Recitation 12: ProxyLab Part 1

Instructor: TA(s)
April 11, 2022

Outline

- Reminders
- Proxies
- Networking
- PxyDrive Demo

Reminder:

- Shell Lab due Thursday April 14th! (Final deadline is Sunday April 17th)
- Proxy Lab still comes out Tuesday April 12th
- Please sign up for code reviews for Shell Lab by Thursday April 14th

Proxy Lab

- Checkpoint is worth 2%, due Thursday April 21
- Final is worth 6%, due Thursday April 28
- Current situation w/ grace / late days:
  - 1 grace / late day allowed for both checkpoint and final

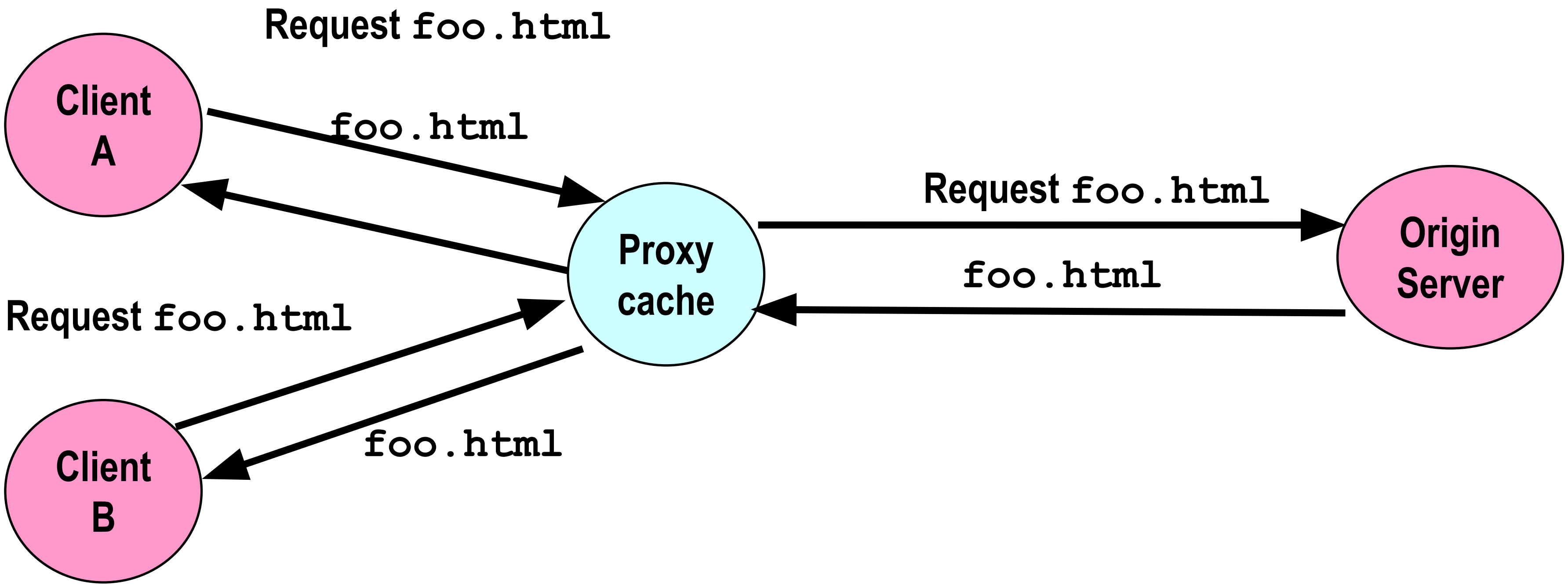
- You are submitting an entire project
  - Modify the makefile
  - Split source file into separate pieces

- Submit regularly to verify proxy builds on Autolab

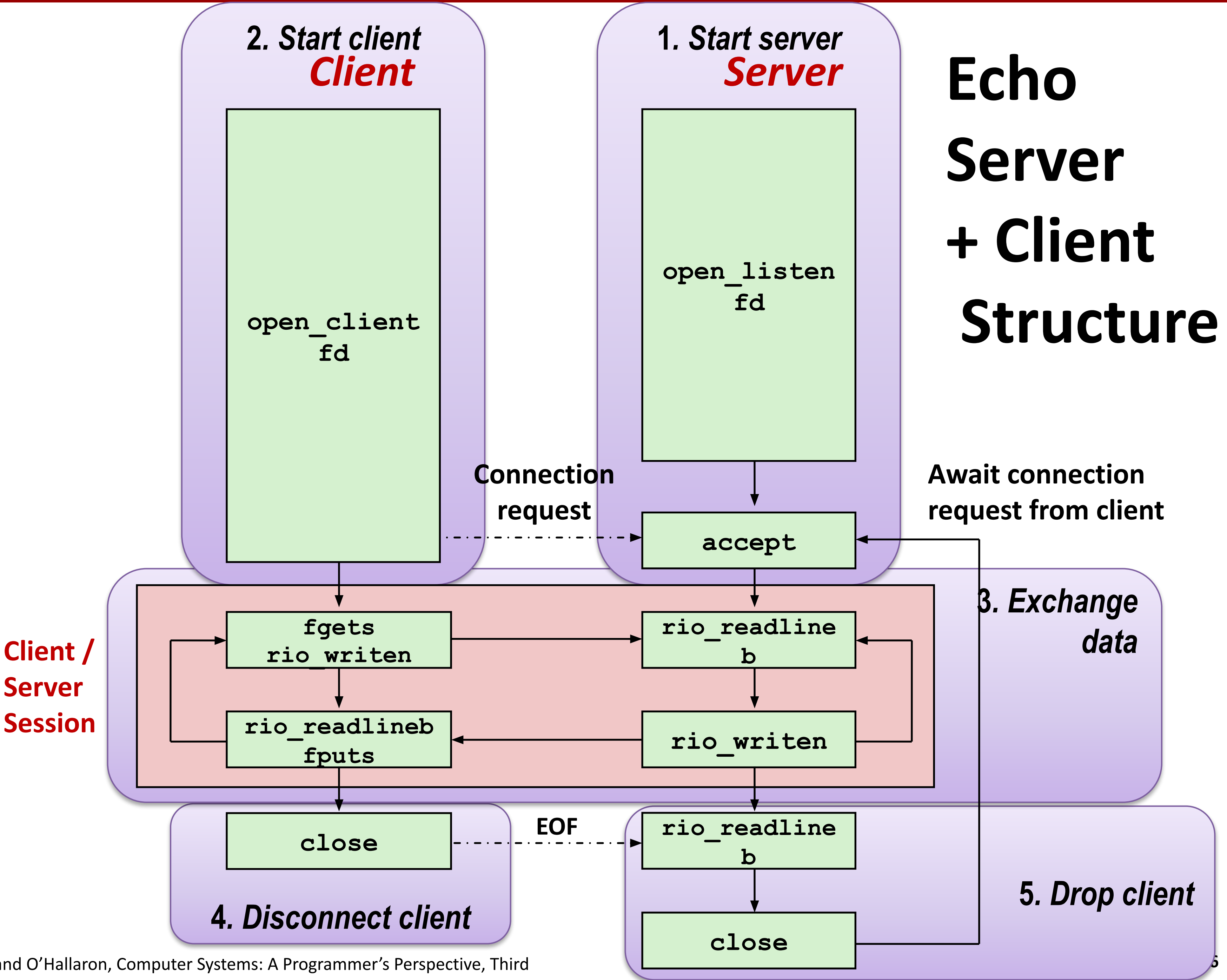
- Your proxy is a server, it should not crash!

Why Proxies?

- Proxies are both clients and servers
- Can perform useful functions as requests and responses pass by
  - Examples: Caching, logging, anonymization, filtering, transcoding



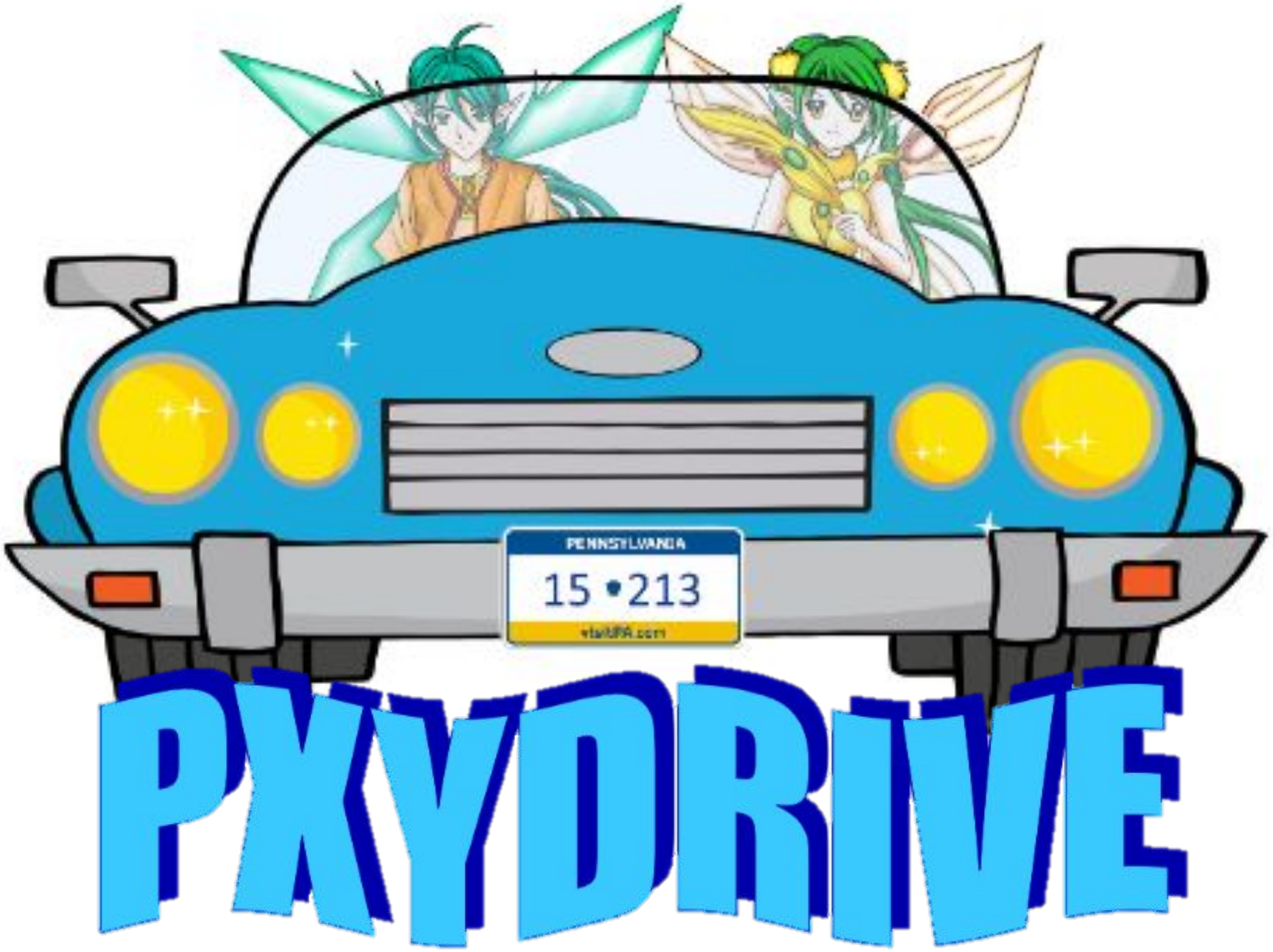
Echo Server + Client Structure

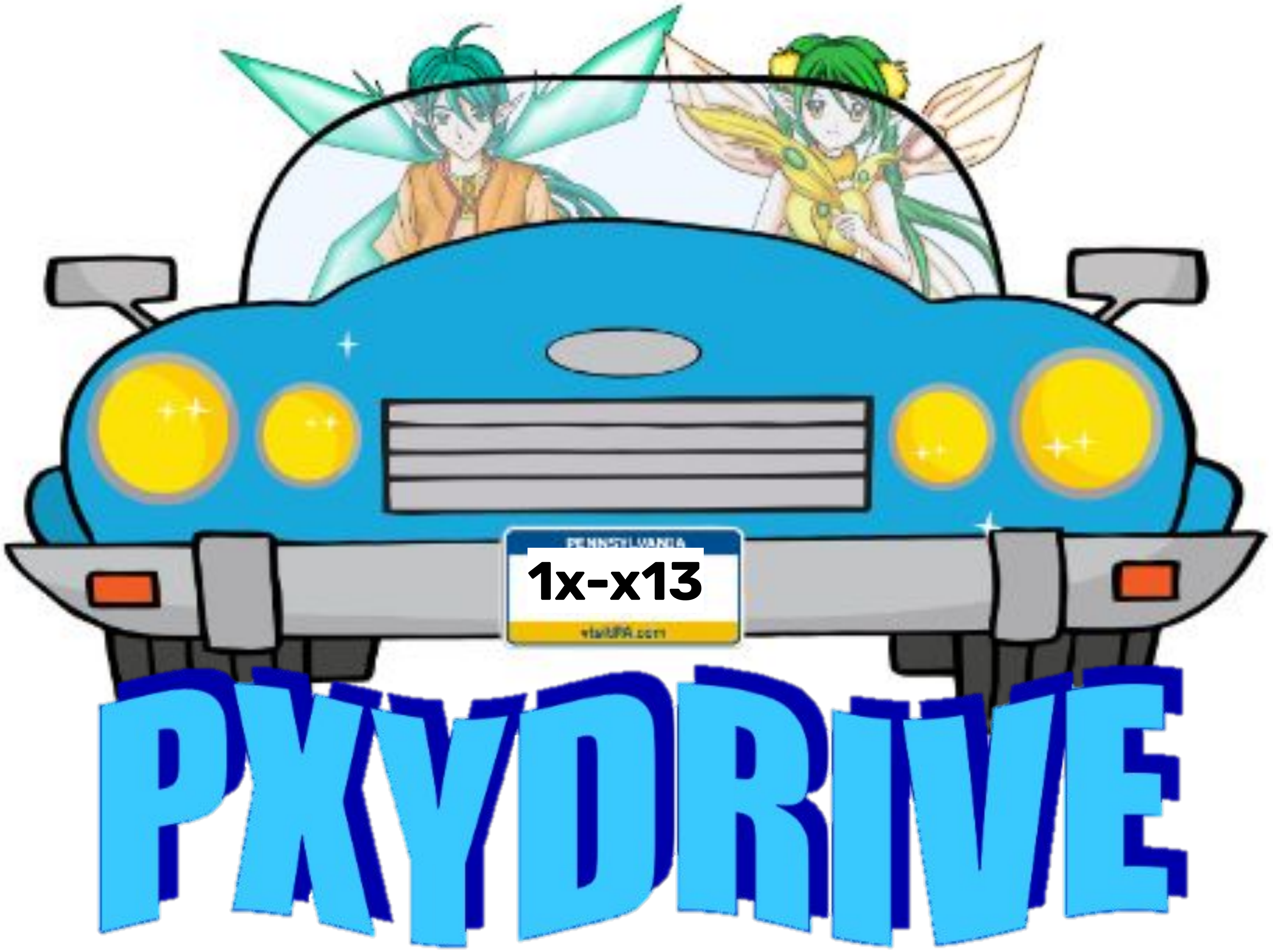


Transferring HTTP Data

If something requests a file from a web server, how does it know that the transfer is complete?

A) It reads a NULL byte.
B) The connection closes.
C) It reads a blank line.
D) The HTTP header specifies the number of bytes to receive.
E) The reading function receives EOF.


PENNSYLVANIA
15•213
visitPA.com
PXYDRIVE


PENNSYLVANIA
1x-x13
visitPA.com
PXYDRIVE

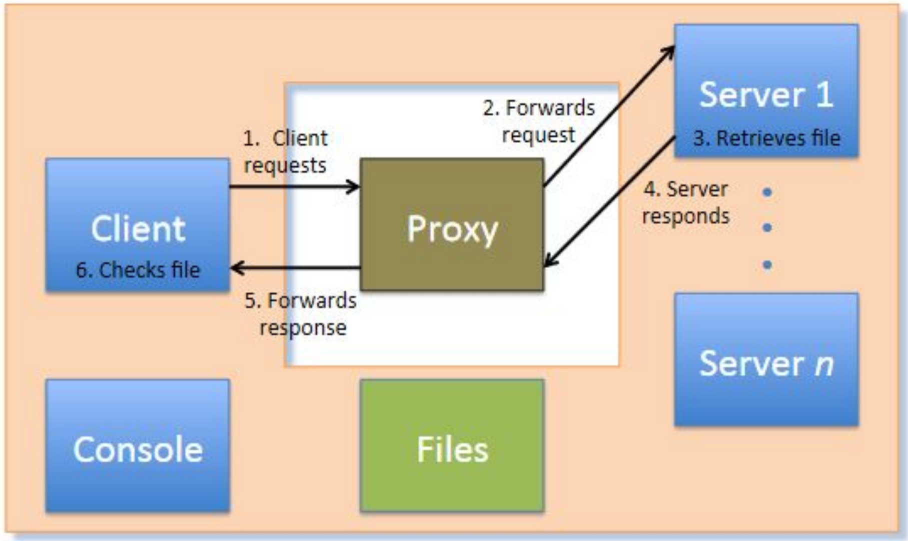
Introducing PxyDrive[1]

- **A REPL for testing your proxy implementation**
  - We also grade using this
- **Typical pre-f18 proxy debugging experience:**
  - Open up three terminals:
    for Tiny server, **gdb proxy** and curl
  - Can make multiple requests, but need more terminals for multiple instances of the Tiny server
  - If the data is corrupted, need to manually inspect lines of gibberish binary data to check error
- **Not anymore with PxyDrive!**

[1] Not typing PxyDrive in small-caps is a style violation.

Introducing PxyDrive

- **General workflow**
  - Generate text and binary data to test your proxy with
  - Create (multiple) server
  - Make **transactions**
  - Trace transactions to inspect headers and response data



- **Transaction**

Some practice

- Get the tarball

```
$ wget https://www.cs.cmu.edu/~213/activities/rec12.tar
$ tar -xvf rec12.tar
$ cd pxydrive-tutorial
```

Trying out PxyDrive

- **It's a REPL: the user can run commands**
- **`$ ./pxy/pxydrive.py`**
  - Just starts PxyDrive
  - Try entering commands:
    - **`>help`**
    - **`>help help help help help help...`**
    - **`>quit`**
- **`$ ./pxy/pxydrive.py -p ./proxy-ref`**
  - Starts PxyDrive and specifies a proxy to run
  - **`Proxy set up at <someshark>:30104`**
  - Picks the right port and starts the proxy
  - **`./proxy-ref`** is the reference proxy

PxyDrive Tutorial 1

- **Introducing basic procedures:**
  generate data, create server, fetch / request file from server, trace transaction

- Open **`s01-basic-fetch.cmd`**

PxyDrive Tutorial 1

- `>generate data1.txt 1K`
  - Generates a 1K text file called *data1.txt*
- `>serve s1`
  - Launches a server called *s1*
- `>fetch f1 data1.txt s1`
  - Fetches *data1.txt* from server *s1*, in a transaction called *f1*
- `>wait *`
  - Waits for all transactions to finish
  - Needed in the trace, not in the command-line
- `>trace f1`
  - Traces the transaction *f1*
- `>check f1`
  - Checks the transaction *f1*

PxyDrive Tutorial 1

- Run trace with –f option:
- `$ ./pxy/pxydrive.py -f s01-basic-fetch.cmd -p ./proxy-ref`

Look at the trace of the transaction!

- Identify:
  - GET command
  - Host header
  - Other headers
  - Request from client to proxy
  - Request from proxy to server
  - Response by server to proxy
  - Response by proxy to client

PxyDrive Tutorial 1

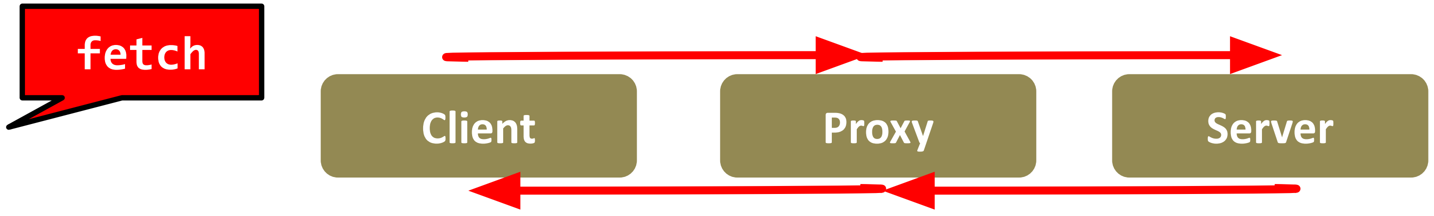
- Run a different trace
- `$ ./pxy/pxydrive.py -f s02-basic-request.cmd -p ./proxy-ref`
- You should get a different output from the first trace
- Why? Let’s look at this trace…

PxyDrive Tutorial 1

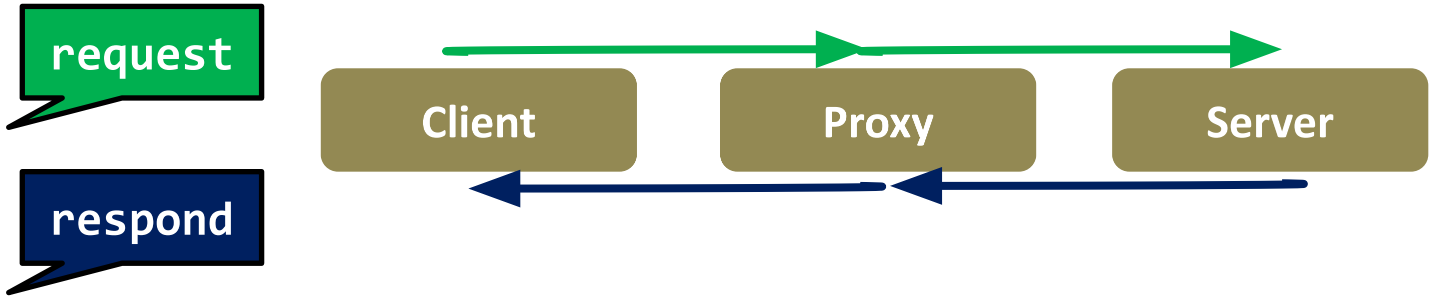
- `>generate data1.txt 1K`
- `>serve s1`
- `>request r1 data1.txt s1`
  - Requests *data1.txt* from server *s1*, in a transaction called *r1*
- `>wait *`
- `>trace r1`
- `>respond r1`
  - Allow server to respond to the transaction *r1*
- `>wait *`
- `>trace r1`
- `>check r1`
  - Checks the transaction *r1*

PxyDrive Tutorial 1

- The fetch command makes the server immediately respond to a request.
- All steps of a transaction are complete after a fetch.



- The request command does not complete a transaction.
- A request needs a respond to complete its transaction.

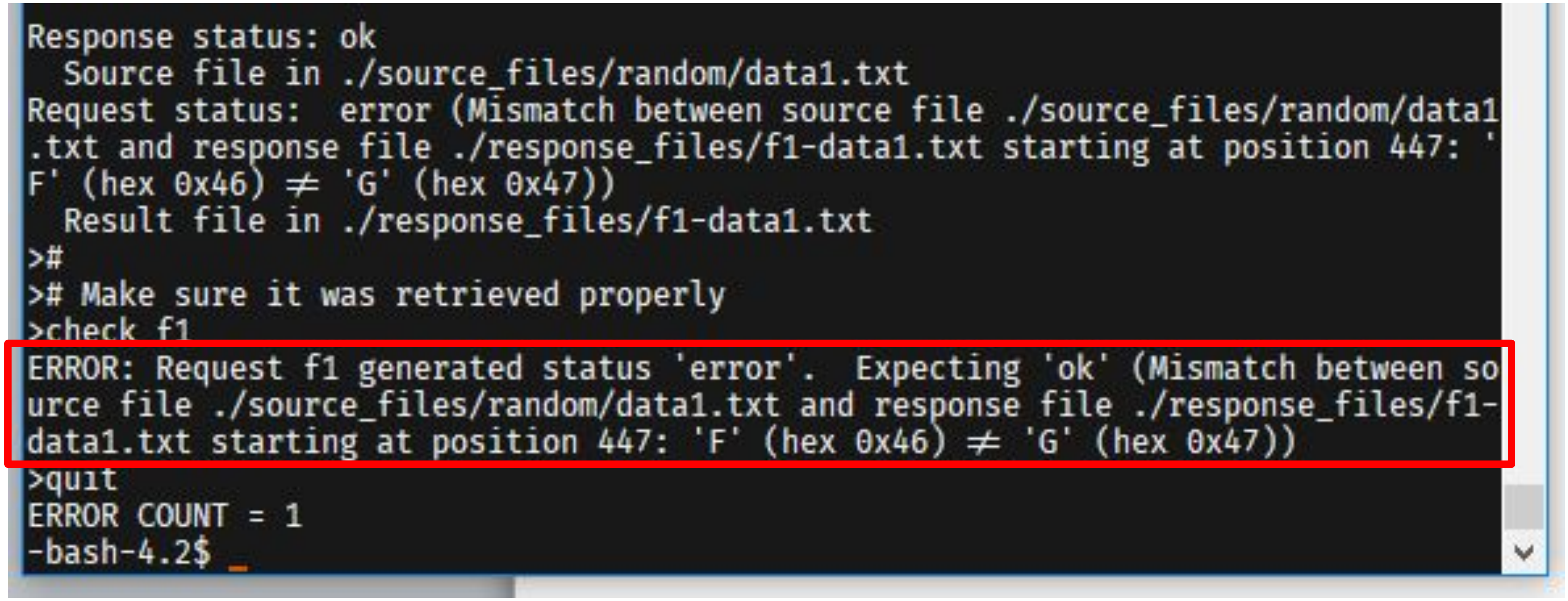


PxyDrive Tutorial 2

- Debugging a proxy that clobbers responses
- Run the same trace but with a faulty proxy

-
  ```
  $ ./pxy/pxydrive.py -f s01-basic-fetch.cmd
    -p ./proxy-corrupt
  ```

What went wrong?



```
Response status: ok
  Source file in ./source_files/random/data1.txt
Request status:  error (Mismatch between source file ./source_files/random/data1
.txt and response file ./response_files/f1-data1.txt starting at position 447: '
F' (hex 0x46) ≠ 'G' (hex 0x47))
  Result file in ./response_files/f1-data1.txt
>#
># Make sure it was retrieved properly
>check f1
ERROR: Request f1 generated status 'error'.  Expecting 'ok' (Mismatch between so
urce file ./source_files/random/data1.txt and response file ./response_files/f1-
data1.txt starting at position 447: 'F' (hex 0x46) ≠ 'G' (hex 0x47))
>quit
ERROR COUNT = 1
-bash-4.2$ _
```

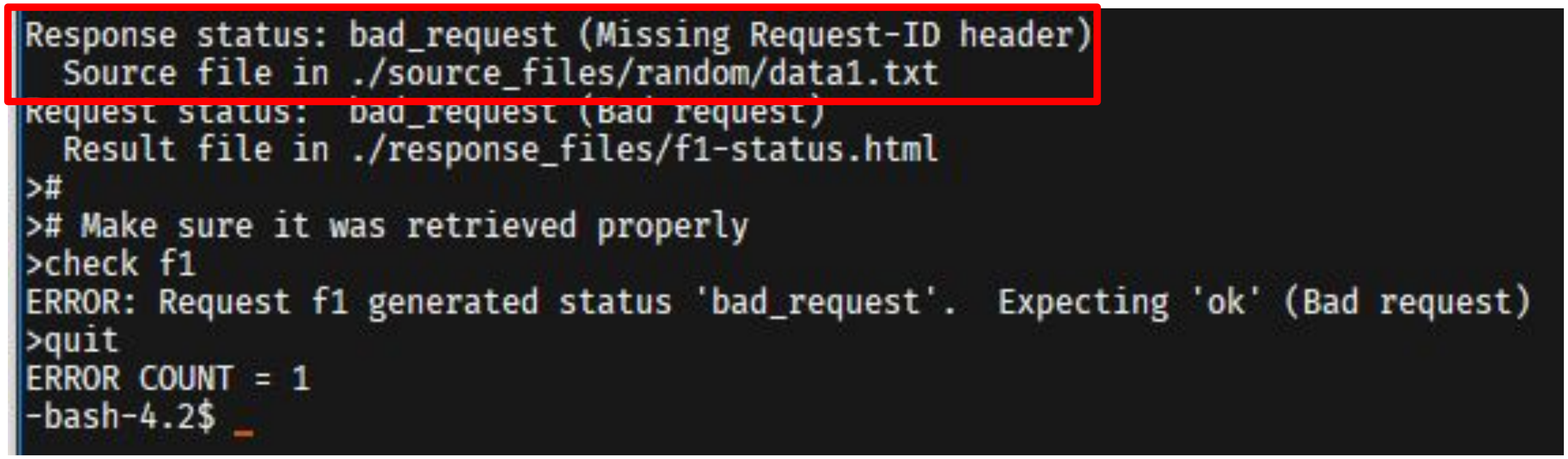
PxyDrive Tutorial 3

- Debugging a proxy that clobbers headers
- Run the same trace but with another faulty proxy

-
  ```
  $ ./pxy/pxydrive.py -f s01-basic-fetch.cmd
    -p ./proxy-strip -S 3
  ```

- -S specifies strictness level

What went wrong?



```
Response status: bad_request (Missing Request-ID header)
  Source file in ./source_files/random/data1.txt
Request status:  bad_request (Bad request)
  Result file in ./response_files/f1-status.html
>#
># Make sure it was retrieved properly
>check f1
ERROR: Request f1 generated status 'bad_request'.  Expecting 'ok' (Bad request)
>quit
ERROR COUNT = 1
-bash-4.2$ _
```

PxyDrive Tutorial 4

- Debugging a proxy that crashes
- Run the same trace but with yet another faulty proxy

-
  ```
  $ ./pxy/pxydrive.py -f s03-overrun.cmd
     -p ./proxy-overrun
  ```

- Is the error message helpful?

PxyDrive Tutorial 4

- We resort to multi-window debugging
- Set up another window and run GDB in one:

- `$ gdb ./proxy-overrun`
- `(gdb) run <port>`

`./port-for-user.pl`
Run this to get your unique port!

- In the other window, run PxyDrive:

-
  ```
  $ ./pxy/pxydrive.py -P localhost:<port>
    -f s03-overrun.cmd
  ```
  - -P specifies the host and port the proxy is running on

Reminders

- **Read the writeup**
- **One grace / late day for both checkpoint and final**
- **So you really have to start early**
  - Come to office hours this week, before it gets crowded!
- **Work incrementally and take breaks**
- **Simpler tests should be completed in the first week!**

So you wanna TA for 213?

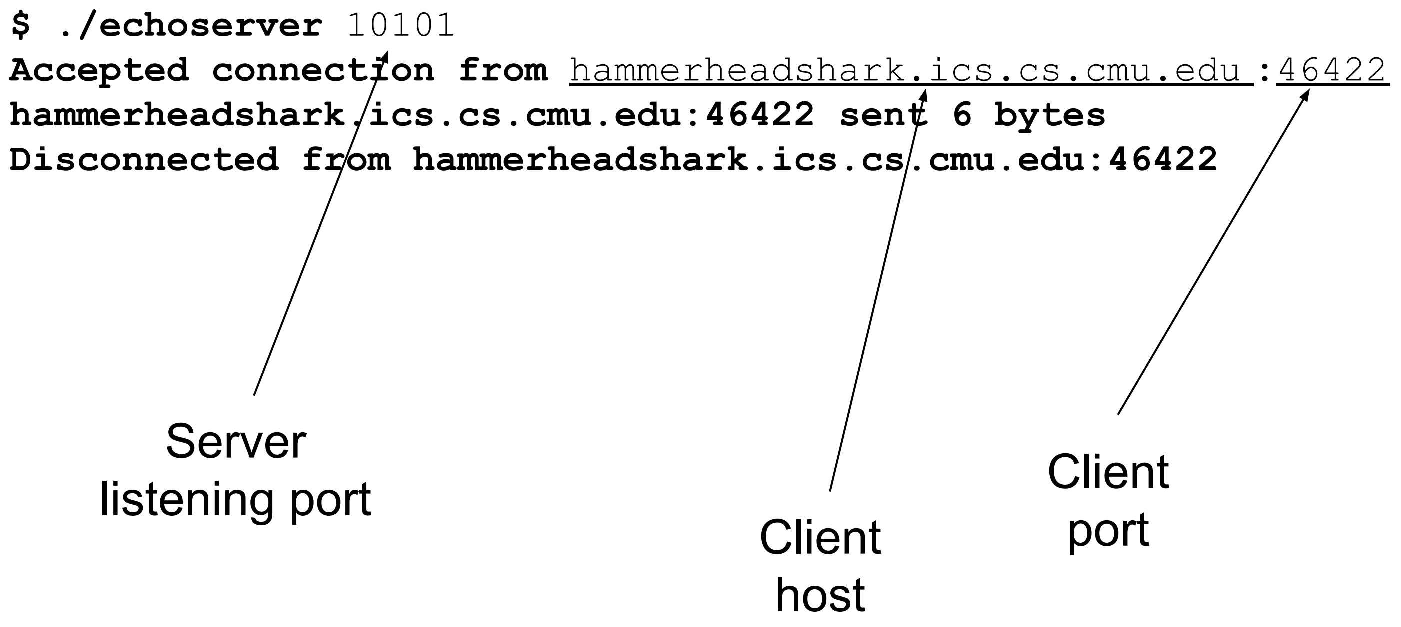
- What qualifications are we looking for?
  - Decent class performance, but also critical thinking skills
  - Like computer systems + want to help others like systems!
  - Have a reasonable ability to gauge your schedule + responsibilities
  - Leadership potential! Take initiative, we love to see it 😌
  - Ability to tell students:
    - “Did you write your heap checker”
    - “Run backtrace for me”
    - rinse and repeat, it’s mouthwash baby

Appendix on echoserver / client

Echo Demo

- See the instructions written in the telnet results to set up the echo server. Get someone nearby to connect using the echo client.

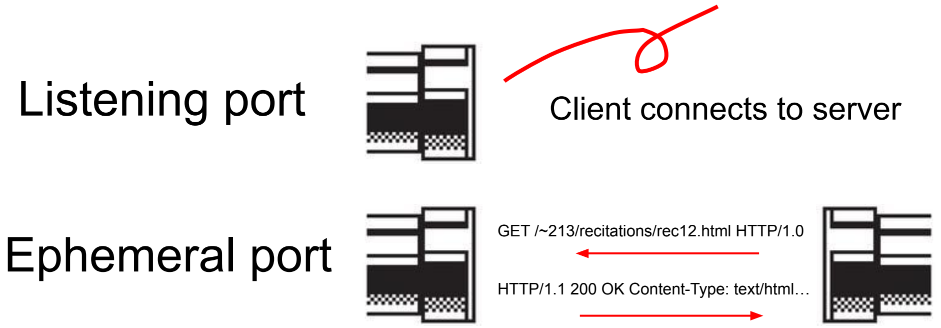
- What does echoserver output? (Sample output:)



```
$ ./echoserver 10101
Accepted connection from hammerheadshark.ics.cs.cmu.edu :46422
hammerheadshark.ics.cs.cmu.edu:46422 sent 6 bytes
Disconnected from hammerheadshark.ics.cs.cmu.edu:46422
```

Echo Demo

- **Look at echoclient.c**
  - Opens a connection to the server
  - Reads/writes from the server
- **Look at echoserver output**
  - Why is the printed client port different from the server's listening port?
  - Server opens **one "listening"** port
    - Incoming clients connect to this port
  - Once server **accepts** a connection, it talks to client on a **different "ephemeral"** port


Listening port
Client connects to server
Ephemeral port
GET /~213/recitations/rec12.html HTTP/1.0
HTTP/1.1 200 OK Content-Type: text/html…

Echo Demo

- **Try to connect two clients to the same server.**
- **What happens?**
  - Second client has to wait for first client to finish!
  - Server doesn't even accept second client's connection
  - Where/why are we getting stuck?
- **Because we're stuck in echo() talking to the first client, echoserver can't handle any more clients**
- **Solution: multi-threading**

Echo Server Multithreaded

- **How might we make this server multithreaded? (Don’t look at echoserver_t.c)**

```
while (1) {
    // Allocate space on the stack for client info
    client_info client_data;
    client_info *client = &client_data;

    // Initialize the length of the address
    client->addrlen = sizeof(client->addr);

    // Accept() will block until a client connects to the port
    client->connfd = Accept(listenfd,
            (SA *) &client->addr, &client->addrlen);

    // Connection is established; echo to client
    echo(client);
}
```

Echo Server Multithreaded

- **echoserver_t.c isn't too different from echoserver.c**
  - To see the changes: `diff echoserver.c echoserver_t.c`
- **Making your proxy multithreaded will be very similar**
- **However, don't underestimate the difficulty of addressing race conditions between threads!**
  - Definitely the hardest part of proxylab
  - More on this next time...