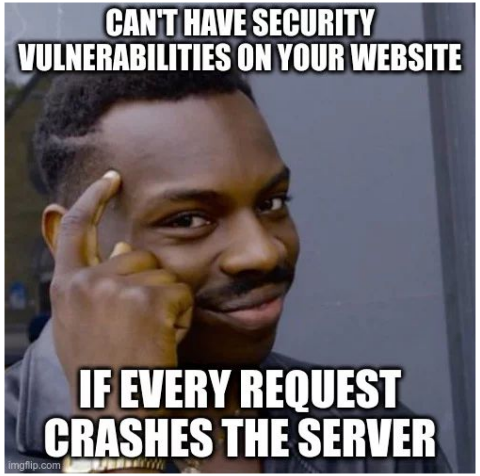
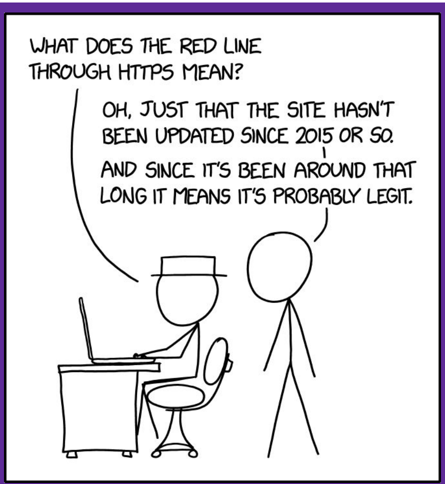
CSE 333 Section 9

HW4, HTTP, and Boost

I AM ALTERING THE WEB SERVER
PRAY I DON'T ALTER IT ANY FURTHER
quickmeme.com


CAN'T HAVE SECURITY VULNERABILITIES ON YOUR WEBSITE
IF EVERY REQUEST CRASHES THE SERVER
imgflip.com


WHAT DOES THE RED LINE THROUGH HTTPS MEAN?
OH, JUST THAT THE SITE HASN'T BEEN UPDATED SINCE 2015 OR SO.
AND SINCE IT'S BEEN AROUND THAT LONG IT MEANS IT'S PROBABLY LEGIT.

Logistics

- Exercise 12 due week of 12/4 @10PM (monday)
- Homework 4 due Wed 12/6 @10 PM (wednesday)

HTTP Review

HTTP Review

1. What does HTTP stand for?

Hyper**T**ext **T**ransfer **P**rotocol

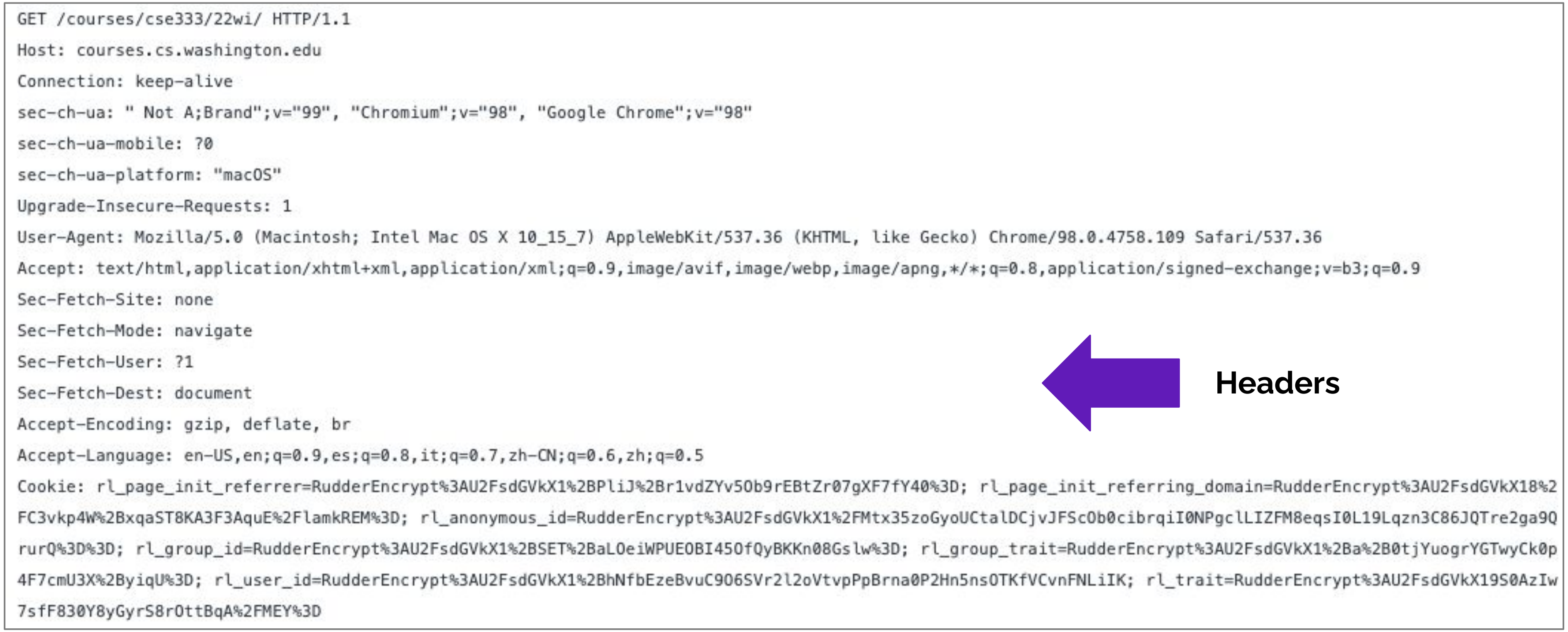
2. What layer does HTTP reside in?

Application Layer

3. What does HTTP define?

HTTP defines how we should send information between a client and a server

Method URI Version



```
GET /courses/cse333/22wi/ HTTP/1.1
Host: courses.cs.washington.edu
Connection: keep-alive
sec-ch-ua: " Not A;Brand";v="99", "Chromium";v="98", "Google Chrome";v="98"
sec-ch-ua-mobile: ?0
sec-ch-ua-platform: "macOS"
Upgrade-Insecure-Requests: 1
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/98.0.4758.109 Safari/537.36
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,image/apng,*/*;q=0.8,application/signed-exchange;v=b3;q=0.9
Sec-Fetch-Site: none
Sec-Fetch-Mode: navigate
Sec-Fetch-User: ?1
Sec-Fetch-Dest: document
Accept-Encoding: gzip, deflate, br
Accept-Language: en-US,en;q=0.9,es;q=0.8,it;q=0.7,zh-CN;q=0.6,zh;q=0.5
Cookie: rl_page_init_referrer=RudderEncrypt%3AU2FsdGVkX1%2BPliJ%2Br1vdZYv5Ob9rEBtZr07gXF7fY40%3D; rl_page_init_referring_domain=RudderEncrypt%3AU2FsdGVkX18%2
FC3vkp4W%2BxqaST8KA3F3AquE%2FlamkREM%3D; rl_anonymous_id=RudderEncrypt%3AU2FsdGVkX1%2FMtx35zoGyoUCtalDCjvJFScOb0cibrqiI0NPgclLIZFM8eqsI0L19Lqzn3C86JQTre2ga9Q
rurQ%3D%3D; rl_group_id=RudderEncrypt%3AU2FsdGVkX1%2BSET%2BaLOeiWPUEOBI45OfQyBKKn08Gslw%3D; rl_group_trait=RudderEncrypt%3AU2FsdGVkX1%2Ba%2B0tjYuogrYGTwyCk0p
4F7cmU3X%2ByiqU%3D; rl_user_id=RudderEncrypt%3AU2FsdGVkX1%2BhNfbEzeBvuC9O6SVr2l2oVtvpPpBrna0P2Hn5nsOTKfVCvnFNLiIK; rl_trait=RudderEncrypt%3AU2FsdGVkX19S0AzIw
7sfF830Y8yGyrS8rOttBqA%2FMEY%3D
```

Headers

HTTP Request Format

```
[METHOD] [request-uri] HTTP/[version]\r\n

[headerfield1]: [fieldvalue1]\r\n

[headerfield2]: [fieldvalue2]\r\n

[...]

[headerfieldN]: [fieldvalueN]\r\n

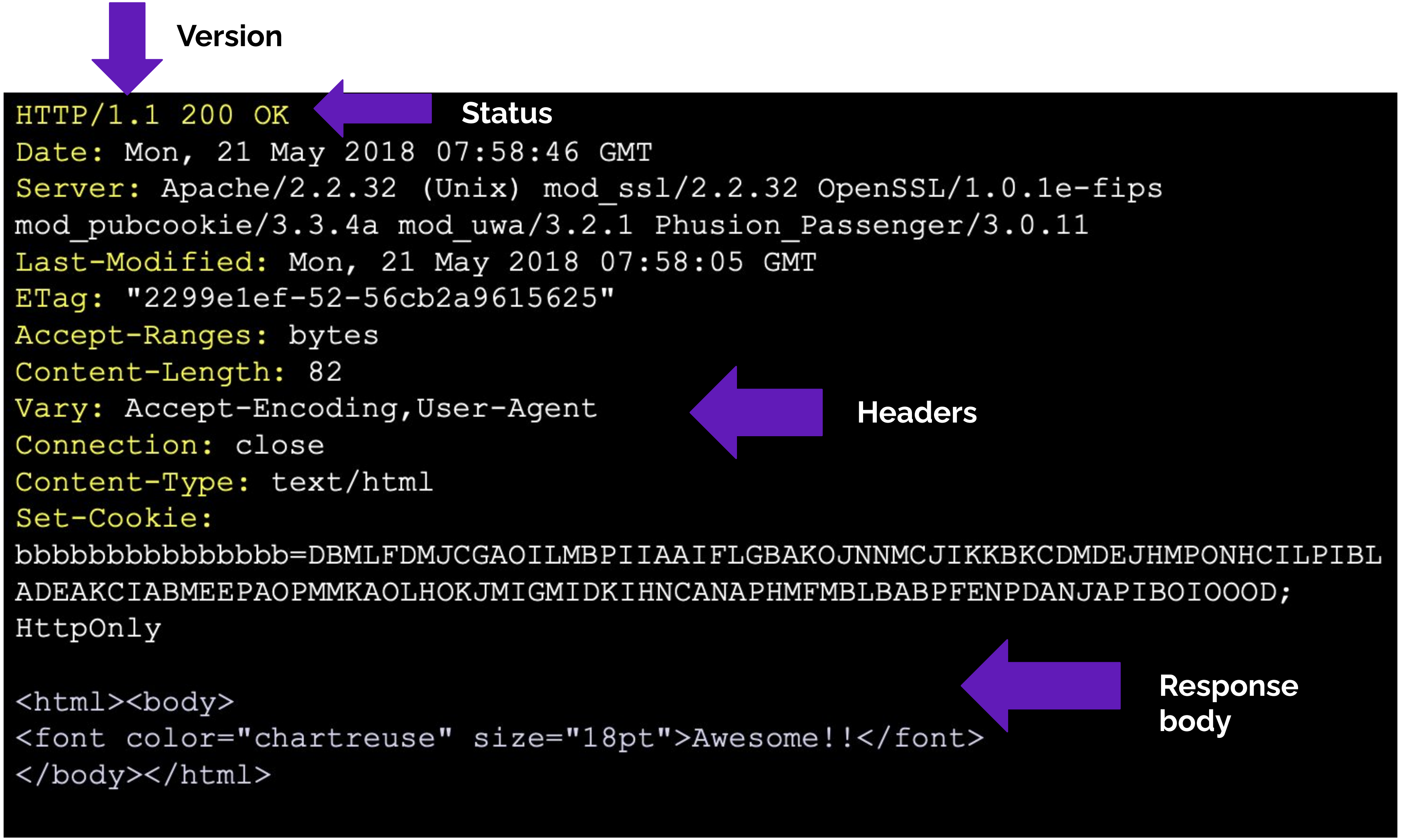
\r\n

[request body, if any]
```

Note: Double return indicates the end of the headers section

HTTP Methods

GET	The GET method requests a representation of the specified resource. Requests using GET should only retrieve data.
HEAD	The HEAD method asks for a response identical to that of a GET request, but without the response body.
POST	The POST method is used to submit an entity to the specified resource, often causing a change in state or side effects on the server.
PUT	The PUT method replaces all current representations of the target resource with the request payload.
DELETE	The DELETE method deletes the specified resource.
CONNECT	The CONNECT method establishes a tunnel to the server identified by the target resource.
OPTIONS	The OPTIONS method is used to describe the communication options for the target resource.
TRACE	The TRACE method performs a message loop-back test along the path to the target resource.
PATCH	The PATCH method is used to apply partial modifications to a resource.



```
HTTP/1.1 200 OK
Date: Mon, 21 May 2018 07:58:46 GMT
Server: Apache/2.2.32 (Unix) mod_ssl/2.2.32 OpenSSL/1.0.1e-fips
mod_pubcookie/3.3.4a mod_uwa/3.2.1 Phusion_Passenger/3.0.11
Last-Modified: Mon, 21 May 2018 07:58:05 GMT
ETag: "2299e1ef-52-56cb2a9615625"
Accept-Ranges: bytes
Content-Length: 82
Vary: Accept-Encoding,User-Agent
Connection: close
Content-Type: text/html
Set-Cookie:
bbbbbbbbbbbbbb=DBMLFDMJCGAOILMBPIIAAIFLGBAKOJNNMCJIKKBKCDMDEJHMPONHCILPIBL
ADEAKCIABMEEPAOPMMKAOLHOKJMIGMIDKIHNCANAPHMFMBLBABPFENPDANJAPIBOIOOOD;
HttpOnly

<html><body>
<font color="chartreuse" size="18pt">Awesome!!</font>
</body></html>
```

HTTP Response Format

```
HTTP/[version] [status code] [reason]\r\n
[headerfield1]: [fieldvalue1]\r\n
[headerfield2]: [fieldvalue2]\r\n
[...]
[headerfieldN]: [fieldvalueN]\r\n
\r\n
[response body, if any]
```

Note: Double return indicates the end of the headers section

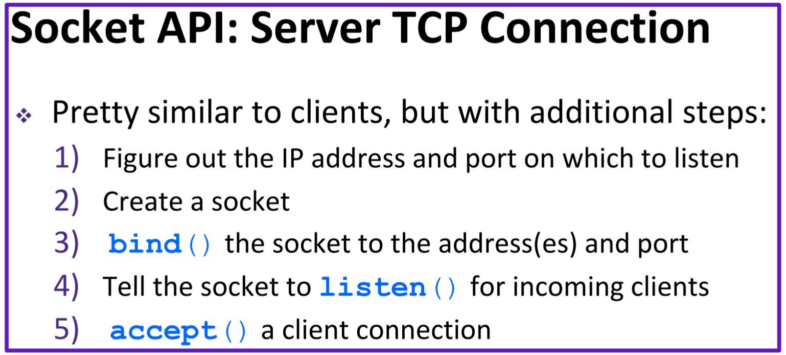
HTTP Response Status Codes

- `HTTP/1.1 200 OK`
  - The request succeeded and the requested object is sent
  - HW4 Ex: User requests a file that is successfully found by the server
- `HTTP/1.1 404 Not Found`
  - The requested object was not found
  - HW4 Ex: User requests a file that has been deleted so server can’t find it
- `HTTP/1.1 301 Moved Permanently`
  - The object exists, but its name has changed
  - The new URL is given as the “`Location:`” header value
  - Ex: washington.edu is redirected permanently to uowash.edu
- `HTTP/1.1 500 Server Error`
  - The server had some kind of unexpected error
  - Ex: Corrupted browser cache

HW4 Overview

HW4: Web Server

1. **Establish client connections**
    a. Server socket set up in `hw4/ServerSocket.cc`



Socket API: Server TCP Connection

- Pretty similar to clients, but with additional steps:
    1) Figure out the IP address and port on which to listen
    2) Create a socket
    3) `bind()` the socket to the address(es) and port
    4) Tell the socket to `listen()` for incoming clients
    5) `accept()` a client connection

Helpful to refer to:

- Server-side networking lecture
- `server_accept_rw_close.cc`
- Exercise 11

HW4: Web Server

1. Establish client connections
   a. Server socket set up
      in `hw4/ServerSocket.cc`
2. **Read client requests**
   a. Parse incoming HTTP requests
      in `hw4/HttpConnection.cc`

```
[METHOD] [request-uri] HTTP/[version]\r\n
[headerfield1]: [fieldvalue1]\r\n
[headerfield2]: [fieldvalue2]\r\n
[...]
[headerfieldN]: [fieldvalueN]\r\n
\r\n
[request body, if any]
```

Notes:

- Request may be split across multiple `read()`’s
- Parse by splitting strings – can have any number of headers
- Working just with GET (*i.e.*, no body)

HW4: Web Server

1. Establish client connections
   a. Server socket set up
      in hw4/`ServerSocket.cc`
2. Read client requests
   a. Parse HTTP requests
      in hw4/`HttpConnection.cc`
3. **Respond to requests**
   a. Write HTTP responses
      in hw4/`HttpServer.cc`

```
HTTP/[version] [status code] [reason]\r\n
[headerfield1]: [fieldvalue1]\r\n
[headerfield2]: [fieldvalue2]\r\n
[...]
[headerfieldN]: [fieldvalueN]\r\n
\r\n
[response body, if any]
```

Notes:

- Built up via string manipulation
- Must handle a variety of situations based on request
- Interact with index and static files

HW4: Web Server

1. Establish client connections
   a. Server socket set up
      in hw4/`ServerSocket.cc`
2. Read client requests
   a. Parse HTTP requests
      in hw4/`HttpConnection.cc`
3. Respond to requests
   a. Write HTTP responses
      in hw4/`HttpServer.cc`
4. **Fix security vulnerabilities**
   a. Escape characters in hw4/`Utils.cc`

Cross-site scripting flaw:
Clients can supply code for execution!

```
hello <script>alert("Boo!");</script>
```

Directory traversal attack:
Clients can gain unauthorized access to files!

```
/static/../hw4/http333d.cc
```

HW4: Web Server

1. Establish client connections
    a. Server socket set up
       in hw4/`ServerSocket.cc`
2. Read client requests
    a. Parse HTTP requests
       in hw4/`HttpConnection.cc`
3. Respond to requests
    a. Write HTTP responses
       in hw4/`HttpServer.cc`
4. Fix security vulnerabilities
    a. Escape characters in hw4/`Utils.cc`

Steps 2, 3, and 4 involve a lot of string manipulation which can be tedious!

HW4 Tools Demo (Telnet and Browser)

(Helpful for debugging!!!)

Executables

- Running make in hw4/ will produce **`test_suite`** and **`http333d`**
    - `test_suite` is always a good place to start to start debugging using the usual tools (program output and GDB)
    - You can test with `http333d` (even if it's not complete) by sending it requests via **telnet** or a **web browser**
- You also have access to `solution_binaries/http333d` and `solution_binaries/http333d_withflaws`
    - Do NOT leave the version with flaws running on an attu machine!
- Launching the server:
    - `./http333d <port> ../projdocs/ unit_test_indices/*`
    - Or replace `./http333d` with `./solution_binaries/http333d`

Writing an HTTP Request

- Generic HTTP request layout can be easily found in `HttpRequest.h`
- HW4 request types:
  - Example file request:
    - `GET /static/test_tree/books/artofwar.txt HTTP/1.1`
  - Example query request:
    - `GET /query?terms=books+of+war HTTP/1.1`
- Headers:
  - For HW4, can get away with no headers
  - Can see others in browser-generated requests or looking at the HTTP lecture slides

Sending a Request (and Viewing Response)

Telnet:

1. `telnet <HostName> <port>`
2. Manually type out HTTP request.
3. Finish request by hitting [Enter] *twice*.
4. Exit using `Ctrl+]` then `Ctrl+d` or entering in `quit`

`*Telnet is no longer on attu, can download on local computer`

Browser:

1. `http://<HostName>:<port>`
2. Append URIs from last slide to URL to send different types of request.
3. Open the Network tab in Developer Tools to see request and response.
   a. `<F12>` or `Ctrl+Shift+I` (Chrome, Firefox)
   b. Warning: the UX here can be a little confusing
4. Close browser tab when done.

Debugging Your Server’s Responses

- Generic HTTP response layout can be easily found in `HttpResponse.h`
    - Responses will have a body!
- Copy what `solution_binaries/http333d` does
    - Can simply copy the HTML if you’re not familiar
- `Content-Type` is really important!
    - Tells client how to handle/interpret the response body
    - Your server should work with a variety of file types
      (in particular, see `projdocs/bikeapalooza_2011/`)

Using Telnet with HW4

1. Launch the server

```
./http333d <port> ../projdocs/ unit_test_indices/*
```

2. Connect with telnet

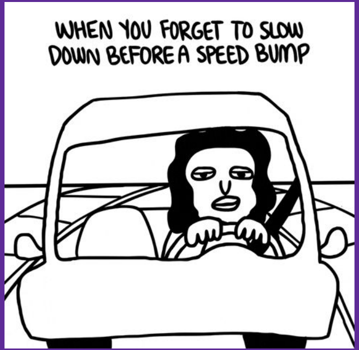
```
telnet <HostName> <port>
```

3. Write an HTTP request and send it

4. To exit telnet:
    - **`Ctrl+]`** then **`Ctrl+d`**

Debugging for HW4

- Telnet
  - Form requests to your server
  - Look at the HTTP Responses
- Browser Developer Tools (see lecture for a [brief] demo)
  - Can compare (between provided solution and your implementation):
    - The HTML
    - HTTP Requests Sent
    - HTTP Replies
- Other strategies you have been using all quarter :)
  - Examining intermediate values (parsing/building replies)



Boooooooooooost

Boost

Boost is a free C++ library that provides support for various tasks in C++

- **Note:** Boost does NOT follow the Google style guide!!!

Boost adds many string algorithms that you may have seen in Java

- Include with `#include <boost/algorithm/string.hpp>`

We are showcasing a few we think could be useful for HW4, but more can be found here:

- https://www.boost.org/doc/libs/1_60_0/doc/html/string_algo.html

trim

```
void boost::trim(string& input);
```

- Removes all leading and trailing whitespace from the string
- `input` is an input *and* output parameter (non-const reference)

```
string s("    HI    ");
boost::algorithm::trim(s);

// results in s == "HI"
```

replace_all

```
void boost::replace_all(string& input, const string& search,
                                                  const string& format);
```

- Replaces all instances of `search` inside `input` with `format`

```
string s("ynrnrt");
boost::algorithm::replace_all(s, "nr", "e");
// results in s == "yeet"
```

replace_all

```
void boost::replace_all(string& input, const string& search,
                                   const string& format);
```

- Replaces all instances of `search` inside `input` with `format`

```
string s("queue?");
boost::algorithm::replace_all(s, "que", "q");
// results in s == "que?"
```

`replace_all()` guarantees that ‘`format`’ will be in the final result if-and-only-if ‘`search`’ existed.

`replace_all()` makes a *single* pass over `input`.

split

```
void boost::split(vector<string>& output,
                  const string& input,
                  boost::PredicateT match_on,
                  boost::token_compress_mode_type compress);
```

- Split the string by the characters in `match_on`
- `Note: leading and trailing delimiter is` **`ignored`** `(treated as “”)`

```
boost::PredicateT boost::is_any_of(const string& tokens);
```

- Returns predicate that matches on any of the characters in tokens

split Examples

```
vector<string> tokens;

string s("I-am--split");

boost::split(tokens, s, boost::is_any_of("-"),
                        boost::token_compress_on);
// results in tokens == ["I", "am", "split"]

boost::split(tokens, s, boost::is_any_of("-"),
                        boost::token_compress_off);
// results in tokens == ["I", "am", "", “split"]
```

Exercise 1

Write a function called `ExtractRequestLine` that takes in a well-formatted HTTP request as a `string` and returns a map with the keys as `method`, `uri`, `version` and the values from the corresponding request.

Example Input:

```
"GET /index.html HTTP/1.1\r\nHost: www.mywebsite.com\r\nConnection:
keep-alive\r\nUpgrade-Insecure-Requests: 1\r\n\r\n"
```

Map Returned:

```
{
    "method"  : "GET"
    "uri"     : "/index.html"
    "version" : "HTTP/1.1"
}
```

Exercise 1

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```

Map Returned:

```
{
    "method"  : "GET"
    "uri"    : "/index.html"
    "version" : "HTTP/1.1"
}
```

Exercise 1

```
map<string,string> ExtractRequestLine(const string& request) {
  vector<string> lines;
  boost::split(lines, request, boost::is_any_of("\r\n"),
               boost::token_compress_on);
  vector<string> components;
  string firstLine = lines[0];
  boost::split(components, firstLine, boost::is_any_of(" "),
               boost::token_compress_on);
  map<string, string> res;
  res["method"] = components[0];
  res["uri"] = components[1];
  res["version"] = components[2];
  return res;
}
```

Exercise 2

Write a function `RemoveDuplicates` that takes in a `string` that contains words separated by whitespace and returns a `vector` that contains all of the words in that `string`, in the same order as they show up, but with no duplicates. Ignore all leading and trailing whitespace in the input `string`.

Example:

```
RemoveDuplicates(" Hi I'm sorry  jon sorry hi\nhihi  hi hi  ")
```

should return `vector`:

```
["Hi", "I'm", "sorry", "jon", "hi", "hihi"]
```

Exercise 2

Write a function `RemoveDuplicates` that takes in a `string` that contains words separated by whitespace and returns a `vector` that contains all of the words in that `string`, in the same order as they show up, but with no duplicates. Ignore all leading and trailing whitespace in the input `string`.

Example:

```
RemoveDuplicates(" Hi I'm sorry  jon sorry hi hihi  hi hi   ")
```

should return `vector`:

```
["Hi", "I'm", "sorry", "jon", "hi", "hihi"]
```

```
vector<string> RemoveDuplicates(const string& input){
     string copy(input);
     boost::algorithm::trim(copy);
     std::vector<string> components;
     boost::split(components, copy, boost::is_any_of(" \t\n"),
                  boost::token_compress_on);

     std::vector<string> result;
     std::set<string> unique_components;
     for (const auto& comp : components) {
       if (unique_components.find(comp) == unique_components.end()) {
          result.push_back(comp);
          unique_components.insert(comp);

        }

     }

     return result;
}
```