Sockets

Lecture 08.01

https://src-code.simons-rock.edu/git/mbarsky/socket_demo.git

Inter-process communication

- Wait for exit status (report when done)
  - Only short integer status
- Pipe (always open for communication)
  - Only between related processes
- Signals (send when you want, handle or ignore)
  - Just a poke

Inter-process communication

- Wait for exit status (report when done)
- Pipe (always open for communication)
- Signals (send when you want, handle or ignore)
- Sockets (open connection with the world)

Sockets

- We want two unrelated processes to talk with each other:
  - Created by different shells
  - Created by different users
  - Running on different machines

- Sockets are communication points on the same or different computers to exchange data
- Sockets are supported by Unix, Windows, Mac, and many other operating systems
- Now they are also supported by all modern browsers

Sockets use file descriptors to talk

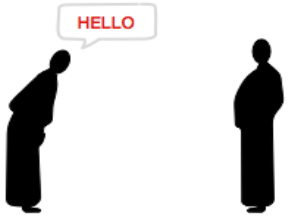
- Every I/O action is done by writing or reading to/from a stream using *file descriptor*
- To a programmer, a socket looks and behaves much like a low-level file descriptor: has read(), write(), close()
- Sockets are **full-duplex (2 way)** – as if opening a stream for both reading and writing

- The only difference – how we set up the socket

If 2 processes are unrelated – we need a *protocol* for communication

SYNTAX

- What to say



SEMANTICS

- In what context

TIMING

- When

Communication protocols

- TCP protocol – how to transfer and receive byte streams
- IP protocol – how to locate and connect to a machine on the internet
- HTTP protocol establishes rules of communication between browser and web server
- Application-level protocols: FTP, SMTP, and POP3

Socket protocols

- The two most common socket protocols:
  - TCP (Transmission Control Protocol)
  - UDP (User Datagram Protocol)

Stream sockets

Datagram sockets

Stream sockets (TCP)

- Message delivery is guaranteed. If delivery is impossible, the sender receives an error indicator
- If you send three items "A, B, C", they will arrive in the same order – "A, B, C"
- Data records do not have any boundaries

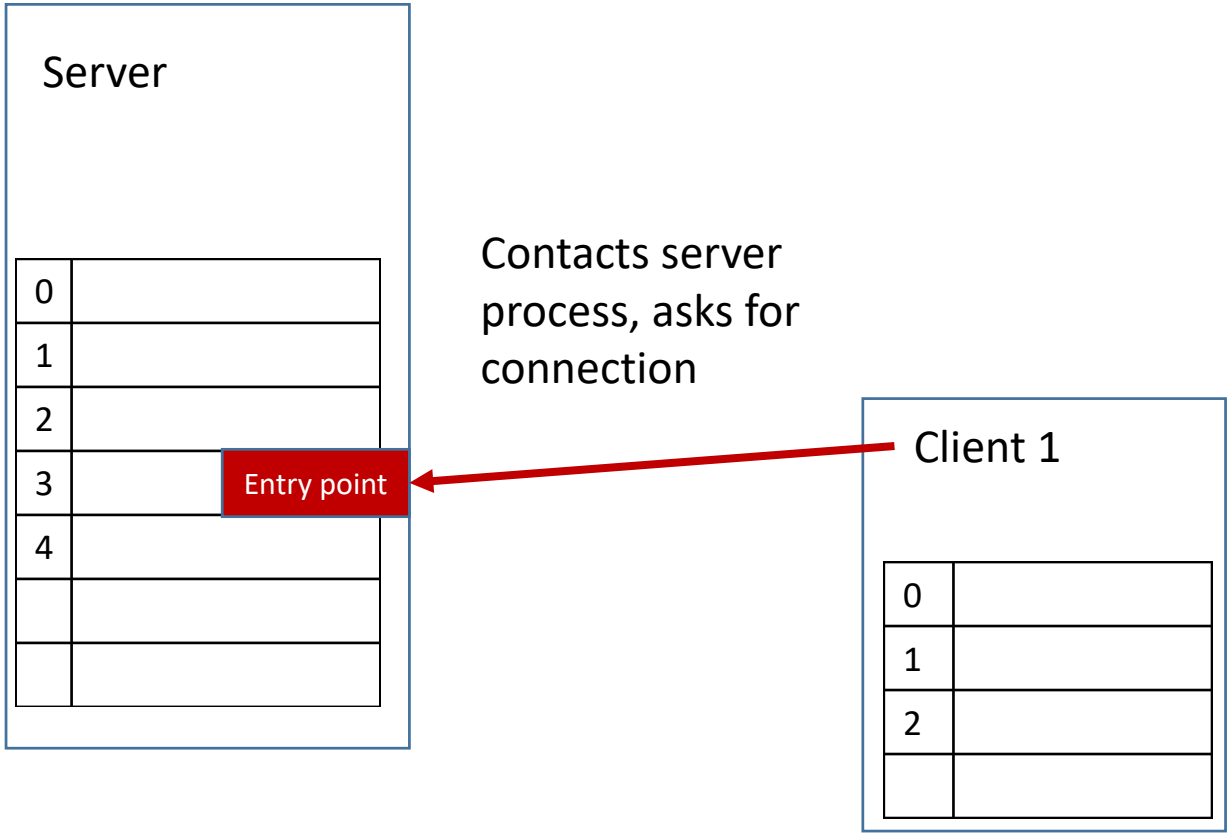
Datagram sockets (UDP)

- Order is not guaranteed
- Connectionless: you don't need to have an open connection as in Stream Sockets – you build a packet with the destination information and send it out
- Delivery is not guaranteed

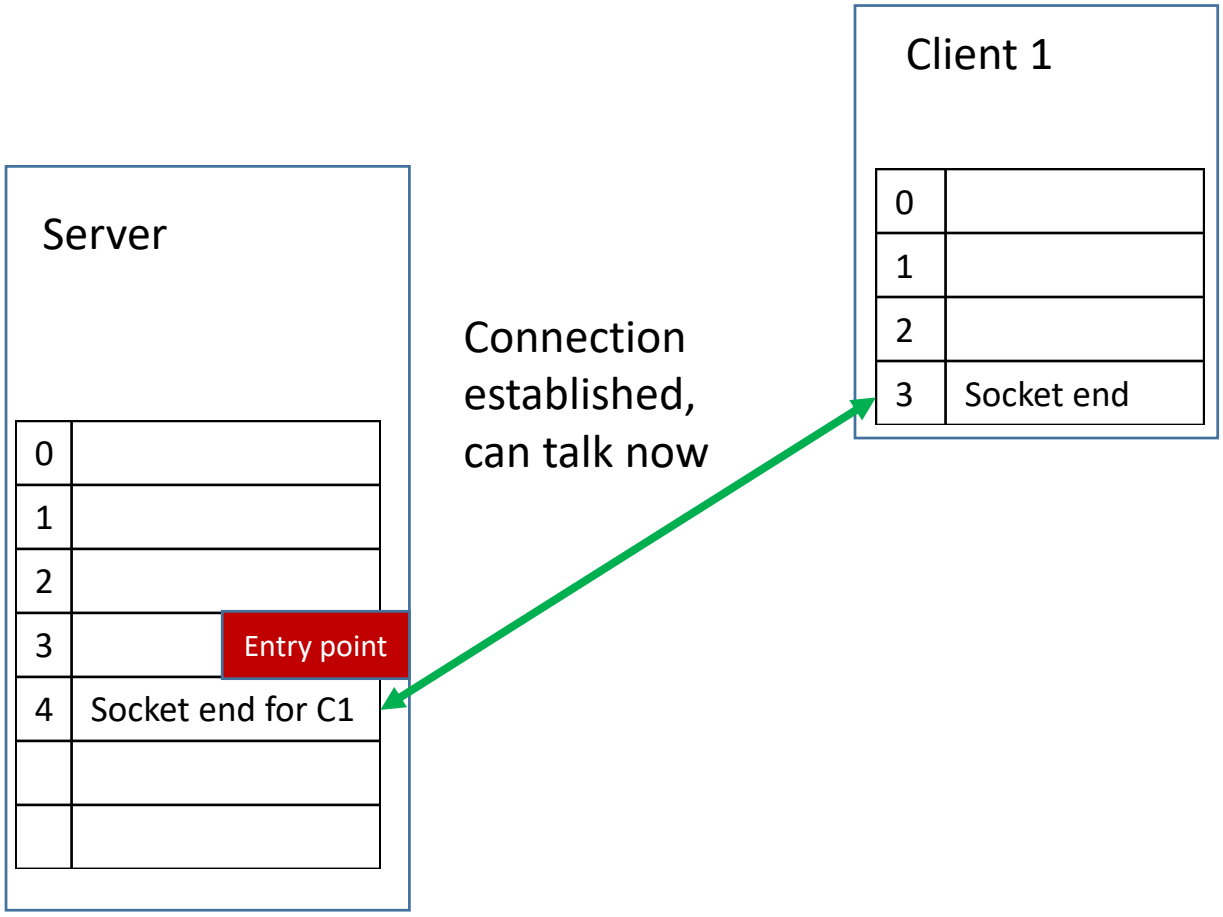
Server

- A *server* is a program that performs some functions on request from a client
- Server serves as a major switch in the phone company
- It is responsible for taking incoming calls from clients and then creating personal connection between a pair of file descriptors: one in the client and one in the server process

How does it work



How does it work



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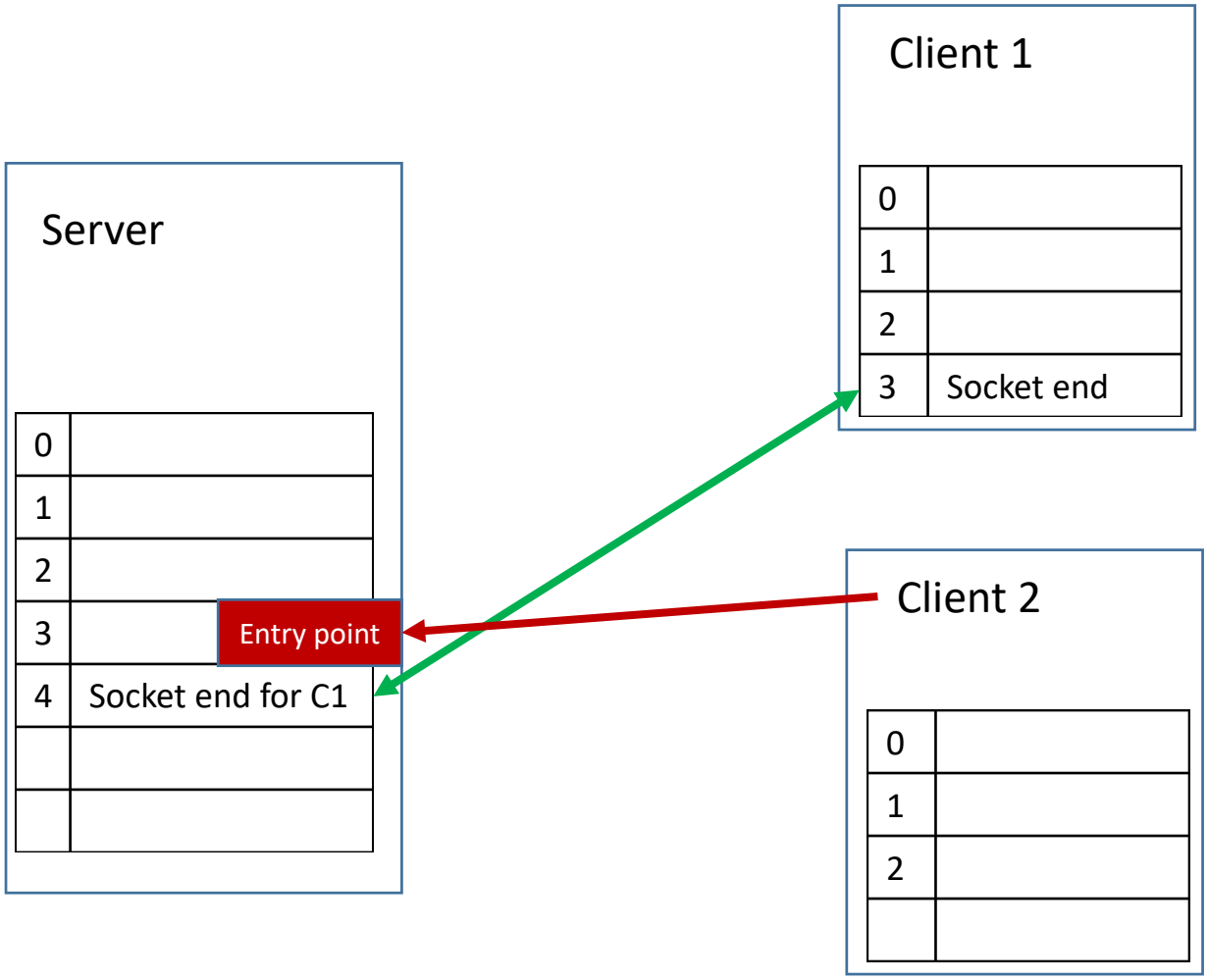

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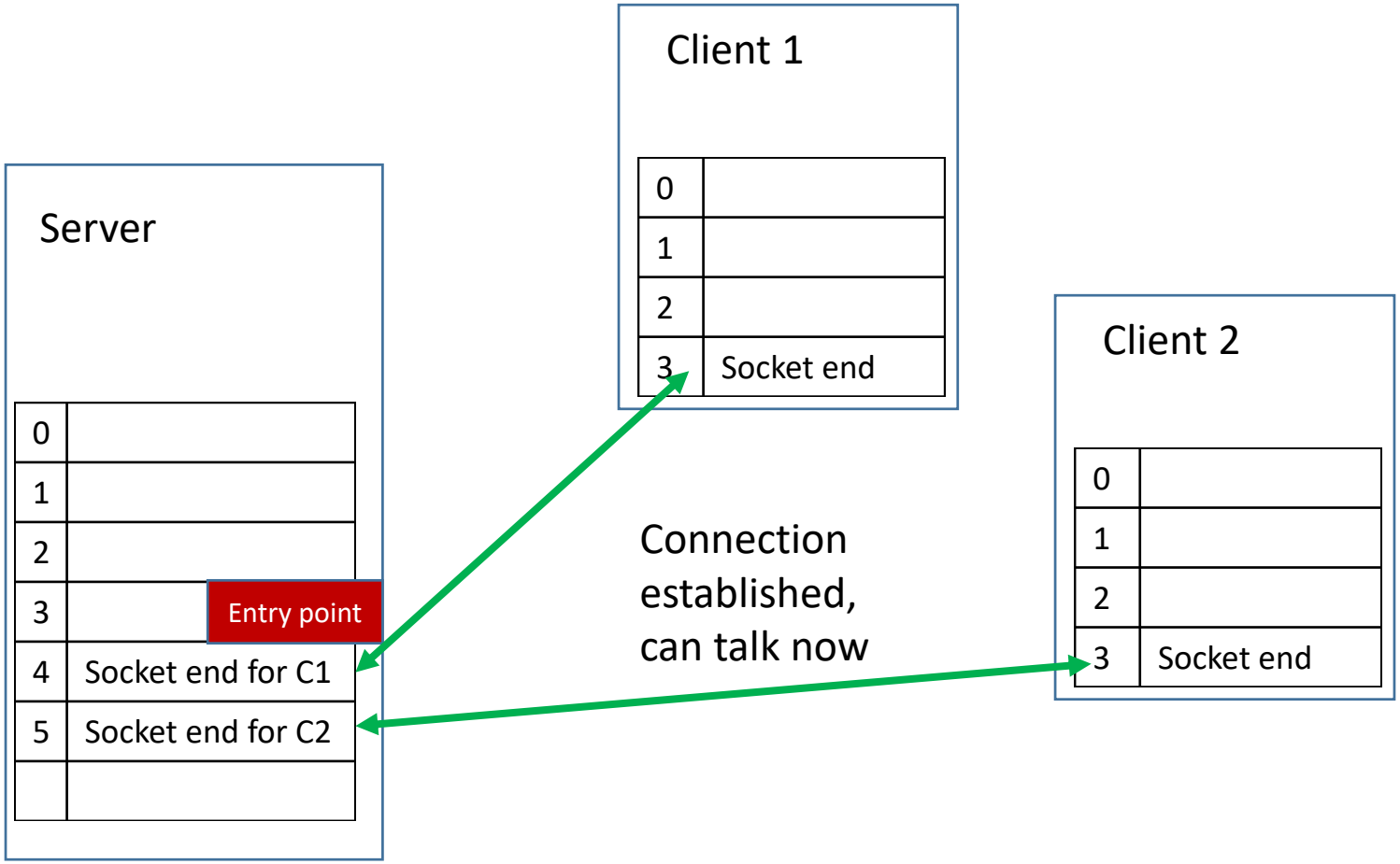

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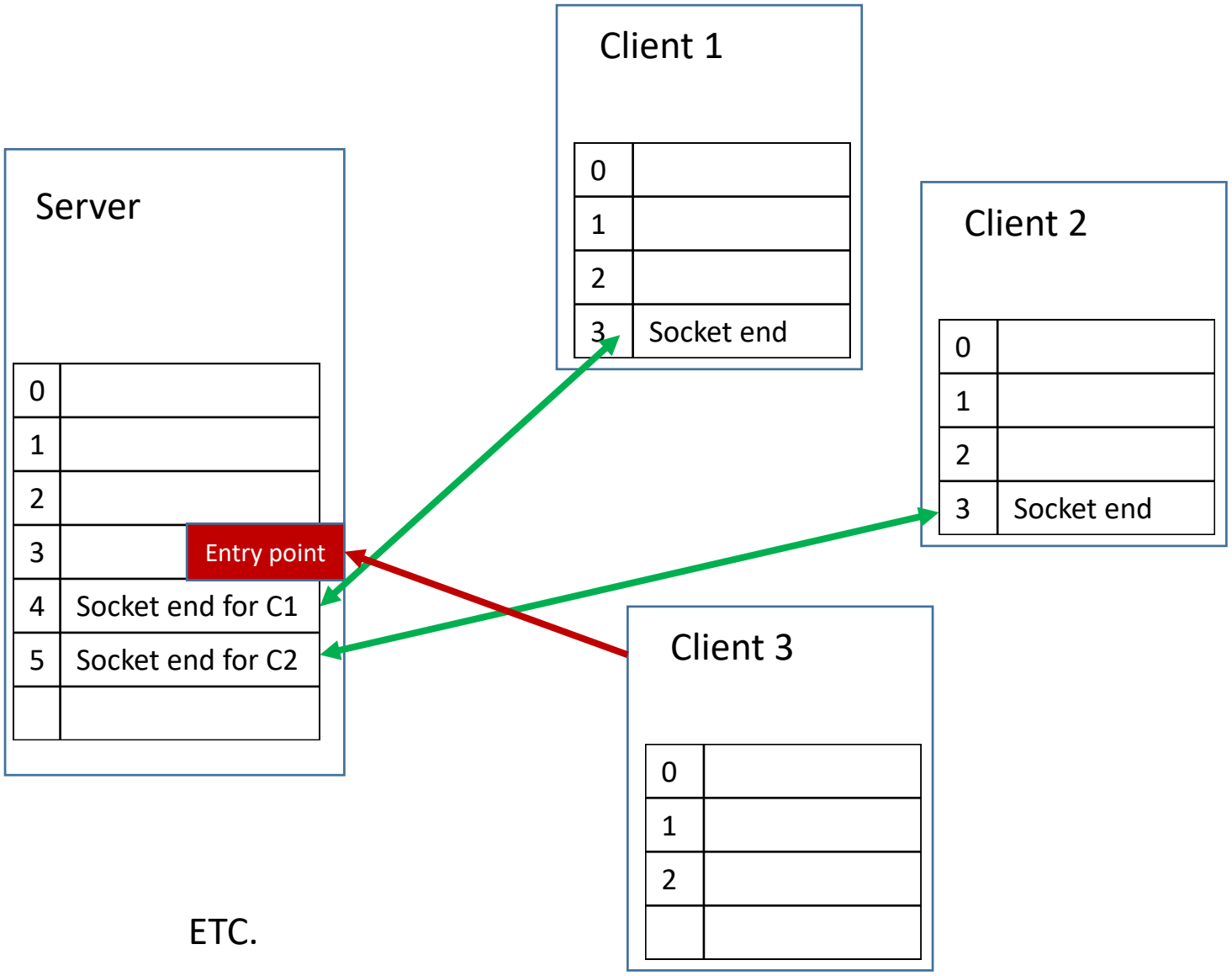
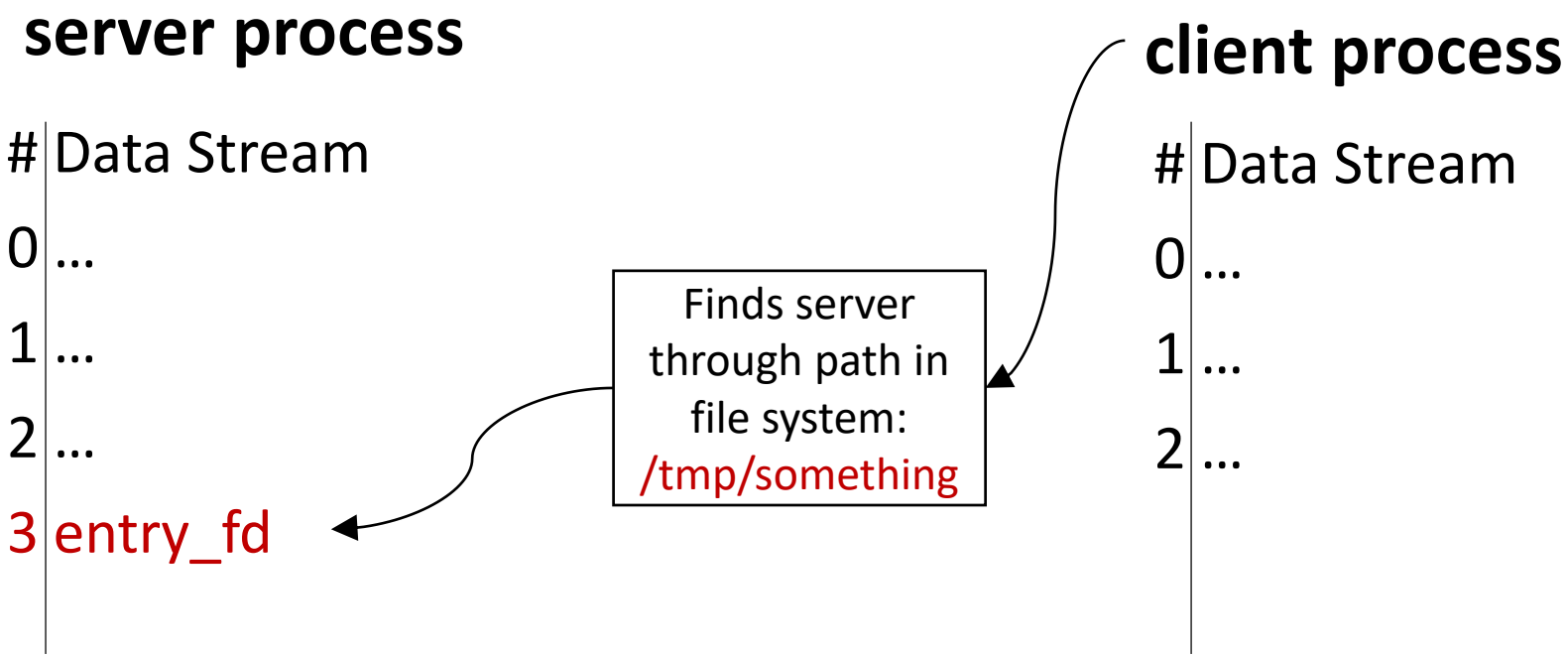


Unix domain socket server

Data communications endpoints for exchanging data between processes executing **on the same Unix host** system

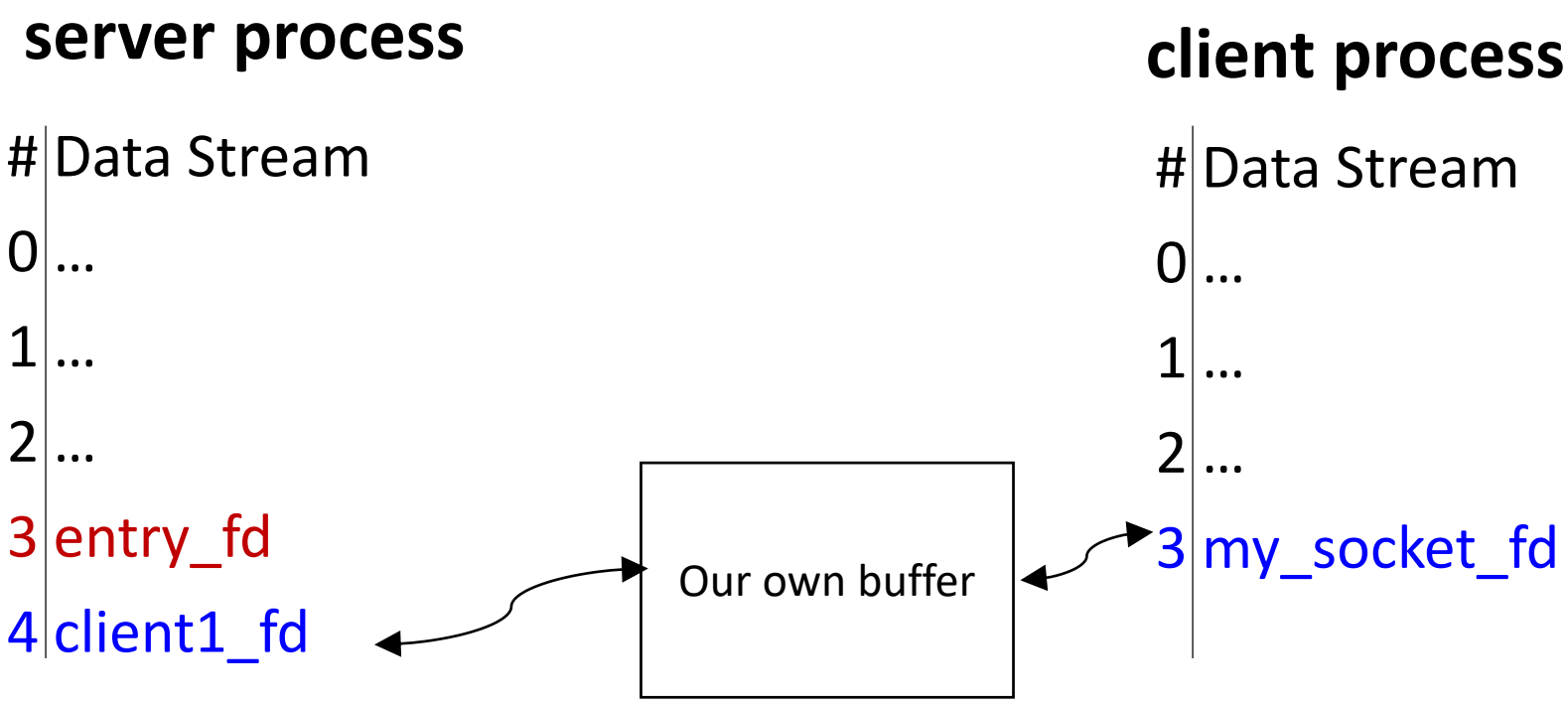
code in *server.c*

Unix domain sockets



Full-duplex communication between two unrelated processes through Unix inode

Unix domain sockets



Full-duplex communication between two unrelated processes through Unix inode

Define socket (like installing a phone socket)

```
int serv_fd;


if ((serv_fd = socket(AF_UNIX, SOCK_STREAM, 0)) < 0) {
        perror ("socket");
        exit (1);
}
```

1 *Socket type – Unix socket*

2 *Protocol type – TCP*

3 *Protocol id – can be multiple protocols, but here only one*

socket() call does not specify where data will be coming from, nor where it will be going to –it just creates the socket prototype of a certain type and assigns it to the file descriptor - *serv_fd*

Assign address to socket (like assigning phone number)

- Socket descriptor prototype from the call to *socket* needs to be assigned an address
- For Unix sockets this address is a *file of a special type* in a file system
- Different processes can access these “files” as file system *inodes*, so two processes can establish communication

Define server socket address

```
struct sockaddr_un server_addr;
```

Declare variable of type *sockaddr_un*

```
memset(&server_addr, '\0', sizeof (server_addr));
```

Clear all bytes to zero

```
server_addr.sun_family = AF_UNIX;
```

Setup address family

```
strcpy(server_addr.sun_path, "/tmp/something");
```

Set file name through which server can be contacted

```
unlink(server_addr.sun_path);
```

Delete file with this name if already exists

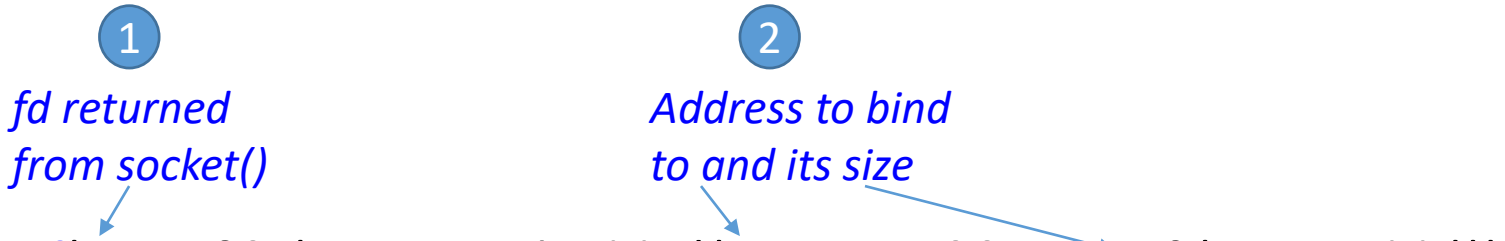
3 steps of socket server setup: BLA

1. Bind
2. Listen
3. Accept

1. Bind

- Bind socket to a connection resource - in this case the socket *inode* (a new kind of "special file") – to create an entry point

struct sockaddr_un **serv_addr**; //all set up – see above




```
if (bind(serv_fd, (struct sockaddr *)&serv_addr, sizeof (serv_addr)))
{
        perror("bind");
        return(1);
}
```

Returns zero on success

Some sort of “polymorphism”

- Because *bind* is designed to work with all kinds of sockets, and the size of the addresses may be different, the second argument of *bind*() is of a general type struct sockaddr*
- We need to cast our Unix socket address of type sockaddr_un to this general type
- Third parameter tells how much space to consider for reading an actual address from a given memory location (different types of address structs have different length)

struct sockaddr_un serv_addr; //all set up above

bind(**serv_fd**, (struct sockaddr *)&**serv_addr**, sizeof (serv_addr)) ;

2. Listen

- Listen — wait for incoming connections
- Also specifies the length of the queue for connections which have not yet been "accepted“
- It is not a limit on the number of people you can talk to - it's just how many can do a connect() before you accept() them

1 *fd returned from socket()*

Backlog for incoming connections 2

```
if (listen(serv_fd, 5)) {
    perror("listen");
    return(1);
}
```

3. Accept

- Accept processes client requests (usually in a loop)
- It returns a new socket file descriptor for talking to that particular client

```
struct sockaddr_un client _addr;
int len = sizeof (client_addr);
```

1 *fd returned from socket()*

2 *Address of a client and the length of this address*

```
if ((client_fd = accept(serv_fd, (struct sockaddr *)&client_addr,
                                                    &len)) < 0) {
    perror("accept");
    return(1);
}
```

Client address is recorded into variable *client_addr*

- When accept() returns, the *client_addr* variable will be filled with the remote side's struct *sockaddr_un*, and *len* will be set to its length
- The new file descriptor *client_fd* is created, and is ready for sending and receiving data for this particular client

```
struct sockaddr_un client _addr;
int len = sizeof (client_addr);

if ((client_fd = accept(serv_fd, (struct sockaddr *)&client_addr, &len)) < 0) {
        perror("accept");
        return(1);
}
```

Read data from a client: example

```
char buf[BUF_SIZE+1];
if ((len = read(client_fd, buf, BUF_SIZE))) < 0) {
      perror("read");
      return(1);
}

// The read is raw bytes.  This turns it into a C string.
buf[BUF_SIZE] = '\0';
printf("The other side said: %s\n", buf);
```

Write data to a client: example

```
//echo data back
if (write(client_fd, buf, strlen(buf)) != strlen(buf) ) {
      perror("write");
      return(1);
}
```

Close

- Closing the client_fd makes the other side see that the connection is closed

close(client_fd);

- Unix domain socket binding is reclaimed upon process exit, but the inode is not. You have to explicitly unlink (delete) it

close(server_fd);

unlink("/tmp/something");

- If you run the server, you can connect to it in a different terminal using a general client program netcat (nc):

```
nc -U /tmp/something
```

- You can see all open unix sockets using netstat:

```
netstat -lxp
```

- You can see that socket in Unix sockets is a ‘file’:

```
ls -l  /tmp/something
```

Unix domain socket client

code in *client.c*

Client program: socket setup

- Create a socket interface of type Unix domain socket:

Client has only one file descriptor used to connect to a remote process and if successfully connected – this will be the fd of the communication

```
if ((fd = socket(AF_UNIX, SOCK_STREAM, 0)) < 0) {
    perror("socket");
    return(1);
}
```

Connect to known address

- The **client** does **connect**(), the **server** does **accept**()
- Fill-in fields of server address – to which to connect:

```
struct sockaddr_un serv_addr;
memset(&serv_addr, '\0', sizeof (serv_addr));
serv_addr.sun_family = AF_UNIX;
strcpy (serv_addr.sun_path, "/tmp/something");
```

```
if (connect(fd, (struct sockaddr *)&serv_addr, sizeof (serv_addr)))
{
    perror("connect");
    return(1);
}
```

Descriptor created with *socket()*

Now client can write and read

```
if ((len = write(fd, "Hello", 5)) != 5) {
      perror("write");
      return(1);
}

if ((len = read(fd, buf, MAX_LINE)) < 0) {
      perror("write");
      return(1);
}
buf[MAX_LINE] = '\0';
```