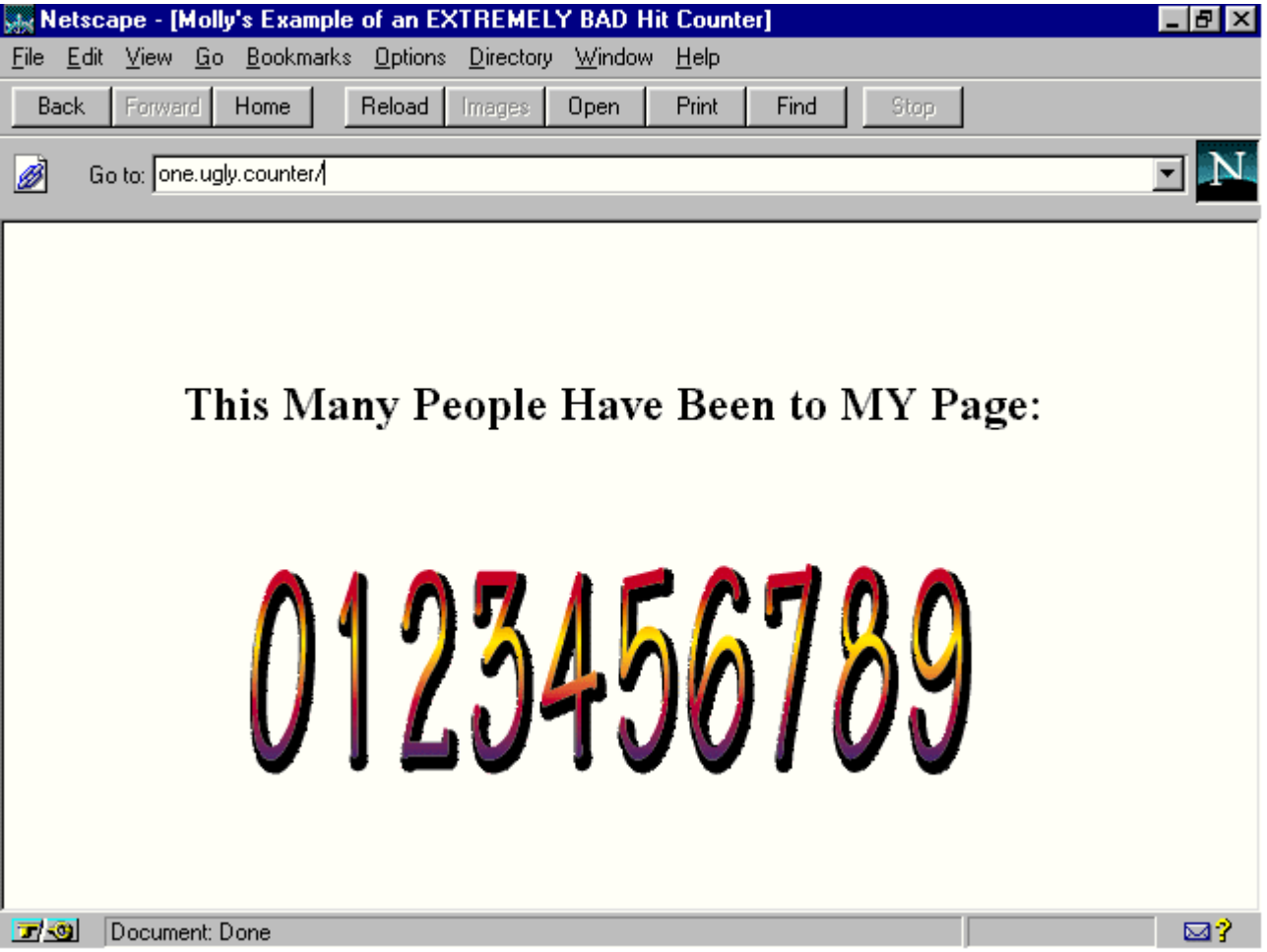
Dynamic Pages



Review: Markup Languages, URLs, and HTTP

- **Markup languages** help you define structure and appearance of a document
  - **HTML** <- you'll use this a lot, plus **CSS**
  - **XML** <- generalization of HTML (btw, MS Office uses this for docx, pptx, etc.)
- **URLs** encode location information for accessing a resource in the request-response cycle
  - protocol://server:port/path?query#fragment
- **HTTP** is the standard protocol for communicating websites between servers and clients
  - **Requests** consist of **methods** like GET, POST, HEAD, etc.
    - Also, **headers** contain useful metadata for the server
  - **Response** contains a HTTP response code (e.g., 200, 404) as well as content
    - Headers also sent here to tell the client about the data being sent

Review: URLs

- Quiz 1.
  - https://dijkstra.eecs.umich.edu/kleach/eecs485/su20/potato.php?salty=true
  - There's no *fragment* and there's no *port*
    - The port is implied for websites, but it's "missing" in the same way that specifying no fragment makes it blank (implicit "#")

- URLs are an important artifact for web services
  - Web APIs are documented according to URL endpoints for various services
    - e.g., GitHub API: https://developer.github.com/v3/,
      Google search API: https://developers.google.com/custom-search/v1/overview,
      DialogFlow API: https://cloud.google.com/dialogflow/docs/reference/rest/v2-overview

Review: HTTP(s)

- HTTP (unsecure) and HTTPS (secure) are *protocols* for communication
  - `curl –verbose http://umich.edu`
  - `telnet umich.edu 80`
  - `GET / HTTP/1.1`
    - etc.

HTTP request methods

- The client's request contains what it wants the server to do
- GET: request a resource
  - Example: load a page
- HEAD: identical to GET, but without response body
  - Example: see if page has changed
- POST: send data to server
  - Example: web form

HTTP request headers

```
$ curl --verbose http://cse.eecs.umich.edu/ > index.html
* Connected to cse.eecs.umich.edu (141.212.113.143) port 80 (#0)
> GET / HTTP/1.1
> Host: cse.eecs.umich.edu
> User-Agent: curl/7.54.0
> Accept: */*
```

- `Host` distinguishes between DNS names sharing a single IP address
  - Required as of HTTP/1.1
- `User-Agent`: which browser is making the request
- `Accept`: which content ("file") types the client will accept

User agent

- When a browser visits a page, it identifies itself with a `User-agent` string
  - For example, check yours out:
  - http://www.whatismyuseragent.net/

- Example from Google Chrome:
  - `Mozilla/5.0 (Macintosh; Intel Mac OS X 10_11_3) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/48.0.2564.103 Safari/537.36`
  - Previously used to indicate compatibility with the Mozilla rendering engine
  - During the "browser wars", some web sites would only send advanced features to some user agents

HTTP status code

- Response starts with a status code
  - 1XX: Informational "hold on"
  - 2XX: Successful "here ya go"
  - 3XX: Redirection Error "go away"
  - 4XX: Error "u screwed up"
  - 5XX: Server Error "sry i screwed up lol"

- `$ curl --verbose http://cse.eecs.umich.edu/`
  `> GET / HTTP/1.1`
  `< HTTP/1.1` **`200 OK`**
- `$ curl --verbose http://cse.eecs.umich.edu/`**`asdf`**
  `> GET /asdf HTTP/1.1`
  `< HTTP/1.1` **`404 Not Found`**

HTTP response headers

- Headers accompany a response
- Most are optional

```
$ curl --verbose http://cse.eecs.umich.edu/
* Connected to cse.eecs.umich.edu
> GET / HTTP/1.1
...
< HTTP/1.1 200 OK
< Date: Tue, 12 Sep 2017 20:04:20 GMT
< Server: Apache/2.2.15 (Red Hat)
< Accept-Ranges: bytes
< Connection: close
< Transfer-Encoding: chunked
< Content-Type: text/html; charset=UTF-8
```

HTTP content type

- Content type describes the "file" type and encoding

```
$ curl --verbose http://cse.eecs.umich.edu/
* Connected to cse.eecs.umich.edu
> GET / HTTP/1.1
...
< HTTP/1.1 200 OK
...
< Content-Type: text/html; charset=UTF-8
```

HTTP content type

- Content type describes the "file" type and encoding

```
$ curl --verbose
http://cse.eecs.umich.edu/eecs/images/CSE-Logo-Mobile.png > CSE-Logo-Mobile.png
* Connected to cse.eecs.umich.edu
> GET /eecs/images/CSE-Logo-Mobile.png HTTP/1.1
...
< HTTP/1.1 200 OK
< Content-Type: image/png
```

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MIME Types

`Content-Type: text/html; charset=UTF-8`

- MIME: Multipurpose Internet Mail Extensions
- Way to identify files
- Browser can open or display content correctly
- **`<type>/<subtype>`**

- https://developer.mozilla.org/en-US/docs/Web/HTTP/Basics_of_HTTP/MIME_types/Complete_list_of_MIME_types

Character encodings

`Content-Type: text/html;` **`charset=UTF-8`**

- Most people in the world use languages other than English
- ASCII -> char in C++

- 我太帅了 => ?
  - Encode with Unicode: \xE6\x88\x91\xE5\xA4\xAA\xE5\xB8\x85\xE4\xBA\x86
  - (think `char x = 0xE6;` in C; each of these is a byte in UTF-8)

- In olden times, you used to have to configure your browser ahead of time to know how to interpret a string – UTF-8 is a modern time saver!

Character Encodings

- Things look nasty if not specified!

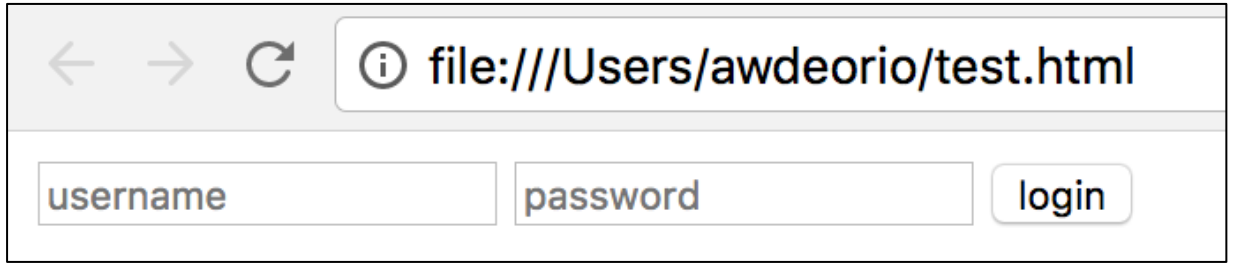
WHAT'S NEW	Vƒ\ƒtƒg‚âXV‹L˜^“™AÅVî•ñ‚Ìƒy[ƒW‚Å‚·B
NINTENDO 64	ƒjƒ“ƒeƒ“ƒhƒE64‚Ìî•ñƒy[ƒW‚Å‚·B
NINTENDO POWER	ƒX[ƒp[ƒtƒ@ƒ~ƒRƒ“ƒ\ƒtƒg‚ª‚«‚Š‚¦‚‰Â”\‚ÉIIƒjƒ“ƒeƒ“ƒhƒEƒpƒ[‚Ìî•ñƒy[ƒW‚Å‚·B
SUPER FAMICOM	ƒX[ƒp[ƒtƒ@ƒ~ƒRƒ“‚Ìî•ñƒy[ƒW‚Å‚·B
GAME BOY	ƒQ[ƒ€ƒ{[ƒC‚Ìî•ñƒy[ƒW‚Å‚·B
PLAYING CARD	ƒgƒ‰ƒ“ƒv‚â‰ÔŽDŠ”ŽDBƒJ[ƒhƒQ[ƒ€‚Ì—V‚Ñ•ûE—ðŽj“™‚Ìî•ñƒy[ƒW‚Å‚·B
COMPANY PROFILE	”C“V“°Š”Ž®‰ïŽÐ‚Ì‰ïŽÐŠT—v‚Ìƒy[ƒW‚Å‚·B
NE SHOP	”C“V“°ƒGƒ“ƒ^[ƒeƒCƒ“ƒgƒVƒ‡ƒbƒv‚Ìˆê——•\‚Å‚·B
PLACEMENT GUIDE	“üŽÐˆÄ“à‚Ìƒy[ƒW‚Å‚·B‚½‚¾‚¢‚Ü’†“rÌ—pŽÓ•åW’†II
OTHER'S	‚»‚Ì‘¼Aƒ|ƒPƒbƒgƒsƒJƒ`ƒ…ƒEAƒtƒ@ƒ~ƒRƒ“ƒfƒBƒXƒNƒVƒXƒeƒ€Aƒjƒ…[ƒXƒšƒš[ƒX“™‚Ìƒy[ƒW‚Å‚·B

WHAT'S NEW	新作ソフトや更新記録等、最新情報のページです。
NINTENDO 64	ニンテンドウ64の情報ページです。
NINTENDO POWER	スーパーファミコンソフトが書き換え可能に！！ニンテンドウパワーの情報ページです。
SUPER FAMICOM	スーパーファミコンの情報ページです。
GAME BOY	ゲームボーイの情報ページです。
PLAYING CARD	トランプや花札・株札。カードゲームの遊び方・歴史等の情報ページです。
COMPANY PROFILE	任天堂株式会社の会社概要のページです。
NE SHOP	任天堂エンターテイメントショップの一覧表です。
PLACEMENT GUIDE	入社案内のページです。ただいま中途採用者募集中！！
OTHER'S	その他、ポケットピカチュウ、ファミコンディスクシステム、ニュースリリース等のページです。

POST request

- POST request sends data from the client to the server
- Commonly used with HTML forms

```
<html>
<body>
  <form action="" method="post" enctype="multipart/form-data">
    <input type="text" name="username" placeholder="username"/>
    <input type="password" name="password" placeholder="password"/>
    <input type="submit" value="login"/>
  </form>
</body>
</html>
```



POST request

- No POST requests needed in project 1
- Example from project 2

```
$ curl \
    --form 'username=awdeorio' \
    --form 'password=password' \
    --form 'submit=login' \
    localhost:8000/accounts/login/
```

HTTP versions

- See the HTTP version in the request and response

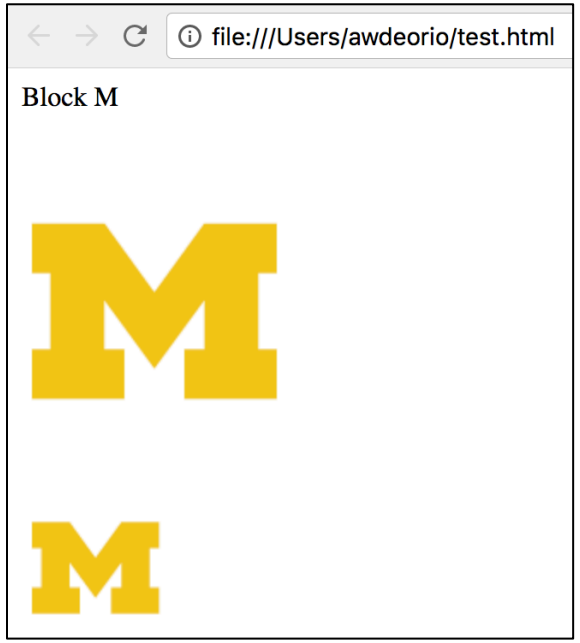
```
 $ curl --verbose http://cse.eecs.umich.edu/
* Connected to cse.eecs.umich.edu
> GET / HTTP/1.1
...
< HTTP/1.1 200 OK
```

- Three versions:
  - HTTP/1.0 (old)
  - **HTTP/1.1 (common)**
  - HTTP/2 (new)

HTTP/1.0 .vs HTTP/1.1

- How many TCP connections?

```
<html>
<body>
  <p>Block M</p>
  <img src="http://cse.eecs.umich.edu/eecs/images/CSE2017-hi-rev.png">
  <img src="http://cse.eecs.umich.edu/eecs/images/CSE2017-rev.png">
</body>
</html>
```



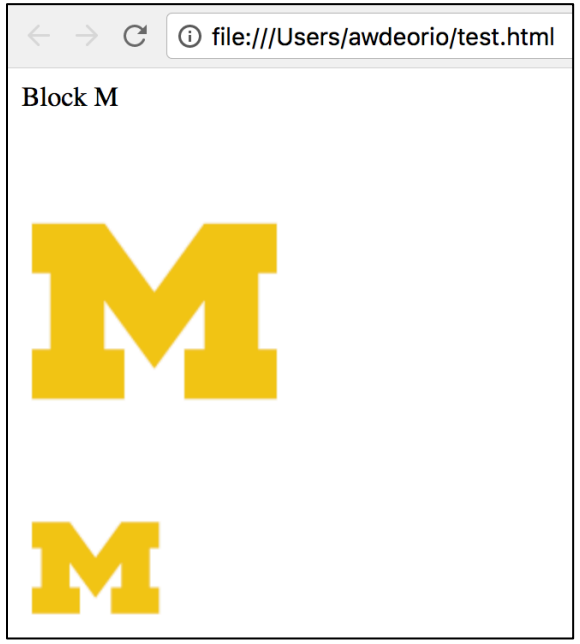
- HTTP/1.0: 3

HTTP/1.0 .vs HTTP/1.1

- How many TCP connections?

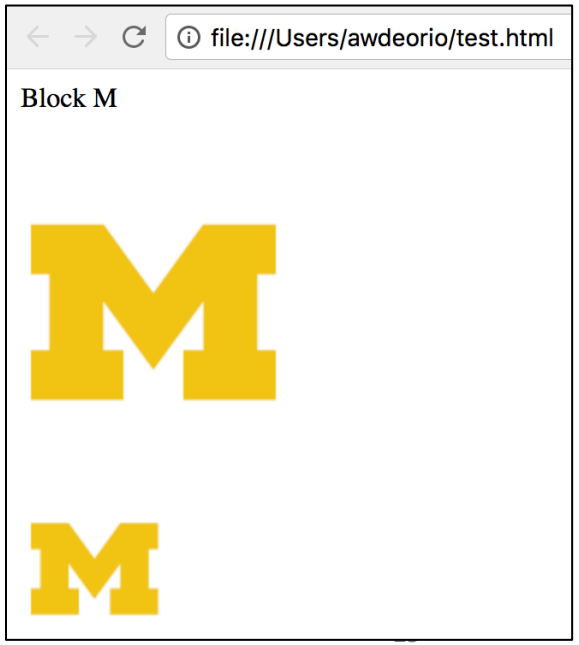
```
<html>
<body>
  <p>Block M</p>
  <img src="http://cse.eecs.umich.edu/eecs/images/CSE2017-hi-rev.png">
  <img src="http://cse.eecs.umich.edu/eecs/images/CSE2017-rev.png">
</body>
</html>
```

- HTTP/1.1: 1
  - Reuse one HTTP connection



HTTP/2

- Methods, status codes, etc. same as HTTP/1.1
- One new feature: server push
  - Server supplies data it knows a web browser will need to render a web page, without waiting for the browser to examine the first response.
  - Example: images in this page are loaded as PUSH commands are sent from the server *after* responding to the original GET /blah.html request



One-Slide Summary: Dynamic Pages

- **Static** web pages remain constant over time
  - **Static pages are boring**: No account management, no statefulness, etc.
- **Dynamic** web pages are built with *server software* that *generates* HTML or DOM subtrees *on the fly!*
  - Recall: HTTP is just sending strings back and forth…
    - Can't you just write a script that prints a bunch of HTML out, then pipe it over HTTP? (Spoiler alert: yes, we use Python Flask in this class)
- Dynamic web pages come in two flavors
  - **Server-side dynamic:** Client gets an *entire new HTML page* on each request
  - **Client-side dynamic:** Client gets *DOM subtrees* on each request
    - Requires the use of JavaScript to modify the DOM on the fly in the client

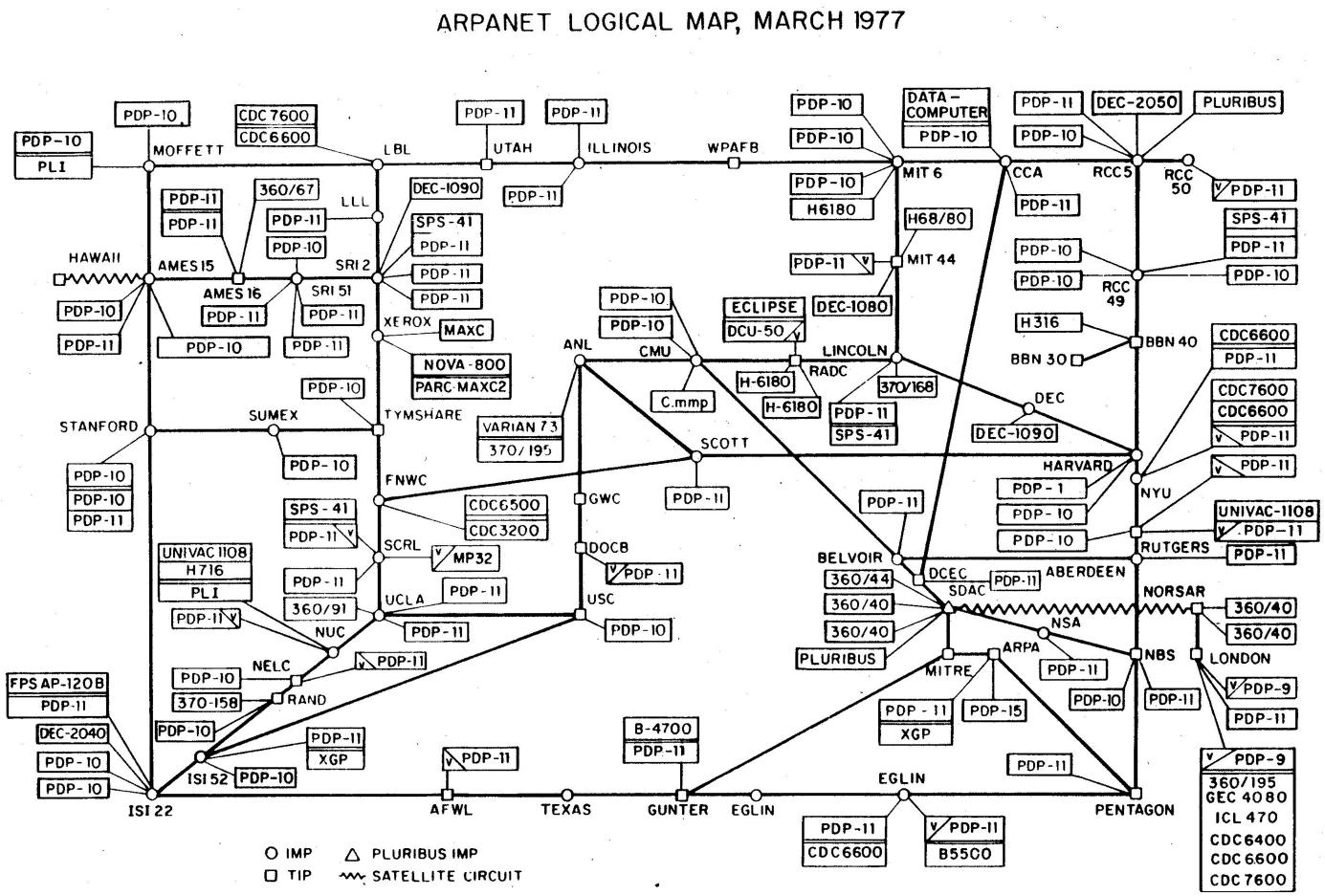
Paleolithic era

- 1965 Gordon Moore proposes law
- 1966 Design of ARPAnet

- 1969 First ARPAnet msg, UCLA -> SRI
- 1970 ARPAnet spans country, has 5 nodes
- 1971 ARPAnet has 15 nodes
- 1972 First email programs, FTP spec

The internet ramps up

- 1983 ARPAnet uses TCP/IP; design of DNS; 1000 hosts on ARPAnet



The internet ramps up

- 1983 ARPAnet uses TCP/IP; design of DNS; 1000 hosts on ARPAnet
- 1985 symbolics.com (computer mfg) is first registered domain name

- 1988 Robert Morris accidentally takes over the Internet
- 1989 100K hosts on Internet
- 1990 Cisco goes public; Tim Berners-Lee creates WWW at CERN; 3M Internet users world-wide

Modern age

- 1993 WWW Wanderer
  - First crawler
- 1995 Yahoo, Amazon
- 1998 Google & PageRank
- 2003 Skype

Modern age

- 2004 Facebook founded
- 2006 Twitter founded
- 2010 Instagram founded
- 2019 Facebook has 2.4 B monthly active uses
  - ~30% of humanity
  - https://investor.fb.com/investor-events/

Static content

- On the server side: HTTP servers are fileservers
- On the client side: browsers are HTML renderers

- Example
  - `python3 -m http.server`
  - Copies files

Static vs. dynamic content

- Static content is the same every time
- Dynamic content changes
- Think of the things that are impossible with simple static pages

Static vs. dynamic content

- Static content is the same every time
- Dynamic content changes
- Think of the things that are impossible with simple static pages
  - Web search
  - Database lookups
  - Current time
  - # visitors to page
  - Everything

Project 1 = Static content

- Project 1: the pages are static

- Pages only change rarely via a manual process
  - You manually update data, templates (with a text editor)
  - Run `insta485generator` to produce new pages
  - Templates are a way to reduce the work of editing
  - Everybody gets same content until next manual update

- Generation of content not specific to each request

Aside: Jinja

- Project 1 has you build static HTML files from Jinja templates

```
<!DOCTYPE html>
<html>
  <head>
    <title>{{ variable|escape }}</title>
  </head>
  <body>
  {%- for item in item_list %}
    {{ item }}{% if not loop.last %},{% endif %}
  {%- endfor %}
  </body>
</html>
```

```
from jinja2 import Template
with open('example.html.jinja') as f:
    tmpl = Template(f.read())
print tmpl.render(
    variable = 'Value with <unsafe> data',
    item_list = [1, 2, 3, 4, 5, 6]
)
```

Aside: Jinja

- Project 1 has you build static HTML files from Jinja templates

```
<!DOCTYPE html>
<html>
  <head>
    <title>Value with &lt;unsafe&gt; data</title>
  </head>
  <body>
    1,
    2,
    3,
    4,
    5,
    6
  </body>
</html>
```

Aside: Jinja… Still static!

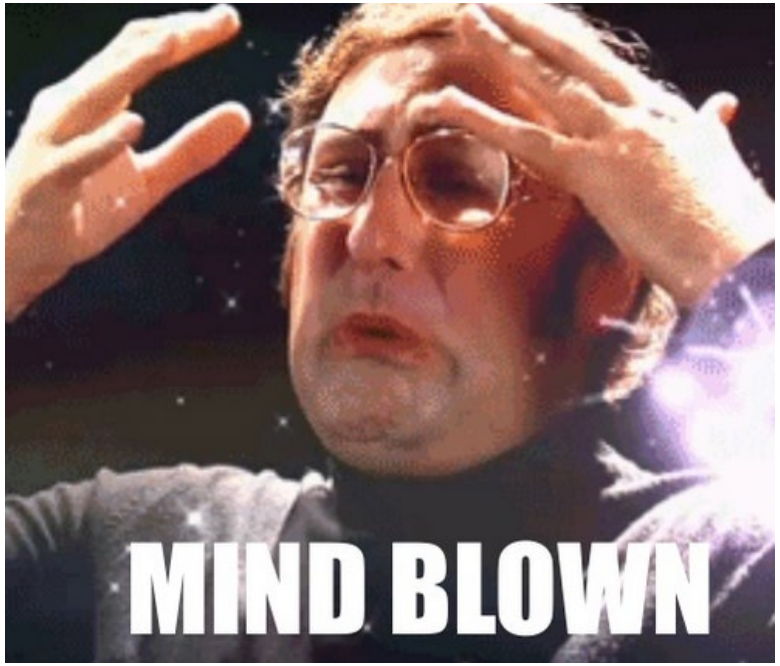
- Project 1 has you build static HTML files from Jinja templates

```html
<!DOCTYPE html>
<html>
  <head>
    <title>Value with &lt;unsafe&gt; data</title>
  </head>
  <body>
    1,
    2,
    3,
    4,
    5,
    6
  </body>
</html>
```

- The HTML files are built before being served up… What about dynamism?

Dynamic server content

- In the old days (1997?), almost all requests were just disk loads
- Computing the page dynamically was a **mind-blowing idea**; today it's assumed
- Each request calls a function in the server software, which generates the response



Why is this useful?

- Most common pattern:
  - Store data in a database
  - Use jinja/templates to create HTML from that data
  - This way, users can change the data

Thought question

- All of these web pages are dynamic. What's the reason why each of these websites could not or were not implemented with static pages?

- Piazza
- Your course schedule on Wolverine Access
- Wikipedia articles
- cse.engin.umich.edu

Dynamic server content

- Project 2: what if we let users create posts?
- When a user creates a new post, save information in database
- When a user loads /u/deorio, call a function to look for newest posts for the user in the database

Dynamic server example

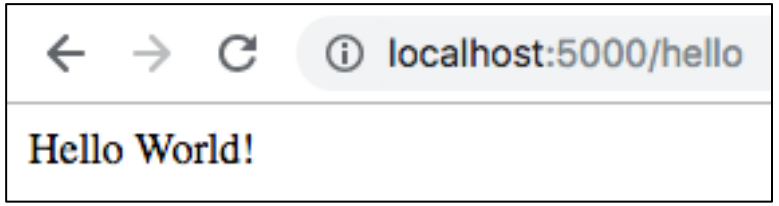

```
# hello.py
import flask
app = flask.Flask(__name__)

@app.route("/hello")
def hello_world():
    return "<html><body>Hello World!</body></html>"

if __name__ == "__main__":
    app.run()
```

Dynamic server example

- Run

```
$ python3 hello.py
 * Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
```

- Browse to http://localhost:5000/hello



- NOTE: `localhost` == `127.0.0.1`

Templating

- Instead of HTML in string, base on template

- Example: Python's `jinja2` library
- Write an HTML file with special keywords
  - e.g., `{% for post in posts %}`
- Run it through a function, along with a data structure of values to fill in
  - e.g., `template.render()`
  - **or** `flask.render_template() in project2`

Template example

- Template is an HTML file containing jinja2 syntax

```
<html>
<head><title>Hello world</title></head>
<body>
{% for word in words %}
{{word}}
{% endfor %}
</body>
</html>
```

Rendered template example

- Rendered template is a string with jinja2 tempate syntax "filled in"

```
<html>
<head><title>Hello world</title></head>
<body>

hello

world

</body>
```

Rendering templates with Flask

```
# hello.py
import flask
app = flask.Flask(__name__)

@app.route("/hello")
def hello_world():
    return "<html><body>Hello World!</body></html>"
    context = {"words": ["Hello", "World!"]}
    return flask.render_template(
        "hello.html", context)

if __name__ == "__main__":
    app.run()
```

Render template, providing values from `context` dictionary

Principle: data/computation duality

- We think of data and computation as separate
- But, they are really two sides of the same coin

- Data instead of computation
  - Pre-computing and storing results

- Computation instead of data
  - Dynamically generating web pages

Project 2 = server-side dynamic content

Client specifies a URL

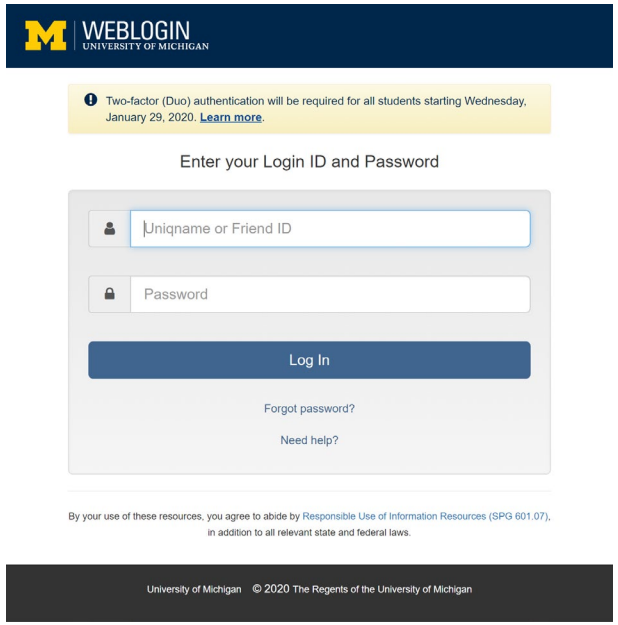
- This *looks* like a file path on the server (remember last lecture?)
- But server *really* runs a function, serves returned output

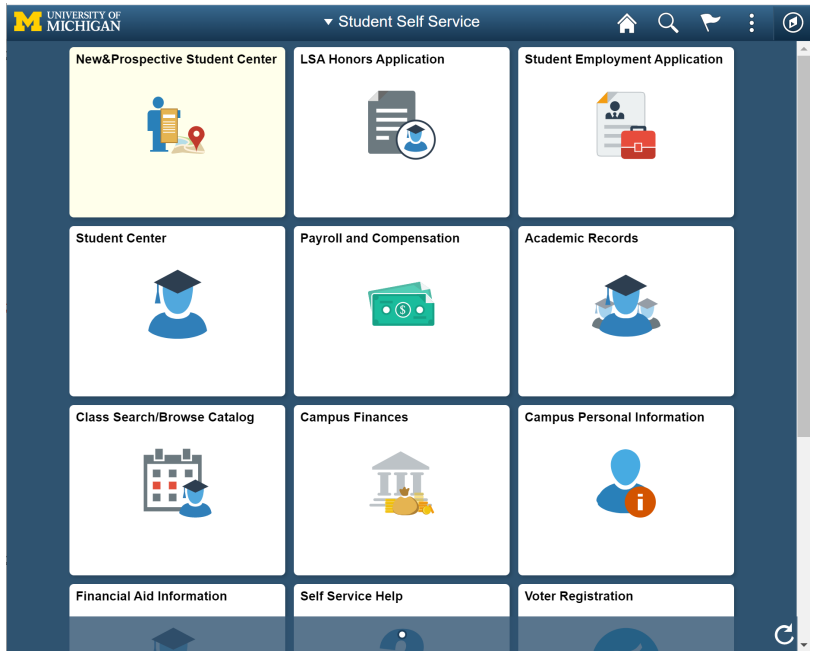
- How does function generate content?
  - State is stored in a database (SQLite)
  - Function issues SQL queries to get relevant state
  - Populates Python object
  - Renders template using object
  - Returns resulting HTML

- Generation of content specific to each request

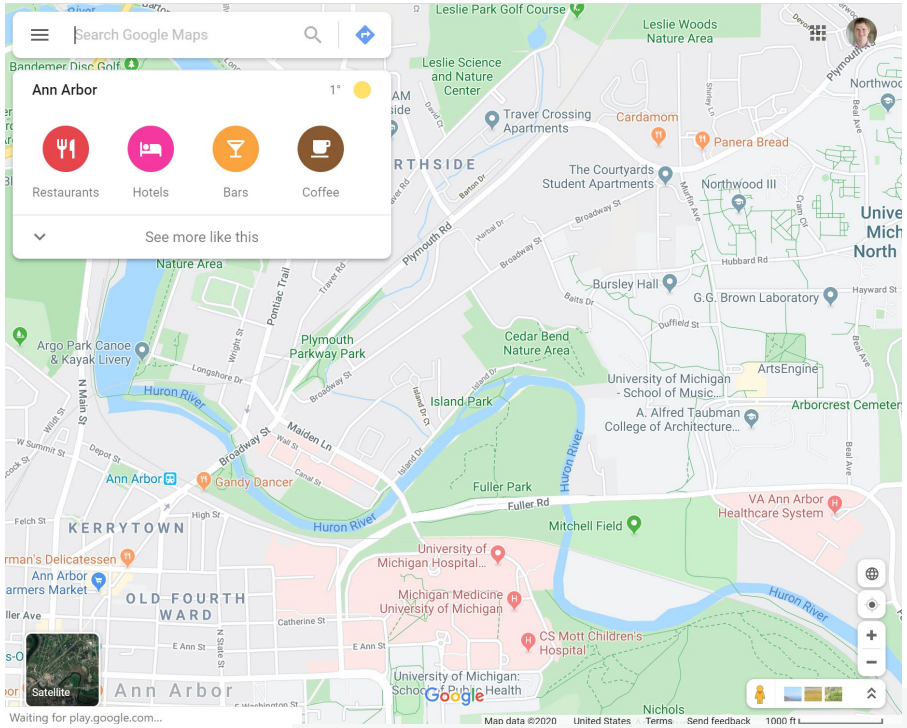
Server-side vs. client-side

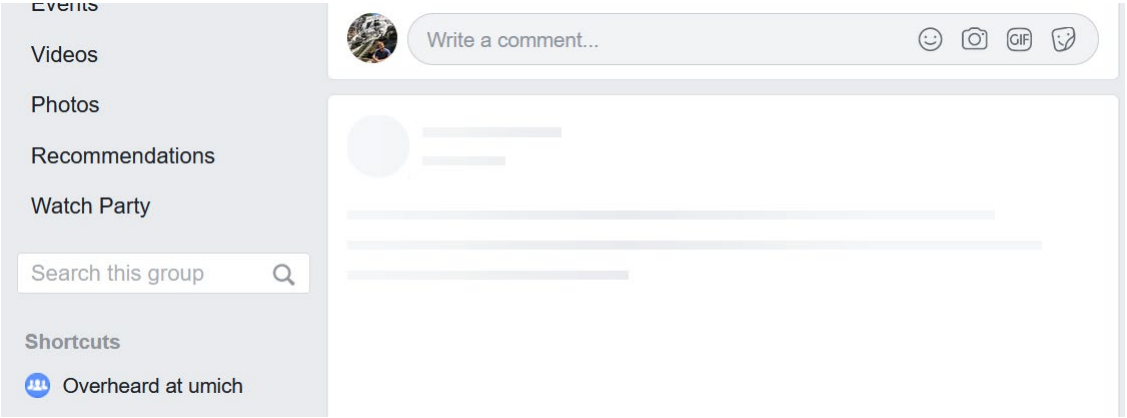
- With server-side dynamic pages:
  - must reload the page for the page to change

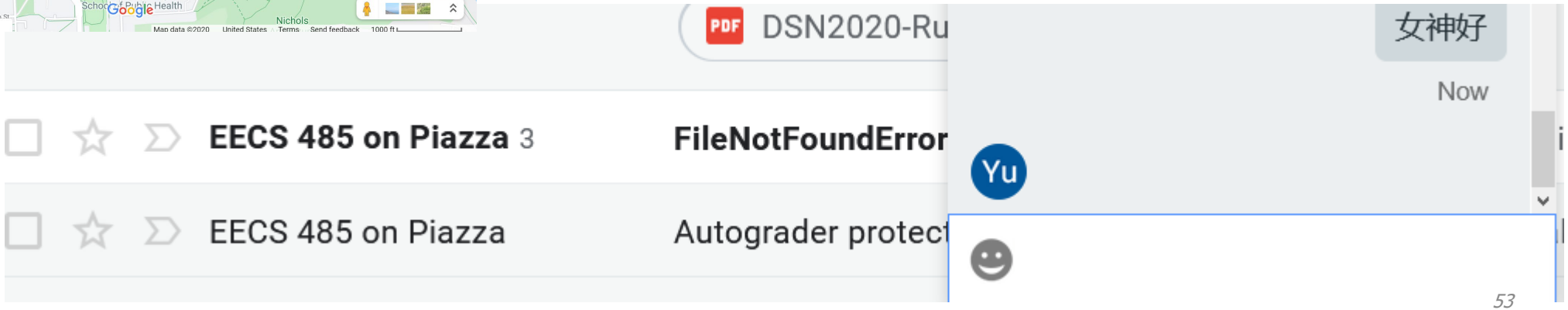




Server-side vs. client-side examples







Client-side dynamic pages

- Website is a program split into 2 parts
  - Client side (in web browser): sees what user wants to do, sends requests to server
  - Server side: responds to program in client side
- The web browser is the environment for the client-side program

How to tell client vs. server side dynamic

- Does the page reload?

- Does the page change after the server has sent it to the client?
  - e.g. a chat app *must* be client-side dynamic or you wouldn’t be able to see new messages after the page loaded

JavaScript

- The client-side dynamic part of a website is written in JavaScript
- Absolutely nothing to do with Java – Java was cool at the same time
- Web browsers have an interpreter/compiler for JavaScript
  - The speed of a web browser mostly depends on how fast its JavaScript engine runs

How JavaScript is used

- document API: change the DOM
  - Use JavaScript to form a small HTTP request to get a DOM subtree to insert in the current DOM

- Events: detect when user does something
  - Click
  - Mouse movement
  - Key press

  - You write an event handler in JS that takes action when such an event occurs!
    - “Asynchronous”

```
> typeof NaN
<· "number"
> 9999999999999999
<· 10000000000000000
> 0.5+0.1==0.6
<· true
> 0.1+0.2==0.3
<· false
> Math.max()
<· -Infinity
> Math.min()
<· Infinity
> []+[]
<· ""
> []+{}
<· "[object Object]"
> {}+[]
<· 0
> true+true+true===3
<· true
> true-true
<· 0
```

```
> true==1
<· true
> true===1
<· false
> (!+[]+[]+![]).length
<· 9
> 9+"1"
<· "91"
> 91-"1"
<· 90
> []==0
<· true
```

`document` API

- JavaScript can interact with the DOM
  - Recall: DOM is the data structure built from HTML

- The `document` API represents the web page loaded in the browser
  - Web page represented as a Document Object Model (DOM)

document API

- How does JavaScript usually modify a page? Find a location in the DOM and modify it.

```
<html><body>
  <div id="JSEntry">Loading ...</div>
  <script>
  document.getElementById("JSEntry").innerHTML =
    "Hello World!";
  </script>
</body></html>
```

Before JS executes

Loading ...

After JS executes

Hello World!

DOM Diagram

```
<html>
  <head></head>
  <body>
    <div id="JSEntry">Loading ...</div>
    <script>
    document.getElementById("JSEntry").innerHTML =
      "Hello World!";
    </script>
  </body>
</html>
```

Thought question

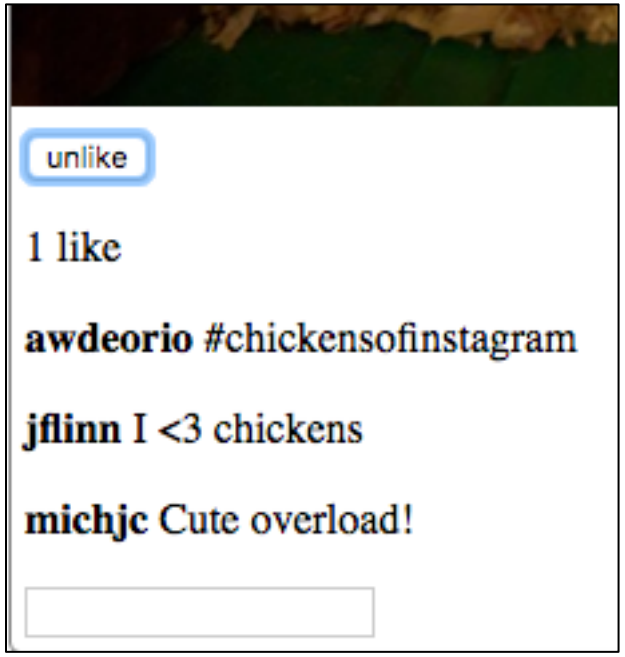
- Does the document API change the HTML source of a page, or just the DOM?

Events

- Example: clicking a button

- Attach a function to a button
- Button causes an *event*
- *Event* runs a function
- Function modifies the DOM

- We'll talk about this later in in the semester



URL routing

- Dynamic pages are created by executing a function at the time of a request
- When a client requests a URL, how does a server know which function to call?
- What about routes like a user page, where the function could have an input?

Routes with inputs

```
from flask import Flask
app = Flask(__name__)

@app.route('/u/<username>')
def show_user(username):
    return "hello {}!".format(username)

@app.route('/p/<postid>')
def show_post(postid):
    return "post {}!".format(postid)

if __name__ == '__main__':
    app.run()
```

Routing in Python/Flask

- Flask uses a Python *decorator* to describe routing
- A *decorator* is a function that changes the behavior of another function
- A decorator is a higher order function

```
from flask import Flask
app = Flask(__name__)

@app.route('/u/<username>')
def show_user(username):
    return "hello {}!".format(username)
```

First class objects

- In Python, functions are *first class objects*
- Recall from EECS 280, that first class objects can be:
  - Passed as input
  - Returned as output
  - Created at runtime
  - Destroyed at runtime

Storing functions in variables

```
def fn():
    print("Hello!")

f = fn
f()
```

Passing functions to other functions

```
def wrapper(fn):
    print("Start")
    fn()
    print("End")

def f():
    print("Hello")

wrapper(f)
```

Returning functions

```
def wrapper(fn):
     print("Wrapping")
     def wrapped():
          print("Start")
          fn()
          print("End")
     return wrapped

def f():
     print("Hello")

w = wrapper(f)
w()
```

Decorator pattern

```
def wrapper(fn):
     print("Wrapping")
     def wrapped():
          print("Start")
          fn()
          print("End")
     return wrapped

@wrapper
def f():
     print("Hello")

@wrapper
def g():
     print("Goodbye")
```

Decorators and Flask

```
from flask import Flask
app = Flask(__name__)

@app.route('/u/<username>')
def show_user(username):
    return "hello {}!".format(username)
```

Further reading

- Decorators can be extended to accept arguments

```
@app.route('/u/<username>')
def show_user(username):
    return "hello {}!".format(username)
```

- Flask's `route()` is a combination of two patterns:
  - Registering plugins with a decorator
    https://realpython.com/primer-on-python-decorators/#registering-plugins
  - Decorators with arguments
    https://realpython.com/primer-on-python-decorators/#decorators-with-arguments
- Tutorial on decorators
  https://realpython.com/primer-on-python-decorators/