CSE 333
Lecture 19 -- HTTP

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HW4 due a week from Thursday
- How’s it look?

Today: http; finish networking/web

Rest of the quarter: concurrency, threads, and processes
- including a pthreads tutorial/demo in section next week
- Probably only one more exercise: pthreads, out next Thur. due following Mon.
Let’s dive down into HTTP

I’d like “foo.html”

Found it, here it is: (foo.html)

A client establishes one or more TCP connections to a server

- the client sends a request for a web object over a connection, and the server replies with the object’s contents

- we have to figure out how let the client and server communicate their intentions to each other clearly

- we have to define a protocol
HTTP is a “protocol”

**Protocol:** the rules governing the exchange of messages, and the format of those messages, in a computing system

- what messages can a client exchange with a server?
  - what do the messages mean?
  - what are legal replies to a message?
  - what is the syntax of a message?
- what sequence of messages is legal?
  - how are errors conveyed?

A protocol is (roughly) the network equivalent of an API
HTTP

Hypertext transport protocol

- a request / response protocol
  - a client (web browser) sends a request to a web server
  - the server processes the request, sends a response
- typically, a request asks the server to retrieve a resource
  - a resource is an object or document, named by a URI
- a response indicates whether the server succeeded
  - and, if so, it provides the content of the requested response
An HTTP request

```
[METHOD] [request-uri] HTTP/[[version]\r\n
[fieldname1]: [fieldvalue1]\r\n
[fieldname2]: [fieldvalue2]\r\n
[...]

[fieldnameN]: [fieldvalueN]\r\n\r\n
[request body, if any]
```

let's use “nc” to see a real request
HTTP methods

There are three commonly used HTTP methods:

- **GET**: “please send me the named document”
- **POST**: “I’d like to submit data to you, such as a file upload”
- **HEAD**: “send me the headers for the named object, but not the object. (I’d like to see if my cached copy is still valid.)”

There are several rarely used methods:

- **PUT**, **DELETE**, **TRACE**, **OPTIONS**, **CONNECT**, **PATCH**, ...
  - **TRACE**: “if there are any proxies or caches in between me and the server, please speak up!”
HTTP versions

All current browsers and servers speak HTTP/1.1

- "version 1.1 of the HTTP protocol"
  - http://www.w3.org/Protocols/rfc2616/rfc2616.html

- introduced around 1996 to fix shortcomings of HTTP/1.0
  - better performance, richer caching features, better support for multi-homed servers, and much more
  - more complicated to implement than HTTP/1.0

HTTP/2 standardized recently — allows higher performance but doesn’t change basic web request/response model

- And will coexist with HTTP/1.1 for a long time
Client headers

The client can provide zero or more request “headers”

- they provide information to the server, or modify how the server should process the request

You’ll encounter many in practice

- Host: the DNS name of the server  [why?]
- User-Agent: an identifying string naming the browser  [why?]
- Accept: the content types the client prefers or can accept
- Cookie: an HTTP cookie previously set by the server
Example...

GET /foo/bar.html HTTP/1.1
Host: futureproof.cs.washington.edu:5555
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_8_2)
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-us
Accept-Encoding: gzip, deflate
Cookie: __utma=59807807.1547453334.1214335349.1301330421.1301339949.30; __utmb=59807807.1300728257.27.14.utmcsr=google|utmccn=(organic)|utmcmd=organic|utmctr=csgordon@u.washington.edu; __utma=80390417.1521666631.1201286098.1302710464.1302717901.34; __utmb=80390417.1301950604.31.15.utmcsr=cs.washington.edu|utmcmd=referral|utmctr=education/courses/cse333/11sp/; __qca=P0-1872143622-1294952393928
Connection: keep-alive
An HTTP response

HTTP/\[version\] \[status code\] \[reason\]\r\n[\[fieldname1\]]: [\[fieldvalue1\]]\r\n[\[fieldname2\]]: [\[fieldvalue2\]]\r\n[...]
[\[fieldnameN\]]: [\[fieldvalueN\]]\r\n\r\n[response body, if any]

*let’s use “telnet” to see a real response*
Status codes, reason phrase

Code: a computer-readable outcome of the request

- three digit integer; first digit identifies the response category
  ‣ 1xx: some kind of informational message
  ‣ 2xx: success of some kind
  ‣ 3xx: redirects the client to a different URL
  ‣ 4xx: the client’s request contained some error
  ‣ 5xx: the server experienced an error

Reason phrase: human-readable explanation

- e.g., “OK” or “Moved Temporarily”
Common status lines

HTTP/1.1 200 OK
- the request succeeded, the requested object is sent

HTTP/1.1 404 Not Found
- the requested object was not found

HTTP/1.1 301 Moved Permanently
- the object exists, but its name has changed
- the new URL is given in the “Location:” header

HTTP/1.1 500 Server Error
- the server had some kind of unexpected error
Server headers

The server can provide zero or more response “headers”

- they provide information to the client, or modify how the client should process the response

You’ll encounter many in practice

- **Server**: a string identifying the server software [why?]
- **Content-Type**: the type of the requested object
- **Content-Length**: size of requested object [why?]
- **Last-Modified**: a date indicating the last time the request object was modified [why?]
Example

HTTP/1.1 200 OK
Date: Fri, 27 May 2011 17:05:53 GMT
Server: Apache/2.2.19 (Fedora)
Last-Modified: Fri, 27 May 2011 17:04:51 GMT
ETag: "2740640-52-4a444ef9392c0"
Accept-Ranges: bytes
Content-Length: 82
Content-Type: text/html
Content-Language: en

<html><body>
<font color="chartreuse" size="18pt">Awesome!!</font>
</body></html>
Cool HTTP/1.1 features

“Chunked Transfer-Encoding”

- a server might not know how big a response object is
  
  ▶ e.g., you’re dynamically generating the content in response to a query or other user input

- how do you send Content-Length?
  
  ▶ could wait until you’ve finished generating the response, but that’s not great in terms of latency
  
  ▶ instead, want to start sending response right away

- chunked message body: response is series of chunks
  
  ▶ try with http://www.cs.washington.edu/
Cool HTTP/1.1 features

Persistent connections

- establishing a TCP connection is costly
  - multiple network “round trips” just to set up the TCP connection
  - TCP has a feature called “slow start”; slowly grows the rate at which a TCP connection transmits to avoid overwhelming networks

- a web page consists of multiple objects, and a client probably visits several pages on the same server
  - bad idea: separate TCP connection for each object
  - better idea: single TCP connection, multiple requests
  - try it on www.cs.washington.edu
20 years later…

Web pages were a few hundred KB with a few dozen objects on each page, now several MB each with hundreds of objects (JS, graphics, …) & multiple domains per page

Much larger ecosystem of devices (phones especially)

Web performance hacks to make HTTP/1.1 tolerable…

- Multiple TCP sockets from browser to server
- Caching tricks; JS/CSS ordering and loading tricks; cookie hacks
- Compression/image optimizations; splitting/sharding requests
- etc., etc. …
Enter HTTP/2

Based on Google SPDY; standardized in 2015

- Binary protocol - easier parsing by machines (harder for humans); sizes in headers, not discovered as requests are processed, …
  
  ▸ But same core request/response model (GET, POST, OK, …)

- Multiple data streams multiplexed on single TCP connections

- Header compression, server push, object priorities, more…

All existing implementations incorporate TLS encryption (https)

Supported by all major browsers and servers since ~2015

Widely used now by all major web sites; coexists with HTTP/1.1

- HTTP/2 used automatically when browser and server both support it
See you on Wednesday!

THE INTERKINGDOM

I SUMMONED HIM REPEATEDLY TO DELIVER A MESSAGE, BUT HE NEVER CAME!

BLAST! ANOTHER CODE 404--PAGE NOT FOUND.