

Hypertext Transport Protocol

CSE 333 Fall 2022

Instructor: Hal Perkins

Teaching Assistants:

Nour Ayad

Frank Chen

Nick Durand

Dylan Hartono

Humza Lala

Kenzie Mihardja

Benedict Soesanto

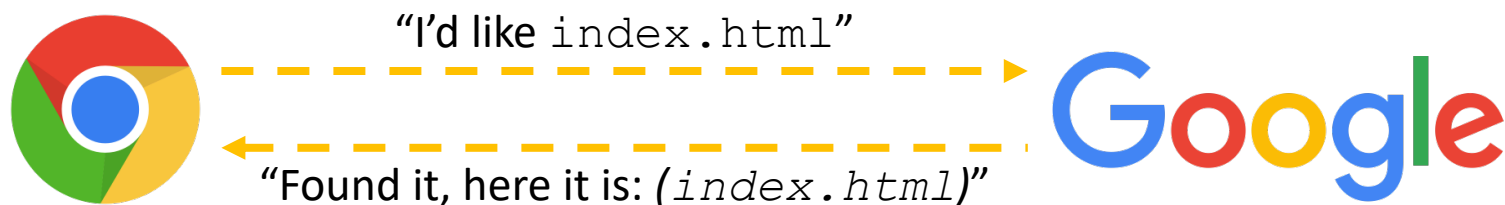
Chanh Truong

Justin Tysdal

Tanay Vakharia

Timmy Yang

HTTP Basics



- ❖ 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 to let the client and server communicate their intentions to each other clearly
 - We have to define a *protocol*

Protocols

- ❖ A **protocol** is a set of rules governing the format and exchange of messages in a computing system
 - What messages can a client exchange with a server?
 - What is the syntax of a message?
 - What do the messages mean?
 - What are legal replies to a message?
 - What sequence of messages are 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 and sends a response
- Typically, a **request** asks a server to retrieve a resource
 - A *resource* is an object or document, named by a Uniform Resource Identifier (**URI**)
- A **response** indicates whether or not the server succeeded
 - If so, it provides the content of the requested response
- Wikipedia:
https://en.wikipedia.org/wiki/Hypertext_Transfer_Protocol

HTTP Requests

❖ General form:

- `[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]`

❖ Demo: use nc to see a real request

HTTP Methods

- ❖ There are three commonly-used HTTP methods:
 - `GET`: “please send me the named resource”
 - `POST`: “I’d like to submit data to you” (*e.g.* file upload)
 - `HEAD`: “Send me the headers for the named resource”
 - Doesn’t send resource; often to check if cached copy is still valid

- ❖ Other methods exist, but are much less common:
 - `PUT`, `DELETE`, `TRACE`, `OPTIONS`, `CONNECT`, `PATCH`, . . .
 - For instance: `TRACE` – “show any proxies or caches in between me and the server”

HTTP Versions

- ❖ All current browsers and servers “speak” **HTTP/1.1**
 - Version 1.1 of the HTTP protocol
 - <https://www.w3.org/Protocols/rfc2616/rfc2616.html>
 - Standardized in 1997 and meant to fix shortcomings of HTTP/1.0
 - Better performance, richer caching features, better support for multihomed servers, and much more

- ❖ HTTP/2 standardized mid 2010’s (published in 2015)
 - Allows for higher performance but doesn’t change the basic web request/response model
 - Will coexist with HTTP/1.1 for a long time

Client Headers

- ❖ The client can provide zero or more request “headers”
 - These 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
 - `User-Agent`: an identifying string naming the browser
 - `Accept`: the content types the client prefers or can accept
 - `Cookie`: an HTTP cookie previously set by the server
 - <https://www.w3.org/Protocols/rfc2616/rfc2616-sec5.html>

A Real Request

```
GET / HTTP/1.1
Host: attu.cs.washington.edu:3333
Connection: keep-alive
Upgrade-Insecure-Requests: 1
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36
(KHTML, like Gecko) Chrome/66.0.3359.181 Safari/537.36
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,
image/apng,*/*;q=0.8
DNT: 1
Accept-Encoding: gzip, deflate
Accept-Language: en-US,en;q=0.9
Cookie: SESS0c8e598bbe17200b27e1d0a18f9a42bb=5c18d7ed6d369d56b69a1c0aa441d7
8f; SESSd47cbe79be51e625cab059451de75072=d137dbe7bbe1e90149797dcd89c639b1;
_sdsat_DMC_or_CCODE=null; _sdsat_utm_source=; _sdsat_utm_medium=; _sdsat_utm_term=;
_sdsat_utm_content=; adblock=blocked; s_fid=50771A3AC73B3FFF-3F18A
ABD559FFB5D; s_cc=true; prev_page=science.%3A%2Fcontent%2F347%2F6219%2F262%
2Ftab-pdf; ist_usr_page=1; sat_ppv=79; ajs_anonymous_id=%229225b8cf-6637-49
c8-8568-ecb53cfc760c%22; ajs_user_id=null; ajs_group_id=null; __utma=598078
07.316184303.1491952757.1496310296.1496310296.1; __utmc=59807807; __utmc=80
...
```

HTTP Responses

❖ General form:

- `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]`

❖ Demo: use telnet to see a real response

Status Codes and Reason

- ❖ *Code*: numeric outcome of the request – easy for computers to interpret
 - A 3-digit integer with the 1st digit indicating a response category
 - 1xx: Informational message
 - 2xx: Success
 - 3xx: Redirect to a different URL
 - 4xx: Error in the client's request
 - 5xx: Error experienced by the server

- ❖ *Reason*: human-readable explanation
 - e.g. "OK" or "Moved Temporarily"

Common Statuses

- ❖ HTTP/1.1 200 OK
 - The request succeeded and 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 as the “Location:” header value

- ❖ 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”
 - These 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
 - `Content-Type`: the type of the requested object
 - `Content-Length`: size of requested object
 - `Last-Modified`: a date indicating the last time the request object was modified
 - <https://www.w3.org/Protocols/rfc2616/rfc2616-sec6.html>

A Real Response

```
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:
bbbbbbbbbbbbbbbb=DBMLFDMJCGAOILMBPIIAAIFLGBAKOJNNMCJIKKBKCDMDEJHMPONHCILPIBL
ADEAKCIABMEEPAOPMMKAOLHOKJMIGMIDKIHNCANAPHMFMBLBABPFENPDANJAPIBOIOOOD;
HttpOnly

<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.* dynamically-generated 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* – we want to start sending the response right away
 - Chunked message body: response is a series of chunks

Cool HTTP/1.1 Features

- ❖ Persistent connections
 - Establishing a TCP connection is costly
 - Multiple network round trips 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

20 years later...

- ❖ World has changed since HTTP/1.1 was adopted
 - 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)
 - Many hacks used to make HTTP/1.1 performance 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. ...

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

hw4 demo

- ❖ Multithreaded Web Server (333gle)
 - Don't worry – multithreading has mostly been written for you
 - `./http333d <port> <static files> <indices+>`
 - Some security bugs to fix, too

Administrivia

- ❖ If we get to this slide on Monday...
- ❖ ... we won't need to have class on Wednesday !

- ❖ So no class this Wednesday
 - But ex16 still due at 10 am (and sample solution posted mid-day)

- ❖ Have a great Thanksgiving break & see you next Monday!



Extra Exercise #1

- ❖ Write a program that:
 - Creates a listening socket that accepts connections from clients
 - Reads a line of text from the client
 - Parses the line of text as a DNS name
 - Connects to that DNS name on port 80
 - Writes a valid HTTP request for “/”
 - ```
GET / HTTP/1.1\r\nHost: <DNS name>\r\nConnection: close\r\n\r\n
```
  - Reads the reply and returns it to the client