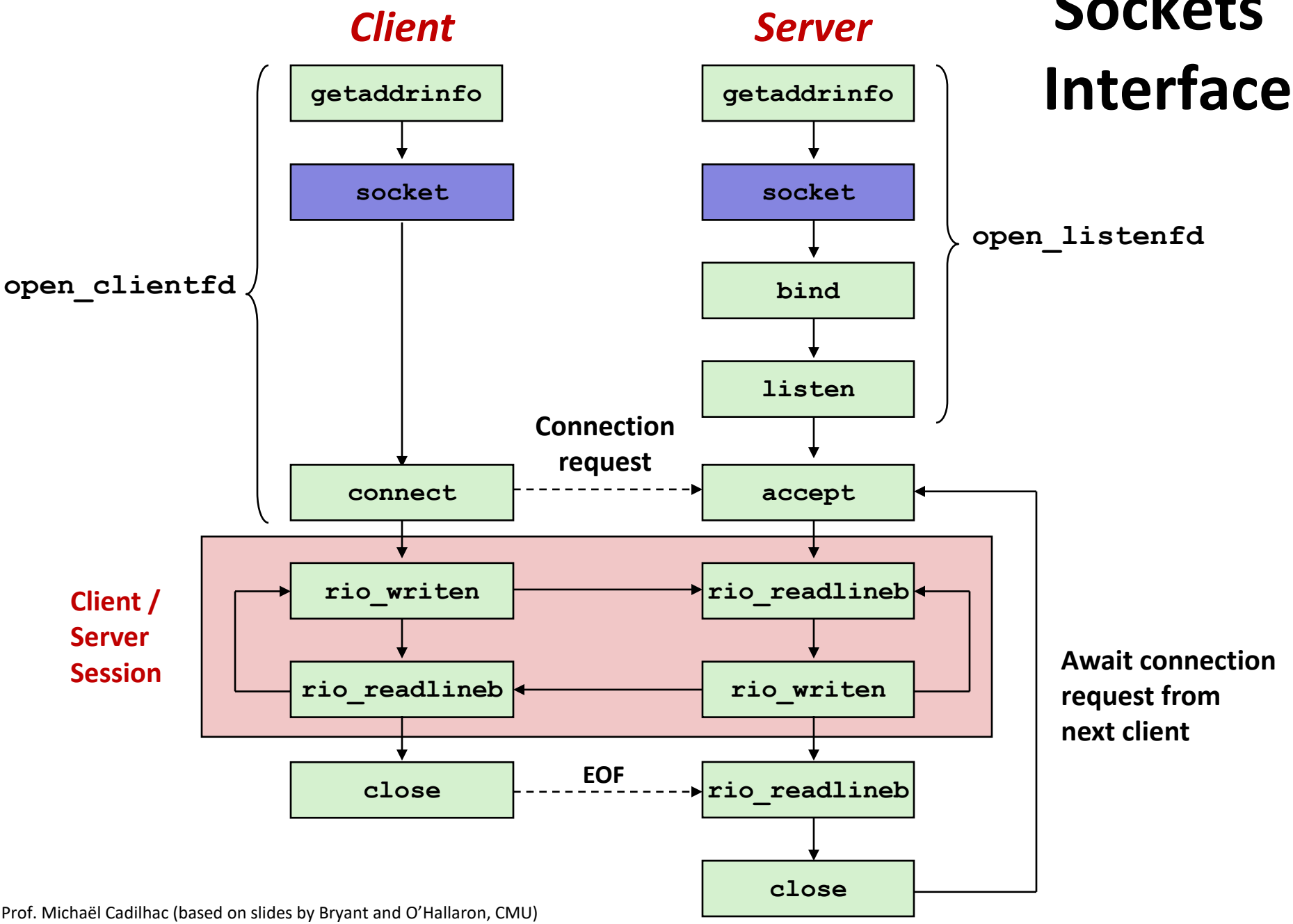
Network Programming:

Basic client/server application:

2. `socket, bind, listen, connect, accept`

Sockets Interface



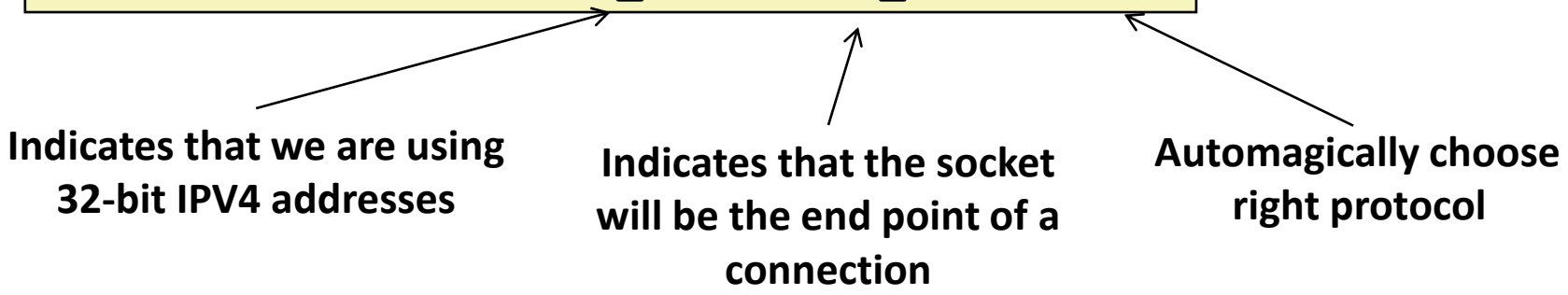
Sockets Interface: `socket`

- Clients and servers use the `socket` function to create a *socket descriptor*:

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

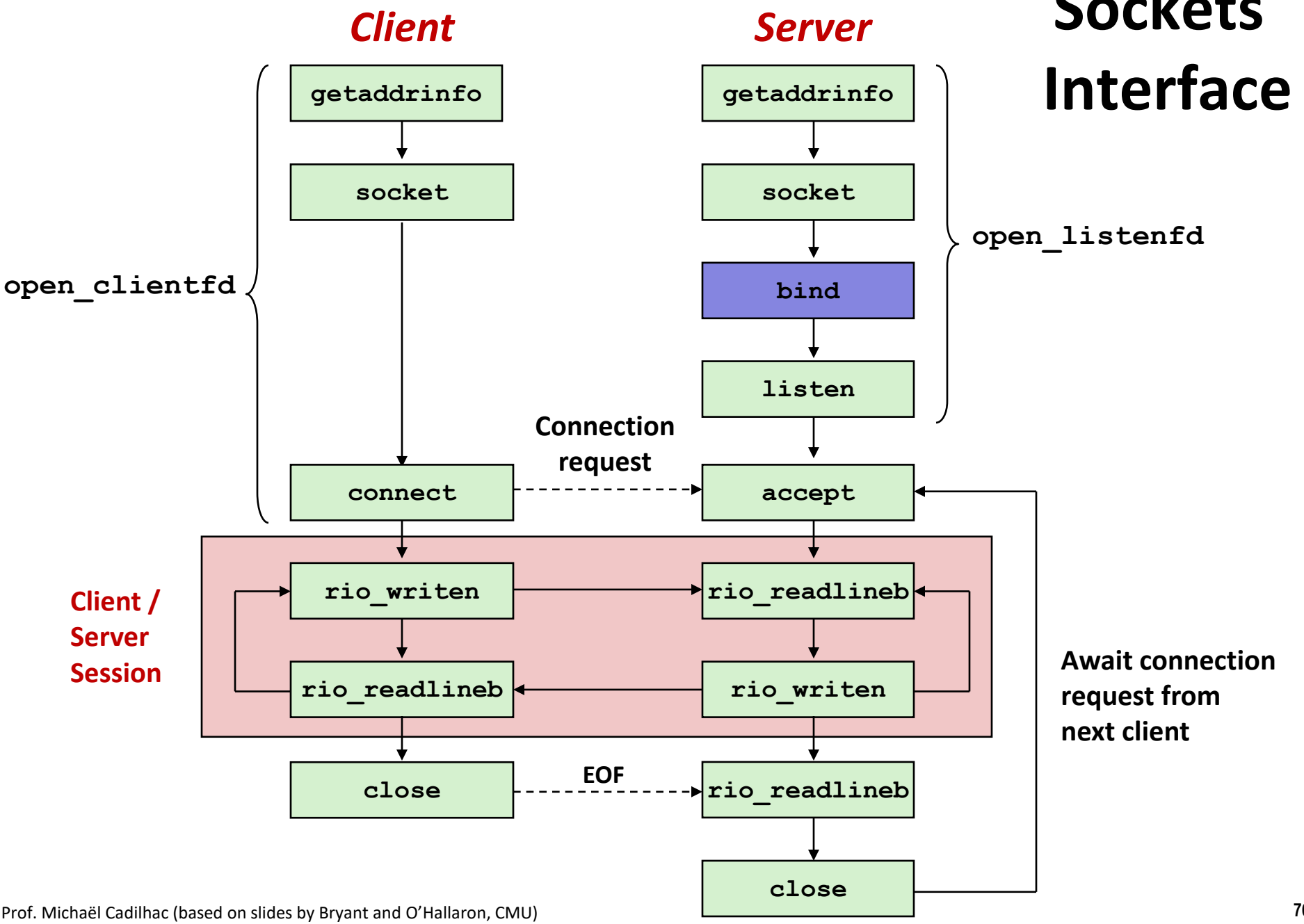
- Example:

```
int clientfd = Socket(AF_INET, SOCK_STREAM, 0);
```



Protocol specific! ***Best practice is to use `getaddrinfo` to generate the parameters automatically, so that code is protocol independent.***

Sockets Interface



Sockets Interface: `bind`

- A server uses `bind` to ask the kernel to associate the server's socket address with a socket descriptor:

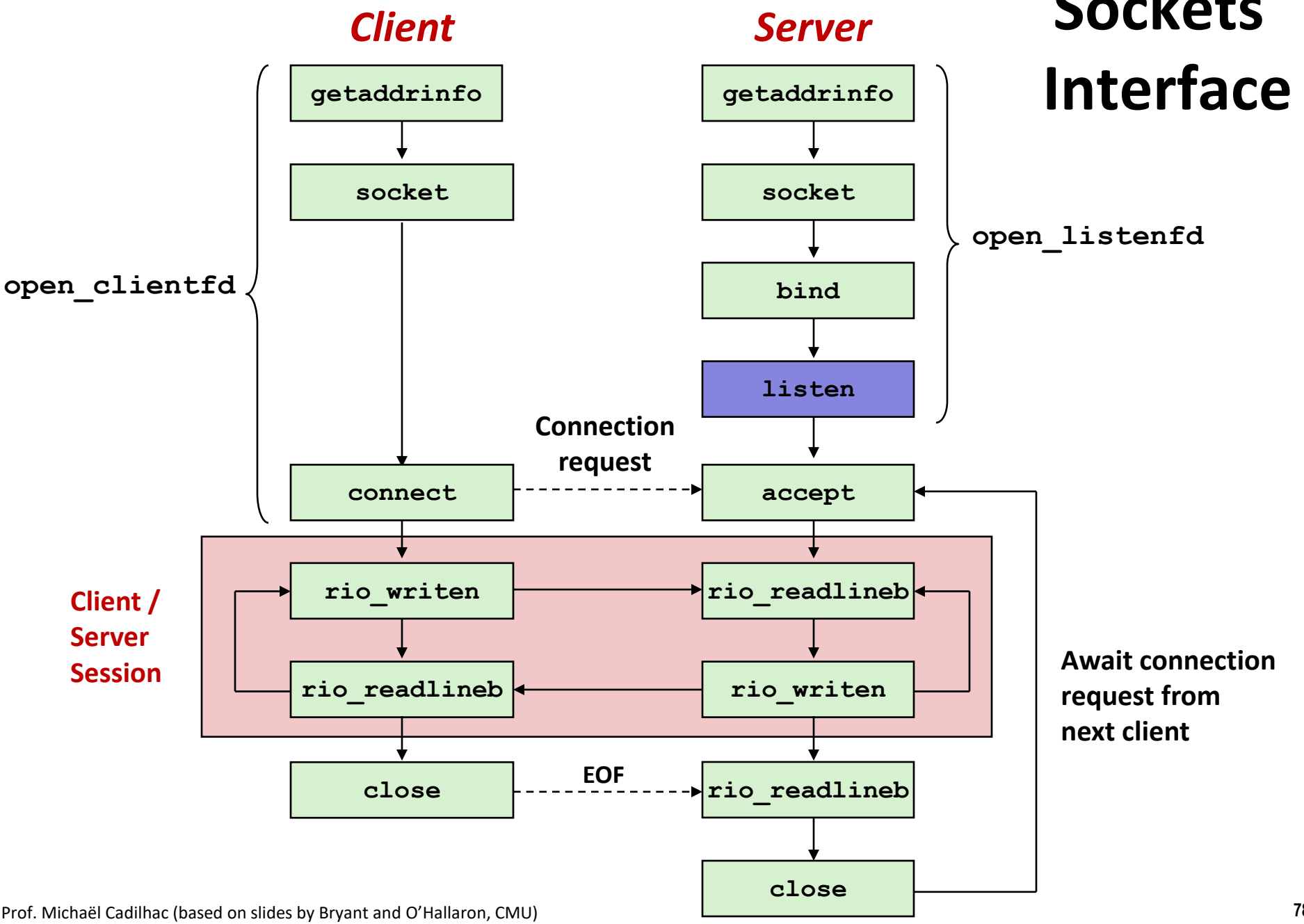
```
int bind(int sockfd, SA *addr, socklen_t addrlen);
```

- The process can read bytes that arrive on the connection whose endpoint is `addr` by reading from descriptor `sockfd`. Similarly for write.
- We won't read/write to `sockfd` directly but use further calls to have one fresh file descriptor per client.

Best practice is to use `getaddrinfo` to supply the arguments `addr` and `addrlen`.

(Note: could be used by a client that does not want an ephemeral port, but never the case in practice.)

Sockets Interface



Sockets Interface: `listen`

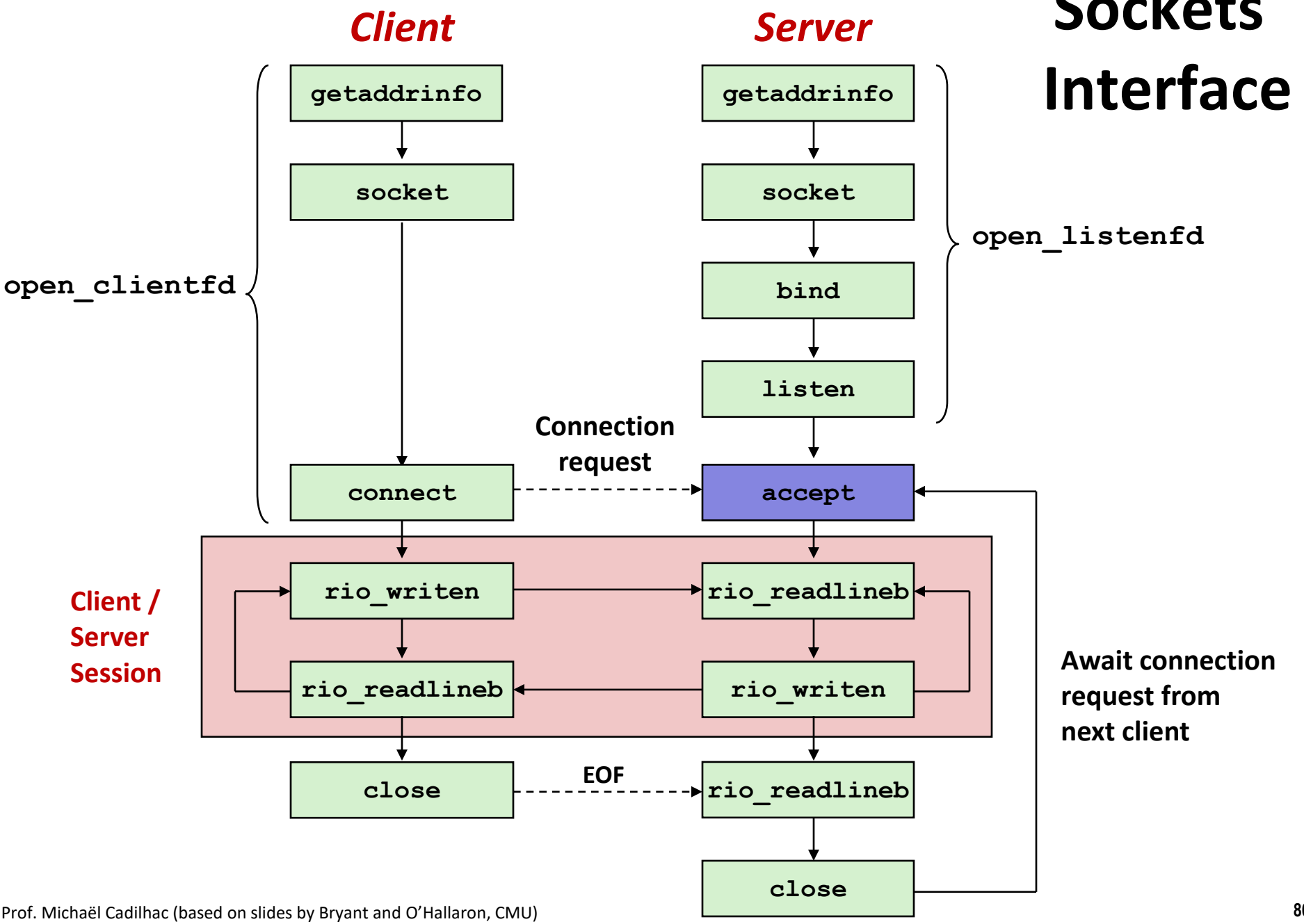
- By default, kernel assumes that descriptor from socket function is an *active socket* that will be on the client end of a connection.
- A server calls the listen function to tell the kernel that a descriptor will be used by a server rather than a client:

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

- Converts `sockfd` from an active socket to a *listening socket* that can accept connection requests from clients.

- `backlog` is a hint about the number of outstanding connection requests that the kernel should queue up before starting to refuse requests.

Sockets Interface



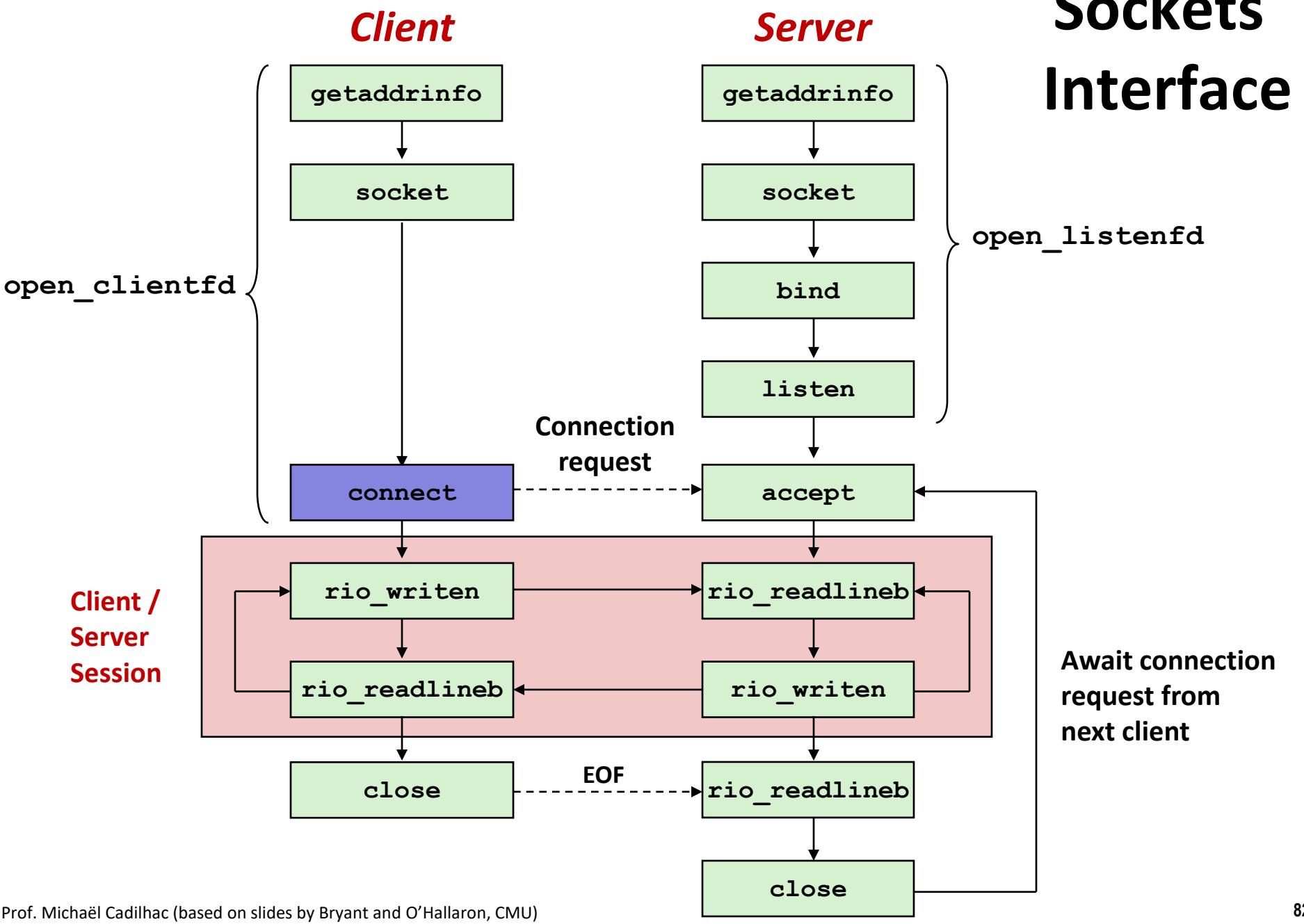
Sockets Interface: `accept`

- Servers wait for connection requests from clients by calling `accept`:

```
int accept(int listenfd, SA *addr, int *addrlen);
```

- Waits for connection request to arrive on the connection bound to `listenfd`, then fills in client's socket address in `addr` and size of the socket address in `addrlen`.
- Returns a *connected descriptor* that can be used to communicate with the client via Unix I/O routines.

Sockets Interface



Sockets Interface: `connect`

- **A client establishes a connection with a server by calling connect:**

```
int connect(int clientfd, SA *addr, socklen_t addrlen);
```

- **Attempts to establish a connection with server at socket address `addr`**
  - If successful, then `clientfd` is ready for reading and writing.
  - Resulting connection is characterized by socket pair

    `(x:y, addr.sin_addr:addr.sin_port)`
    - `x` is client address
    - `y` is ephemeral port that identifies client process on client host

Best practice is to use `getaddrinfo` to supply the arguments `addr` and `addrlen`.

`accept` Illustrated

1. Server blocks in `accept`, waiting for connection request on listening descriptor `listenfd`

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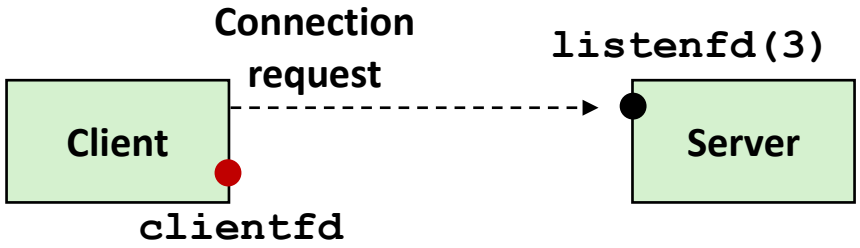
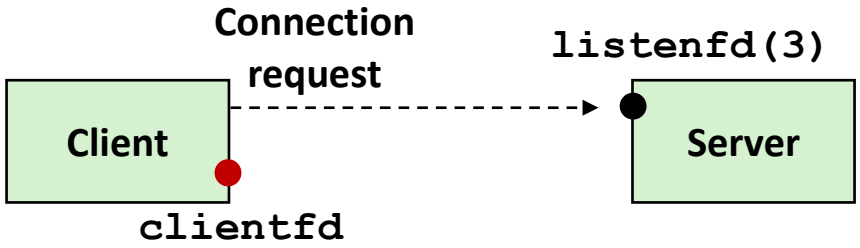


2. Client makes connection request by calling and blocking in `connect`

`accept` Illustrated

1. Server blocks in `accept`, waiting for connection request on listening descriptor `listenfd`



2. Client makes connection request by calling and blocking in `connect`

3. Server returns `connfd` from `accept`. Client returns from `connect`. Connection is now established between `clientfd` and `connfd`

Connected vs. Listening Descriptors

- **Listening descriptor**
  - End point for client connection requests
  - Created once and exists for lifetime of the server

- **Connected descriptor**
  - End point of the connection between client and server
  - A new descriptor is created each time the server accepts a connection request from a client
  - Exists only as long as it takes to service client

- **Why the distinction?**
  - Allows for concurrent servers that can communicate over many client connections simultaneously
    - E.g., Each time we receive a new request, we fork a child to handle the request