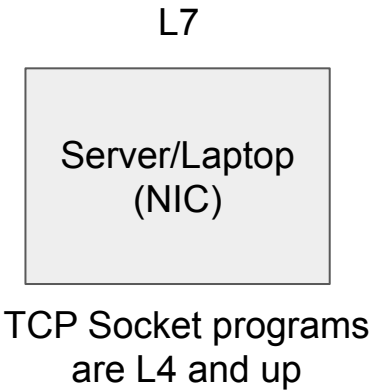
# Greater Scope



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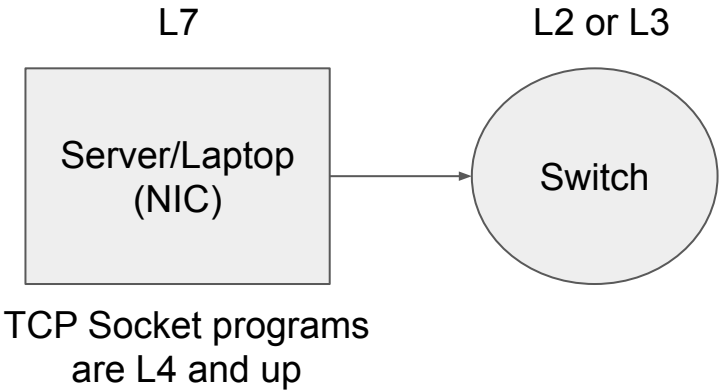

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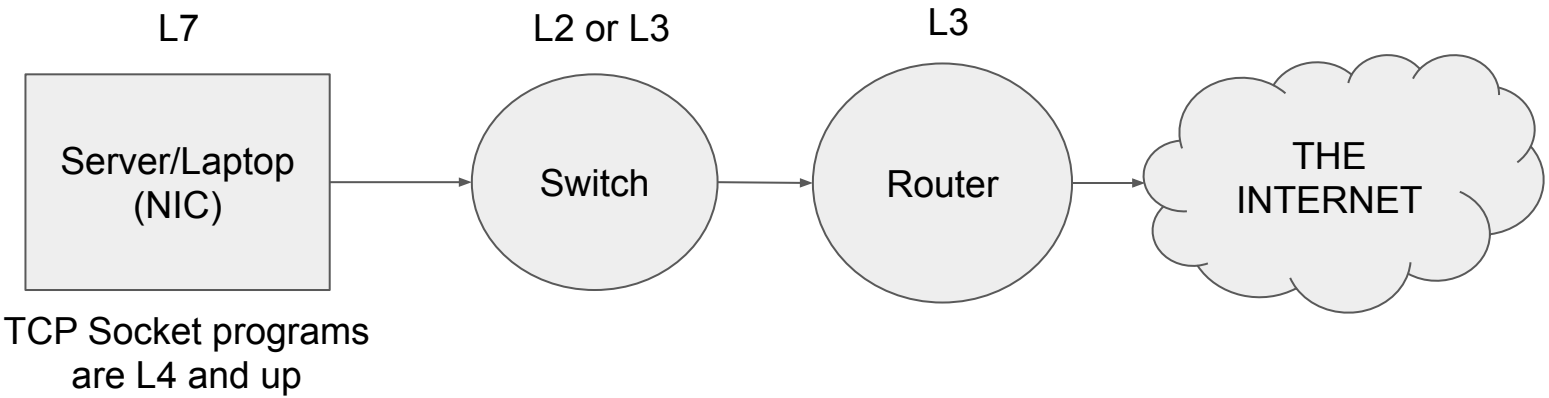

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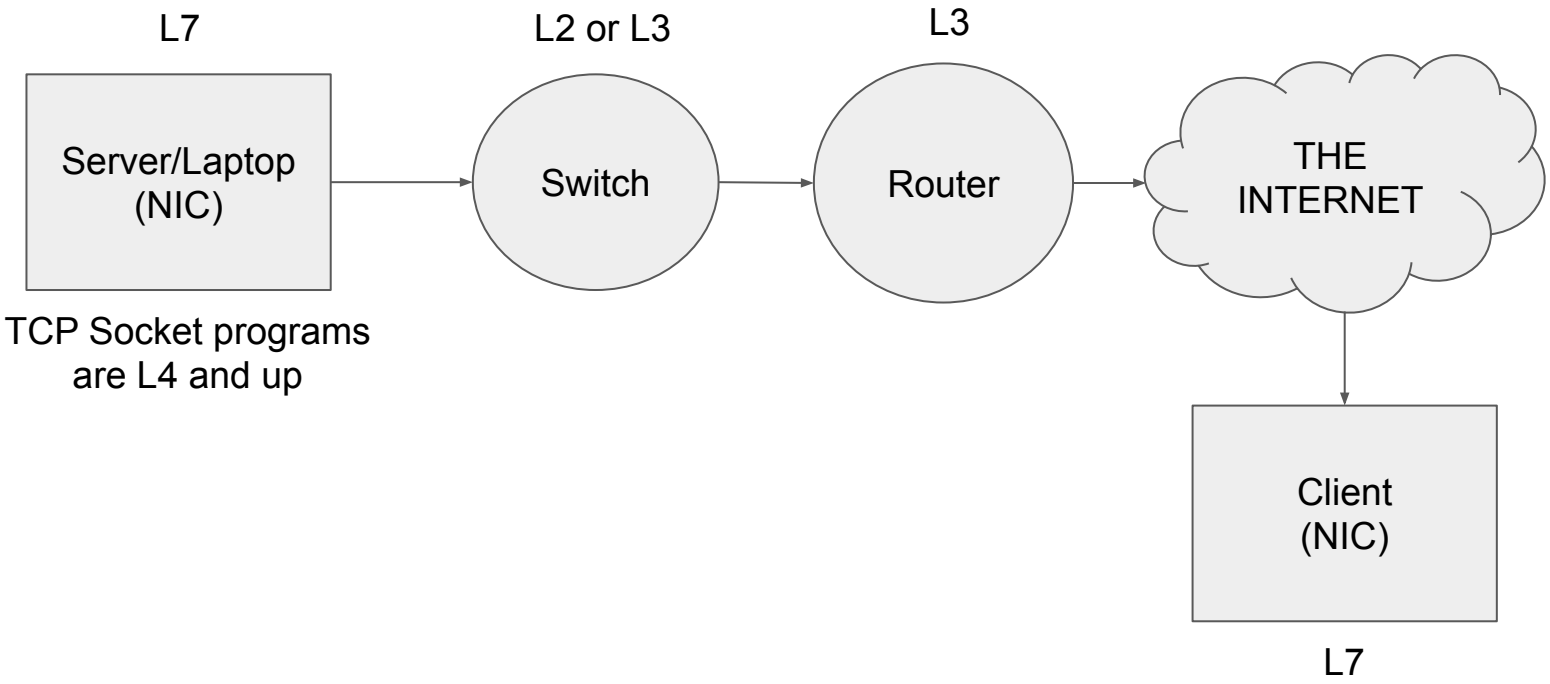

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- Operations done on a variable, not method calls
- Guarantees in order byte stream of data (full duplex, so two byte streams)

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// Instead have to do this
int sockfd = socket();
setsockopt(sockfd, ...);
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# Duplex

Client -> Server

| | | | | | |
|---|---|---|---|---|---|
| 0xDE | 0xAD | 0xBE | 0xEF | 0x00 | 0x00 |

Server -> Client

| | | | | | |
|---|---|---|---|---|---|
| 0xBE | 0xEF | 0xDE | 0xAD | 0xFF | 0xFF |

**TWO SEPARATE BYTE STREAMS**

# TCP Socket API

```
// Server functions (in order)
socket()

setsockopt()

bind()

listen()

accept()

recv() or send()

close()
```

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// Server functions (in order)
socket()

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```

```
// Client functions (in order)
socket()

connect() // does TCP handshake

recv() or send()

close()
```

# TCP Socket Telephone Analogy

Can view these function calls with analogy to a telephone conversation

# Server Functions: socket()

Creates a socket. Like buying a telephone.

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

// Example

sockfd = socket(AF_INET, SOCK_STREAM, IPPROTO_TCP);
```

# Server Functions: setsockopt()

Allows port number to be reused. Similar to configuring the telephone

Prevents “port is already in use” error. PLEASE USE THIS.

```
setsockopt(int sockfd, int level, ...)

// Example

int yes = 1;
setsockopt(sockfd, SOL_SOCKET, SO_REUSEADDR, &yes,
           sizeof(yes));
```

# Server Functions: bind()

Binds a socket to an address. Like registering a phone number for the telephone.

```
int bind(int sockfd, const struct sockaddr * addr,
         socklent_t addrlen);

// Example
struct sockaddr_in addr;
memset(&addr, 0, sizeof(addr));
addr.sin_family = AF_INET;
addr.sin_addr.s_addr = INADDR_ANY; //INADDRY_ANY == 0.0.0.0
addr.sin_port = htons(port);
bind(sockfd, (struct sockaddr *) & addr, sizeof(addr));
```

# AF_INET

```
addr.sin_family = AF_INET; // Use IPv4

addr.sin_family = AF_INET6; // Use IPv6
```

**For this class we will only be using IPv4**

# INADDR_ANY vs 127.0.0.1

```
addr.sin_addr.s_addr = INADDR_ANY; //INADDRY_ANY == 0.0.0.0

addr.sin_addr.s_addr = inet_addr("127.0.0.1");
```

`INADDR_ANY` binds to all interfaces

127.0.0.1 binds to connections only from localhost, meaning no traffic from other hosts

# htons / htonl

```
addr.sin_port = htons(port);
```

htons stands for “host-to-network short”

htonl stands for “host-to-network long”

network might operate in different endianness than the host

- i.e little-endian vs big-endian

# Server Functions: listen()

Listens for a connection on a socket.

Like plugging a phone into the wall, but being able to listen to “backlog” number of calls.

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

// Example
listen(sockfd, 10);
```

# Server Functions: accept()

Accepts a connection on a socket. Returns another socket representing client.

Like picking up the telephone/answering a call.

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

// Example
socklen_t addr_len = sizeof(addr);
int client_sock = accept(sockfd, (struct sockaddr *) & addr,
                         &addr_len);
```

# Client Functions: socket()

Creates a socket, same as server. Like buying a telephone

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

// Example

sockfd = socket(AF_INET, SOCK_STREAM, IPPROTO_TCP);
```

# Client Functions: connect()

Connects to another machine/the server's binded socket.

Similar to calling someone on a telephone.

```
int connect(int sockfd, const struct sockaddr* addr,
            socklen_t addrlen);
// Example
int sockfd = socket(AF_INET, SOCK_STREAM, IPPROTO_TCP);
struct sockaddr_in server;
server.sin_family = AF_INET;
server.sin_port = htons((u_short) portNum);
struct hostent* sp = gethostbyname(hostname.c_str());
memcpy(&server.sin_addr, sp->h_addr, sp->h_length);
connect(sd, (sockaddr*) &server, sizeof(server));
```

# Communication Functions: send()

Send a message.

Similar to saying something during the phone conversation.

```
ssize_t send(int sockfd, const void * buf, size_t len,
             int flags);
// Example
ssize_t bytes_sent = send(sockfd, buffer, MSG_SIZE,
                          MSG_NOSIGNAL);
// bytes_sent is not always == to MSG_SIZE, but for our
// purposes it is (very rarely isn't)
```

# Communication Functions: recv()

Receive a message.

Similar to hearing something during the phone conversation.

```
ssize_t recv(int sockfd, const void * buf, size_t len,
             int flags);
// Example
ssize_t bytes_recvd = recv(sockfd, buffer, MSG_SIZE, 0);
// here bytes_recvd is not always == to MSG_SIZE

// But we also can do
ssize_t bytes_recvd = recv(sockfd, buffer, MSG_SIZE
                           MSG_WAITALL);
// here bytes_recvd is == MSG_SIZE, but we block until then
```

# Communication Functions: close()

Close a socket connection.

Similar to hanging up the phone (or even throwing it away haha)

```
int close(inf sockfd);

// Example
int ret = close(sockfd);
```

# Putting it all together

```
// Server functions (in order)
socket() // Buy phone

setsockopt() // Set up phone

bind() // Register phone num

listen() // Plug in phone

accept() // Pick up phone

recv()/send() // Talk w/Client

close() // Hang up phone
```

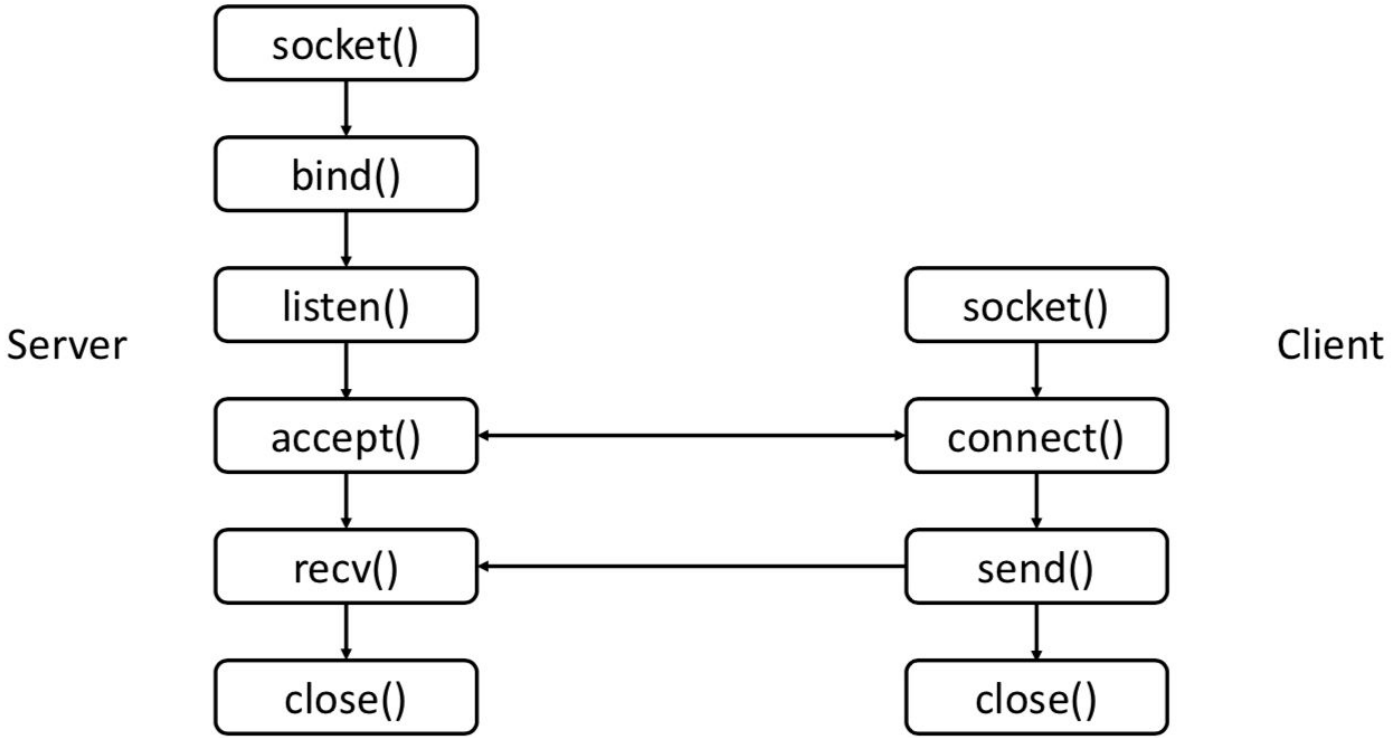
```
// Client functions (in order)
socket() // Buy phone

connect() // Call server

recv()/send()  // Talk to Server

close() // Hang up phone
```

# TCP Socket API - Control Flow



# Socket Demo

Credit to Ben Reeves (482 GSI/IA) for the code for the Demo
(link to the repo and other examples on next slide)

# Socket example projects

Very good example here (demo code we looked at that I did not write):

https://github.com/eecs482/bgreeves-socket-example

Other examples can be found here (anything with socket in the name):

https://github.com/eecs482

Very good references here:

http://www.cs.rpi.edu/~moorthy/Courses/os98/Pgms/socket.html

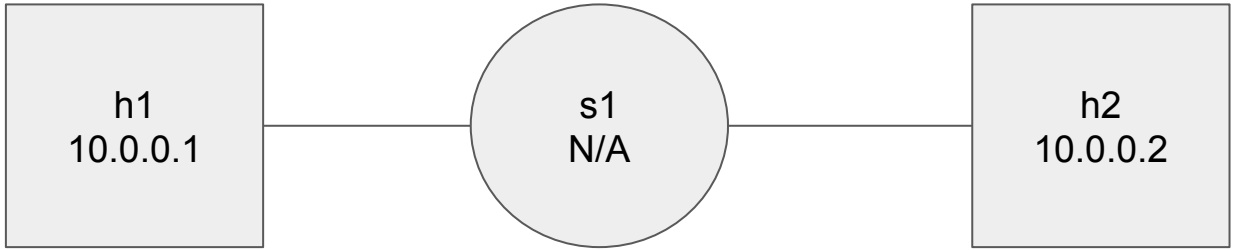
https://beej.us/guide/bgnet/html/

Also see the linux man pages (e.g “man recv”)

# Mininet VM Info

# Default Mininet Topology

```
$ sudo mn
```




Note: There is no DNS configured, no name resolution programs (e.g dig, nslookup, etc.) will work

Please ignore the switches, they don’t matter for this class

# Mininet VM Tips

Use the one from the assignment spec! Already has a desktop env installed

Provision enough hardware resources

- About half of RAM, half of cores, as much VRAM as possible

Shared folders

Follow the mininet walkthrough mentioned in the spec