

CS 188/219

Scalable Internet Services

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September 29, 2015

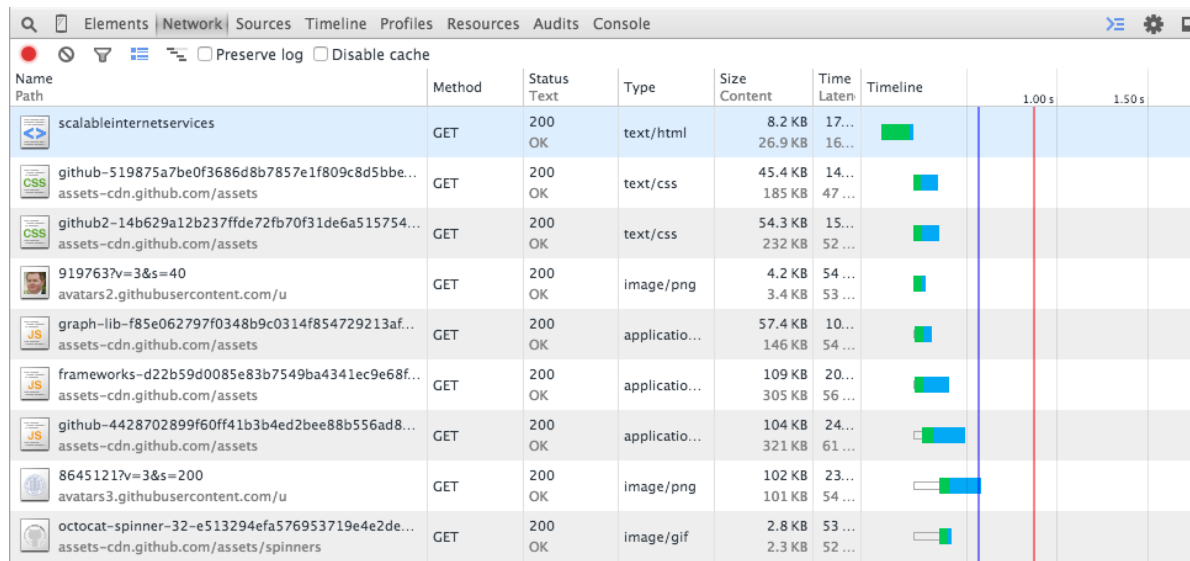


Today's Agenda

- The Lifecycle of a Web Request
- Understand the browser's technology stack
 - HTTP
 - HTML, CSS
- For next time...



For Today

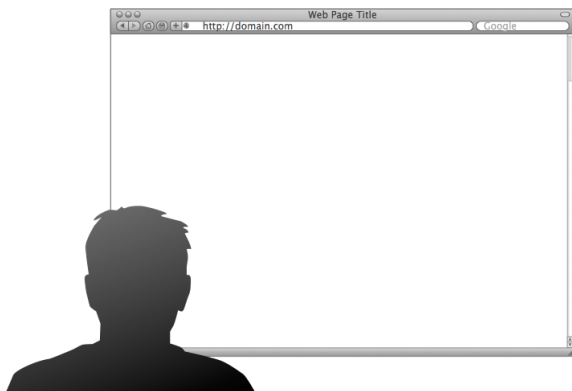


Name Path	Method	Status Text	Type	Size Content	Time Laten	Timeline
scalableinternetservices	GET	200 OK	text/html	8.2 KB 26.9 KB	17... 16...	
github-519875a7be0f3686d8b7857e1f809c8d5bbe... assets-cdn.github.com/assets	GET	200 OK	text/css	45.4 KB 185 KB	14... 47...	
github2-14b629a12b237fde72fb70f31de6a515754... assets-cdn.github.com/assets	GET	200 OK	text/css	54.3 KB 232 KB	15... 52...	
919763?v=3&s=40 avatars2.githubusercontent.com/u	GET	200 OK	image/png	4.2 KB 3.4 KB	54... 53...	
graph-lib-f85e062797f0348b9c0314f854729213af... assets-cdn.github.com/assets	GET	200 OK	applicatio...	57.4 KB 146 KB	10... 54...	
frameworks-d22b59d0085e83b7549ba4341ec9e68f... assets-cdn.github.com/assets	GET	200 OK	applicatio...	109 KB 305 KB	20... 56...	
github-4428702899f60ff41b3b4ed2bee88b556ad8... assets-cdn.github.com/assets	GET	200 OK	applicatio...	104 KB 321 KB	24... 61...	
8645121?v=3&s=200 avatars3.githubusercontent.com/u	GET	200 OK	image/png	102 KB 101 KB	23... 54...	
octocat-spinner-32-e513294efa576953719e4e2de... assets-cdn.github.com/assets/spinners	GET	200 OK	image/gif	2.8 KB 2.3 KB	53... 52...	

After today, you should have all the basic tools you need to understand output like this

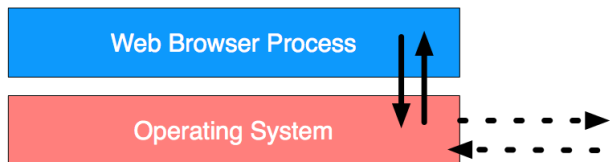


The Lifecycle of a Request



Starting with the basics

- A web browser is a process
- It runs on an operating system
- It responds to user input, renders graphics, and uses the network.

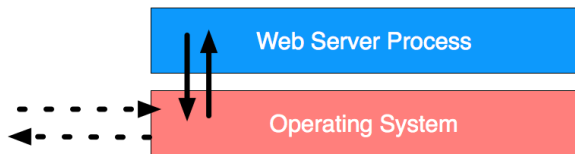


The Lifecycle of a Request

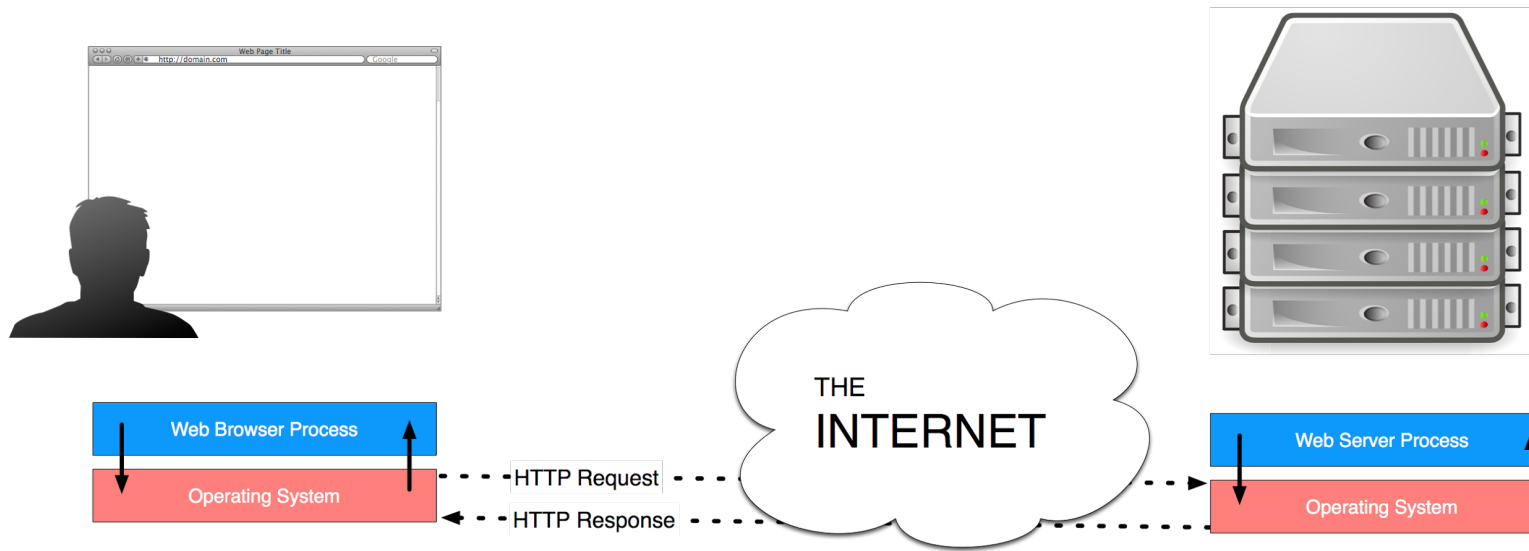


Starting with the basics

- A web server is a process
- It runs on an operating system
- It interacts with the network and the filesystem.



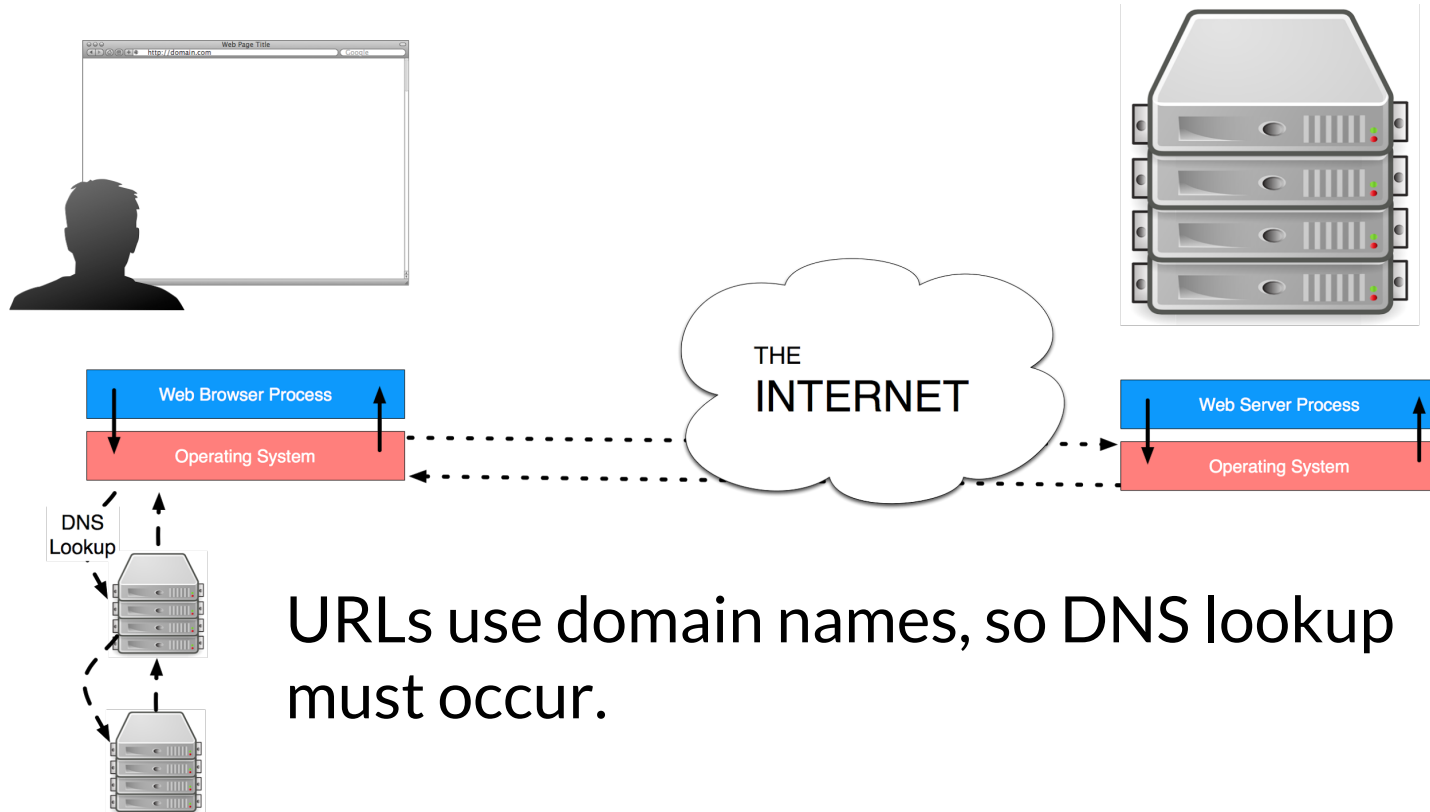
The Lifecycle of a Request



These two processes communicate over the internet.



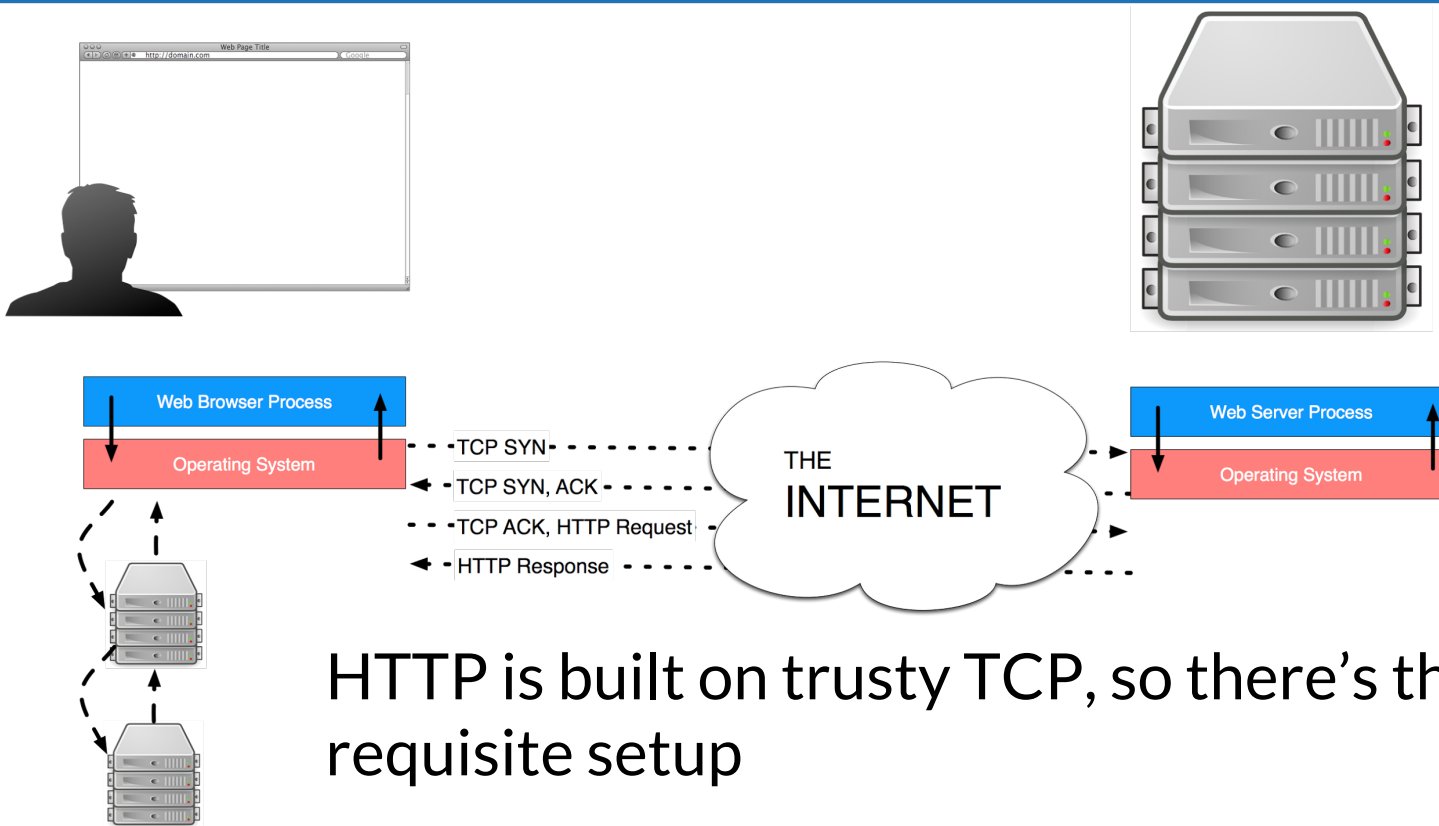
The Lifecycle of a Request



URLs use domain names, so DNS lookup must occur.



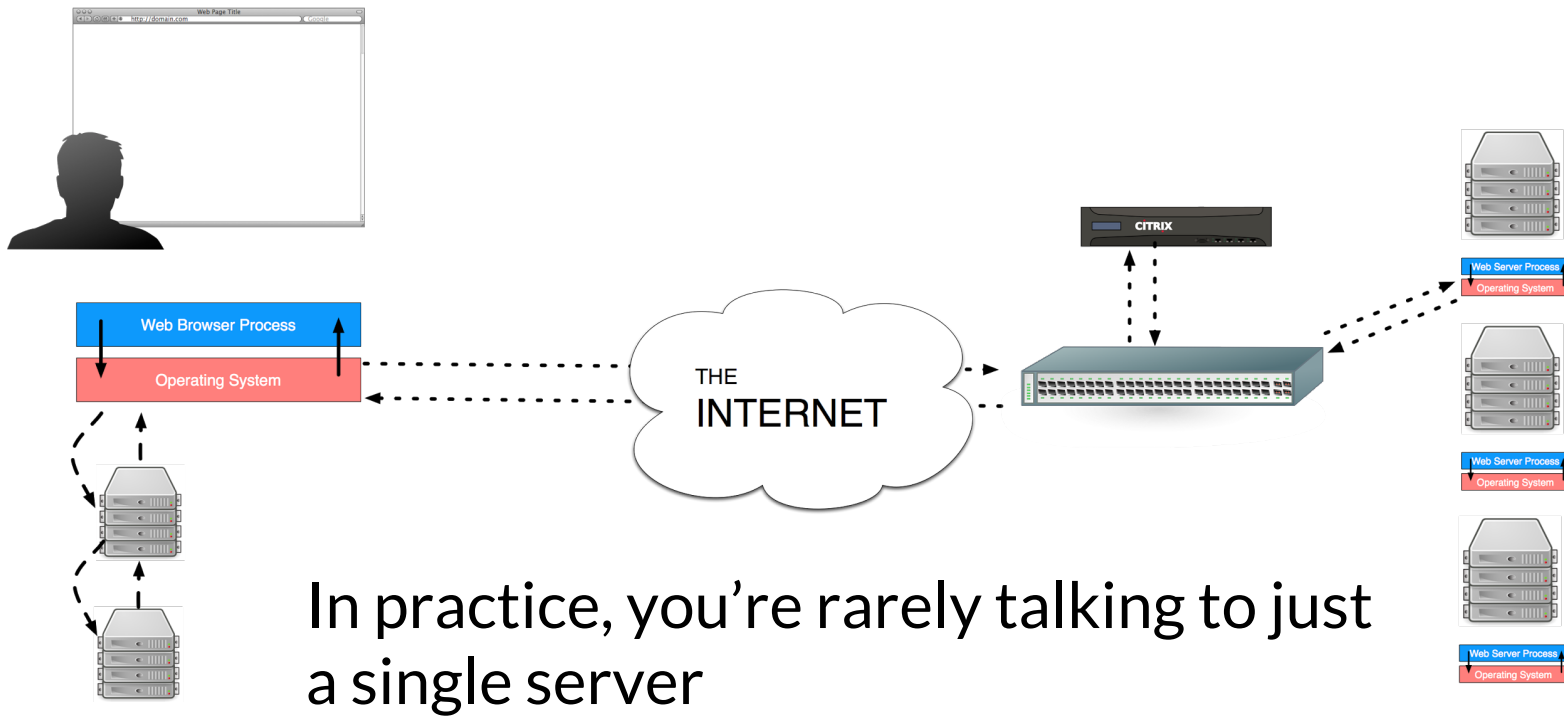
The Lifecycle of a Request



HTTP is built on trusty TCP, so there's the requisite setup



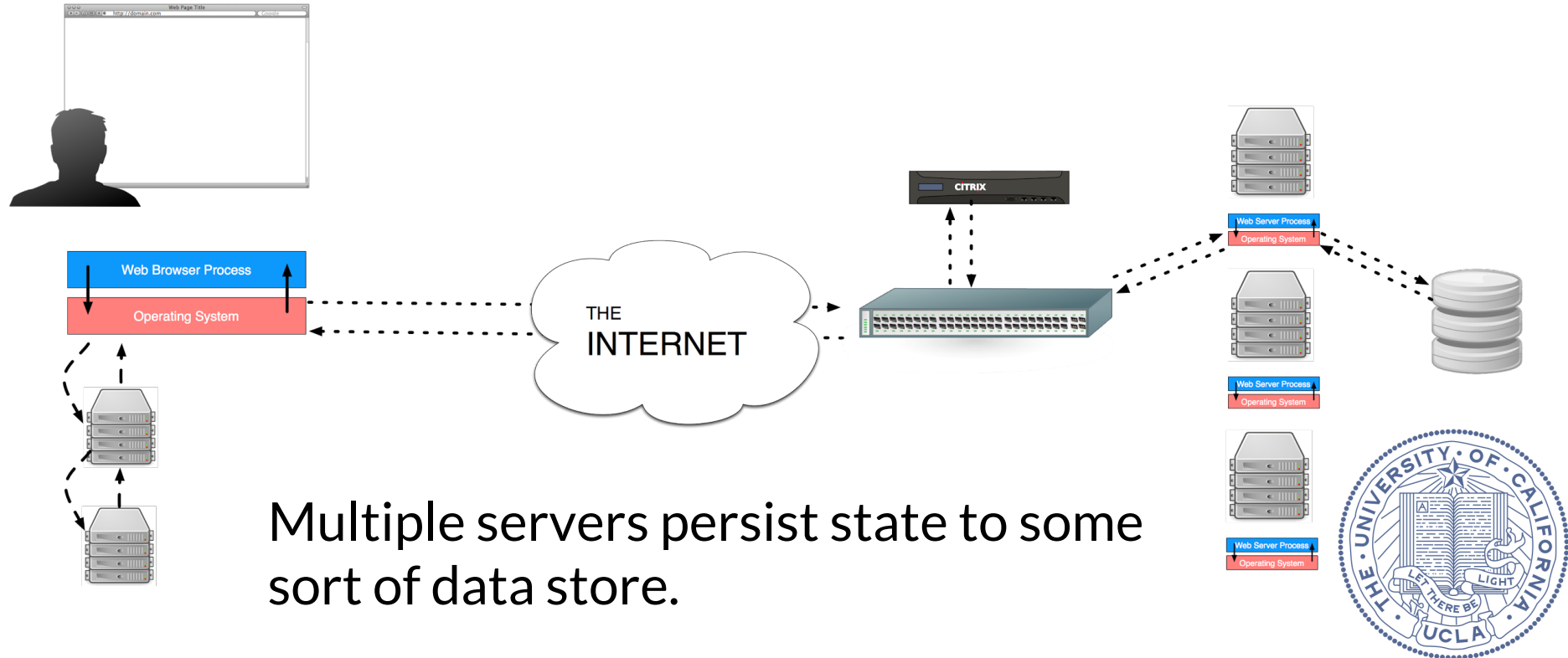
The Lifecycle of a Request



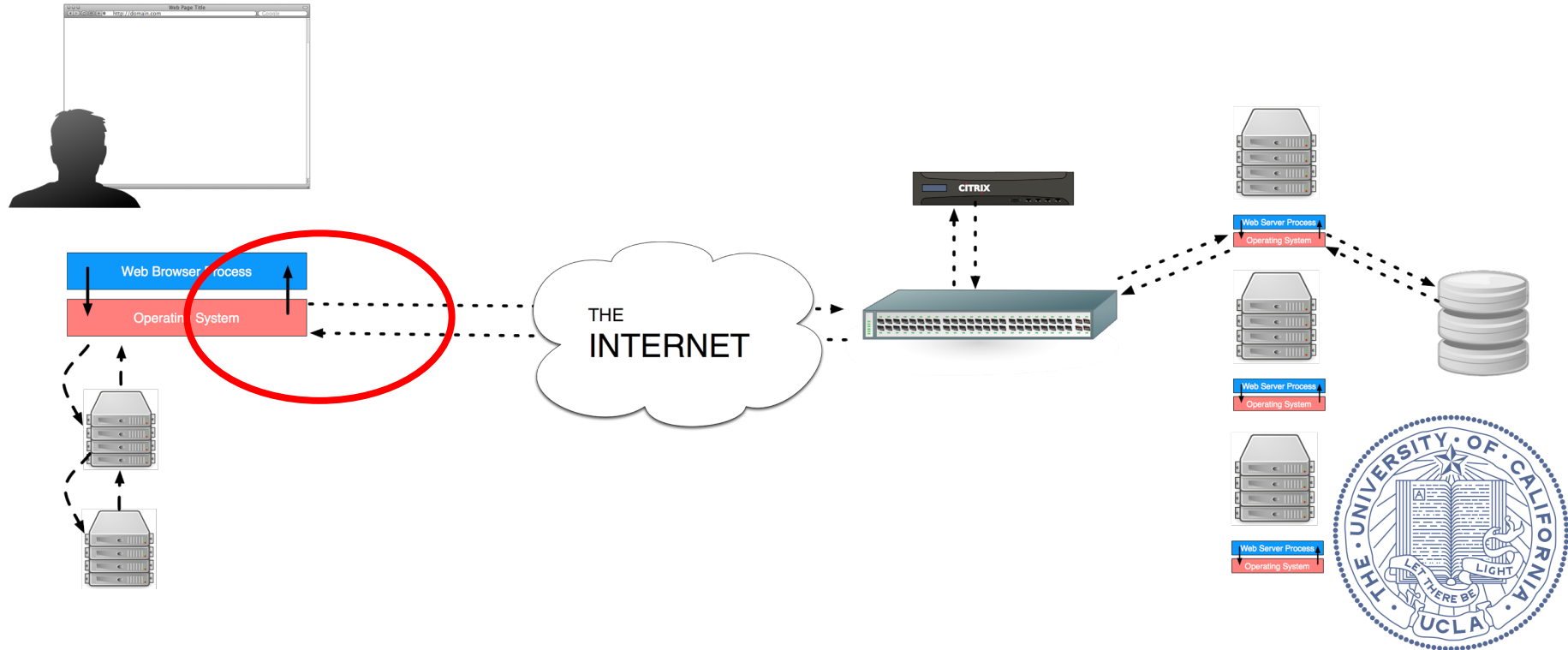
In practice, you're rarely talking to just a single server



The Lifecycle of a Request



HTTP



HTTP

- The year is 1990. The internet has existed for ~20 years, email has existed for ~8 years.
- Tim Berners-Lee is at CERN, and believes that two already-existing technologies could be combined to good effect: the internet and HyperText
 - HyperText is the idea of linking documents together with HyperLinks.
 - Engelbart, Hypercard, Xanadu
 - Berners-Lee creates the first versions of HTTP and HTML
- In 1993, Mosaic is created at the NCSA center at UIUC
- In 1994, Marc Andreessen leaves UIUC and founds Netscape with Jim Clark.



HTTP



HTTP Explained

- Simple ASCII protocol
- In its original, simplest version
 - Open a TCP socket (standard is port 80)
 - Send over a request
 - Response comes back
 - Close the TCP socket
- Originally designed to exchange HTML, extended to send anything
 - Originally designed for web browser to server interaction, today very widely used for server to server APIs



HTTP Explained

- Request:
 - **Verb:** What do you want to do? GET something?
 - **Resource:** What is logical path of the resource you want?
 - **HTTP version:** specify version to aid in compatibility
 - **Headers:** Standard ways to request optional behavior
 - **Body:** A data payload
- Response comes back:
 - **HTTP Version:** specify version to aid in compatibility
 - **Status code:** Success? Failure? Other?
 - **Headers:** Standard ways to convey metadata
 - **Body:** A data payload



HTTP Explained

Verb
Resource
Version
Headers
Status
Body

Request:

GET /about/ **HTTP/1.1**

Accept: text/html

Response:

HTTP/1.1 200 OK

Content-Type: text/html


<!DOCTYPE html>

<html class="example" lang="en">

...



HTTP Verbs



Verb
Resource
Version
Headers
Status
Body

- **GET**

- Get a copy of the resource
- Should have no side-effects
- Example: **GET** /users/sign_out shouldn't be done.

- **POST**

- Sends data to the server. Generally creates a new resource
- Commonly used for form submissions.
- Should be assumed to have side-effects.
- Not idempotent.
 - “Do you want to post your form submission again?”



HTTP Verbs

- **PUT**

▶

Verb

Resource

Version

Headers

Status

Body


- Sends data to the server. Generally updates an existing resource.
- Has side effects, but is idempotent.
 - Does this make sense?
- The difference between **PUT** and **POST** is subtle. We will cover it more later in the course while discussing REST.

- **DELETE**

- Destroys a resource.
- Has side effects, is idempotent.
- This is the right way to do a user signout:
 - **DELETE** /session/<id>



HTTP Verbs



Verb
Resource
Version
Headers
Status
Body

- **HEAD**
 - Just like **GET**, but only returns the headers.
 - What would this be useful for?
 - (Hint: we will be discussing this topic in greater length later)
- These are how the verbs should be used, not everyone understands them or uses them correctly.
 - Example: **GET /blog_postings/5?action=hide**
- What problems can you think of happening through the misuse of HTTP verbs?



HTTP Verbs

- Less commonly used verbs:

▶ Verb

Resource

Version

Headers

Status

Body

- **TRACE**
- **OPTIONS**
- **CONNECT**



HTTP Resource

Verb
Resource
Version
Headers
Status
Body

- The resource specifies the thing you are referring to via a logical hierarchy.
 - This is not the file path location.
 - Good: `http://www.amazon.com/gp/product/1565925092/`
 - Bad: `http://www.cocacola.com/index.jsp?page_id=4251`
- Anything past the question mark is called a query string
 - Query strings are intended to assist in locating the resource
 - Parameters are assigned using equals, concatenated using ampersand
 - Example:
 - <http://www.amazon.com/search?term=dogs&new=1>



HTTP Version

Verb
Resource
Version
Headers
Status
Body

The HTTP version is included with each request/response for ease of protocol development.

Everyone today uses HTTP 1.1, with some support for SPDY/HTTP 2.0

Timeline:

- 1991, HTTP 0.9: Single line protocol. No headers.
- 1996, HTTP 1.0: Headers added, more than just HyperText.
- 1999, HTTP 1.1: Connection keep-alive, more caching mechanisms, everything else we enjoy today
- 2015: HTTP 2.0 finalized. Future lecture with details.



HTTP Headers

Verb
Resource
Version
▶ Headers
Status
Body

HTTP headers are where a lot of the power lies.

- Accept: indicates the preferred format of the resource
 - Accept: text/html
 - Give me the resource as a web page
 - Accept: application/json:
 - Give me the resource as a JSON document
 - Accept: application/json,application/xml:
 - Give me the resource as a JSON document, but if you can't do that then I will accept XML.
- Accept-Encoding: indicates the content should be compressed
 - Accept-Encoding: bzip2,gzip
 - Compress the data using bzip2, and if you don't support that, then use gzip



HTTP Headers

Verb
Resource
Version
Headers
Status
Body

- `Host`: indicates the DNS host the requestor is trying to reach
 - Why is this important? Why isn't the host implied?
- `Accept-Language`: indicates the preferred languages (in order)
 - `Accept-Language: es,en-US`
 - I prefer spanish, but will accept US english.
 - Without this header, every website intended for an international audience would need a massive "choose your language" list on its homepage.
- `User-Agent`: indicates what type of browser or device is connecting.
 - Too often, web applications make decisions based on this.
 - Ridiculousness ensues. Current Chrome User-Agent:
 - `Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/37.0.2062.124 Safari/537.36`



HTTP Headers

Verb
Resource
Version
▶ Headers
Status
Body

- Set-Cookie & Cookie
 - Server includes the Set-Cookie header in a response, and data is stored in the browser.
 - That data will later be provided on all subsequent requests in the Cookie header.
 - What are some examples of application of Cookies?
- Connection: keep-alive
 - Discussed later this talk



HTTP Headers

Verb
Resource
Version
▶ Headers
Status
Body

There are many more headers than we can cover here.

- Some useful headers that we will discuss later in the course regarding caching:
 - ETag, Date, Last-Modified, Cache-Control, Age
- Some useful headers we will later discuss later in the course regarding security:
 - Strict-Transport-Security, X-Frame-Options, X-Forwarded-Proto
- Transfer-Encoding: chunked can be used to serve up resources whose length is not known
- Headers that begin with X- are not part of the specification, but may be commonly used and “standardized”



HTTP Headers

Verb
Resource
Version
Headers
▶ Status
Body

HTTP Status is provided in the response to indicate the outcome of the request.

- The first digit of a status code classifies it:
 - 1XX - Informational
 - 2XX - Successful
 - 3XX - Redirecting
 - 4XX - Client Error
 - 5XX - Server Error



HTTP Headers

Verb
Resource
Version
Headers
Status
Body

A few of the most common response codes:

- 200 OK: The go-right case.
- 301 Moved Permanently: The client should use the provided new URL moving forward.
 - The new URL will be provided in the Location header.
- 302 Found: You should go to a different URL to get this resource, but it hasn't permanently moved there.
- 403 Forbidden: The request is not authorized
- 404 Not Found: Specified resource could not be found
- 418 I'm a Teapot: April fools day joke
- 500 Internal Server Error: Something crashed.
- 503 Service Unavailable: Temporary failure.



HTTP Body

Verb
Resource
Version
Headers
Status
▶ Body

The HTTP body is where content is delivered.

When used in a request, the HTTP body can have key-value pairs for a POST or a PUT.

Example:

```
POST /comments HTTP/1.1
```

```
Content-Type: application/x-www-form-urlencoded
```

```
Content-Length: 32
```

```
username=andrew&comment=Hello%20World
```



HTTP Body

Verb
Resource
Version
Headers
Status
▶ Body

When used in a response, the body most commonly has the data of the resource.

```
GET /about/ HTTP/1.1
```

```
Accept: text/html
```

```
HTTP/1.1 200 OK
```

```
Content-Type: text/html
```

```
<!DOCTYPE html>
```

```
<html>
```

```
<head>...
```



Demoing the protocol

```
%sudo nc -l 80 #after this, tell chrome to go to localhost
```

```
GET / HTTP/1.1
```

```
Host: localhost
```

```
Connection: keep-alive
```

```
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,*/*;q=0.8
```

```
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_9_5) AppleWebKit/537.36 (KHTML,  
like Gecko) Chrome/37.0.2062.124 Safari/537.36
```

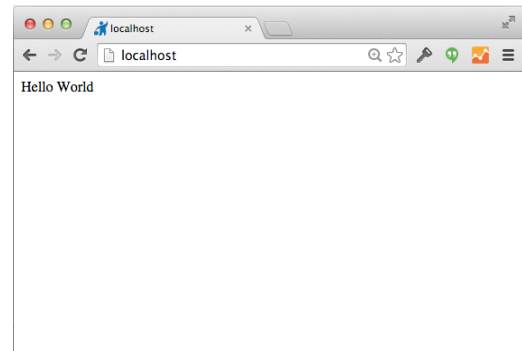
```
Accept-Encoding: gzip,deflate,sdch
```

```
Accept-Language: en-US,en;q=0.8
```



Demoing the protocol

```
%echo "HTTP/1.1 200 OK\nContent-Type: text/html\n\n<html><body>Hello World</body></html>" | sudo nc -l 80
```



Demoing the protocol

```
%echo "GET /about/ HTTP/1.  
1\nAccept: text/html \n\n" | nc  
www.google.com 80
```

```
HTTP/1.1 200 OK  
Vary: Accept-Encoding  
Content-Type: text/html  
Last-Modified: Tue, 26 Aug 2014 10:35:15 GMT  
Date: Tue, 07 Oct 2014 02:42:23 GMT  
Expires: Tue, 07 Oct 2014 02:42:23 GMT  
Cache-Control: private, max-age=0  
X-Content-Type-Options: nosniff  
Server: sffe  
X-XSS-Protection: 1; mode=block  
Alternate-Protocol: 80:quic,p=0.01  
Transfer-Encoding: chunked
```

```
3aae
```

```
<!DOCTYPE html>
```

```
<html class="google" lang="en">
```



Demoing the protocol

```
%echo "GET /about/ HTTP/1.1\nAccept-Language: es\nAccept:\ntext/html \n\n" | nc www.google.com\n80
```

```
HTTP/1.1 200 OK\nVary: Accept-Encoding\nContent-Type: text/html\nLast-Modified: Tue, 26 Aug 2014 10:35:15 GMT\nDate: Tue, 07 Oct 2014 02:38:47 GMT\nExpires: Tue, 07 Oct 2014 02:38:47 GMT\nCache-Control: private, max-age=0\nX-Content-Type-Options: nosniff\nServer: sffe\nX-XSS-Protection: 1; mode=block\nAlternate-Protocol: 80:quic,p=0.01\nTransfer-Encoding: chunked\n\n3954\n<!DOCTYPE html>\n<html class="google" lang="es">
```



Beyond one Request per Connection

Thinking of HTTP as one request per TCP connection can be a useful simplification for reasoning about your application

- In practice this is inefficient. **Why?**



Beyond one Request per Connection

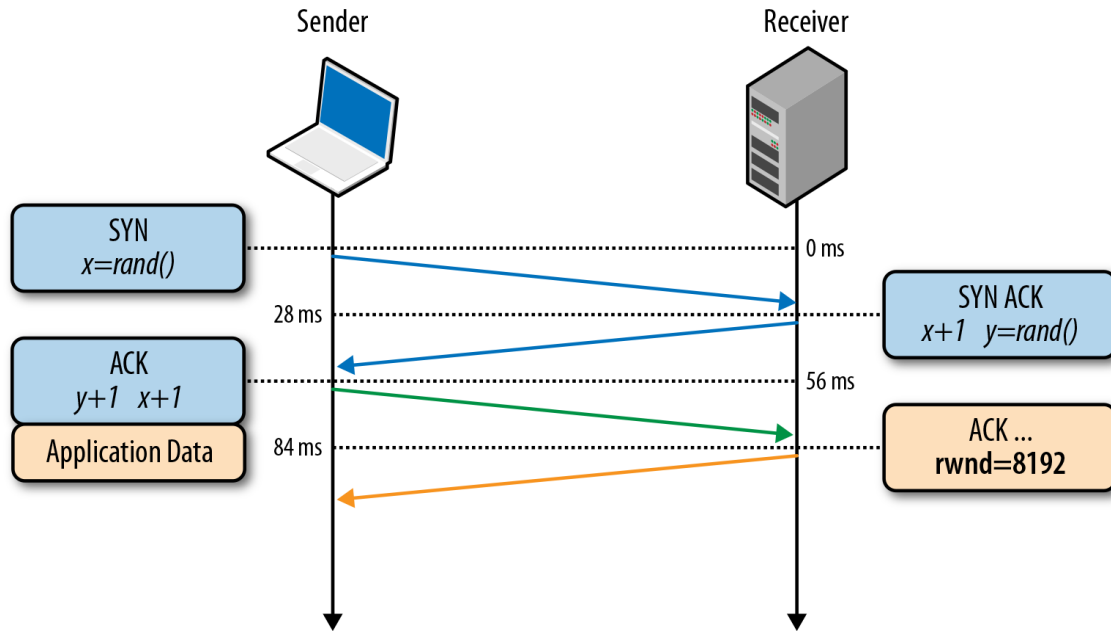
Thinking of HTTP as one request per TCP connection can be a useful simplification for reasoning about your application

- In practice this is inefficient. **Why?**
 - Initial round trips to setup connection
 - TCP connections start out low bandwidth

Lets take a look at both of these...



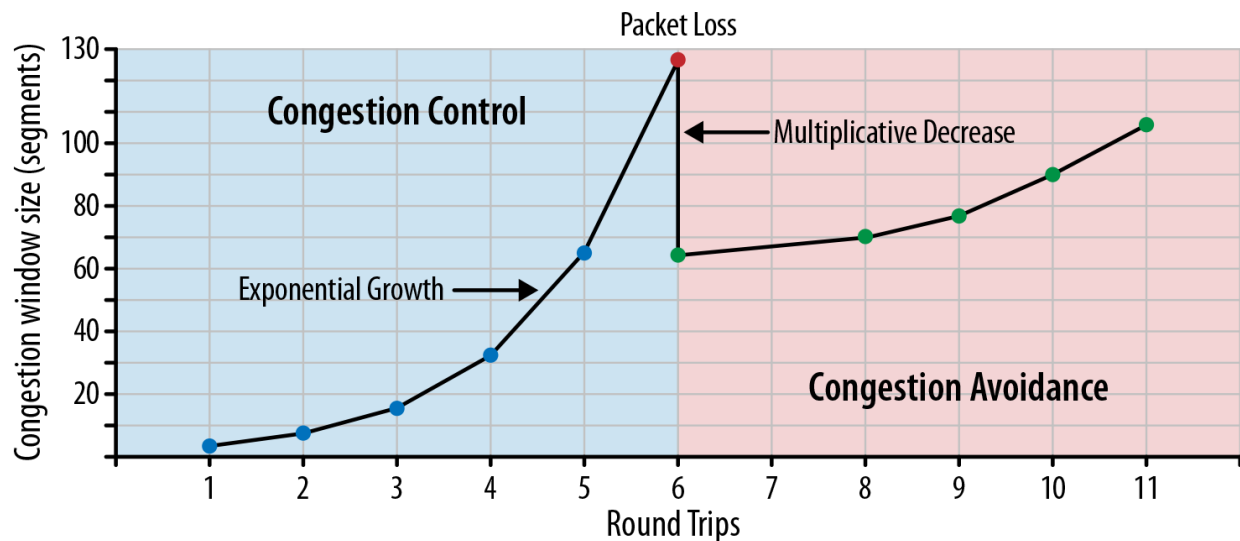
Beyond one Request per Connection



Each TCP connection that is established requires a round trip for setup



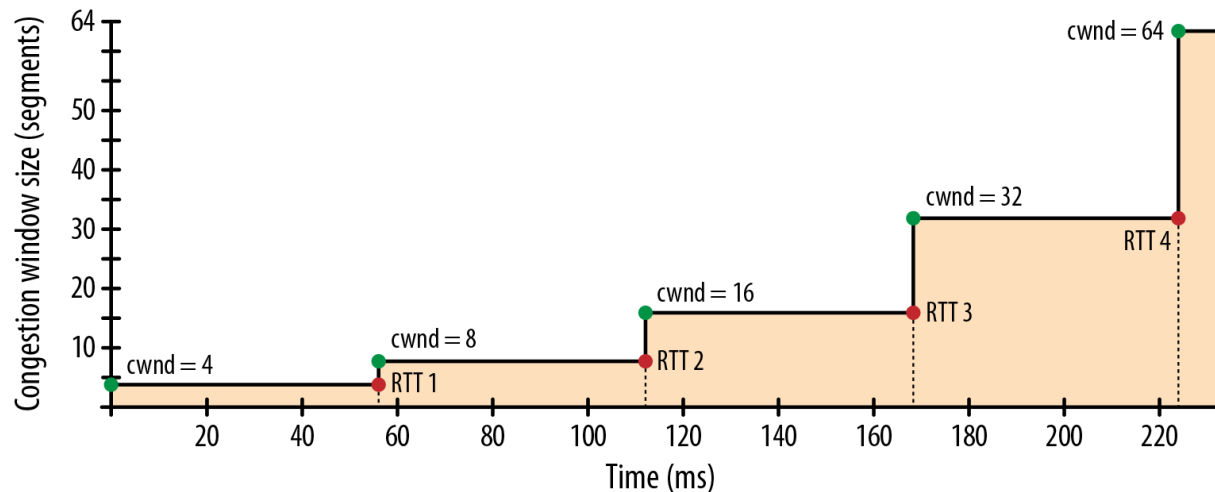
Beyond one Request per Connection



The early phases of a TCP connection are bandwidth constrained



Beyond one Request per Connection



By repeatedly reopening TCP connections, we only use the most constrained part.



Beyond one Request per Connection

HTTP 1.1 introduced connection keep-alive to address this.

- HTTP header exists that is “Connection: keep-alive”, but it is the default behavior as of 1.1
- Simple mechanics:
 - Don't close the socket. Server will expect multiple requests to arrive on the same socket.
 - After receiving one response, send another request



Beyond one Request per Connection

TCP connection #1, Request #1-2: HTML + CSS

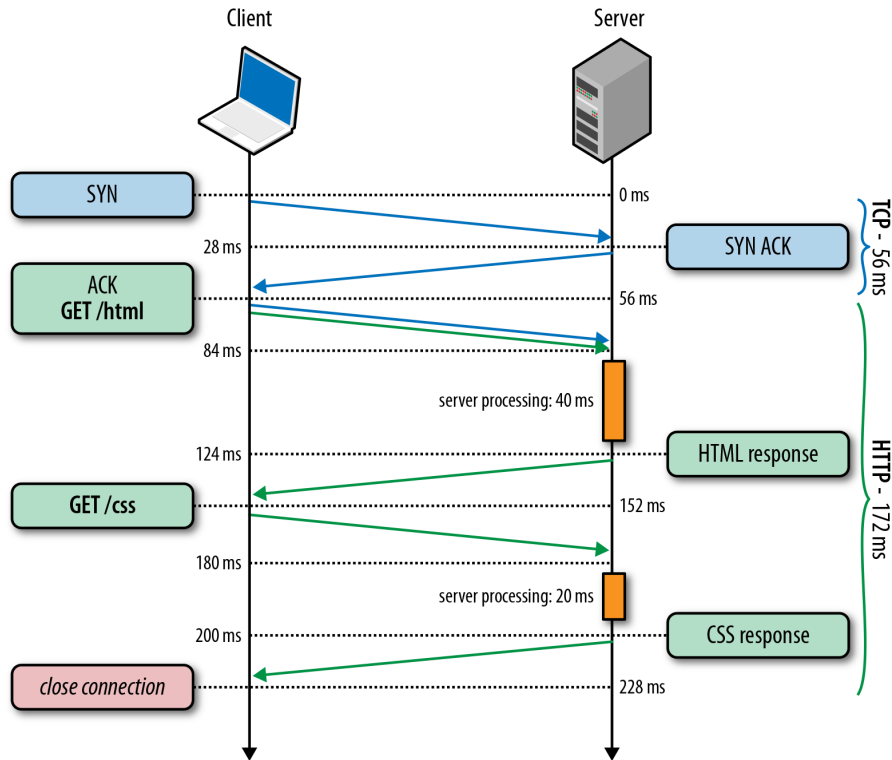


Image Source: “High Performance Browser Networking,”
by Ilya Grigorik



Beyond one Request per Connection

Why not take this a step further?

- Frequently we need many resources from the same server
- Why do we wait for responses before sending subsequent requests?
- Can't we save time on roundtrips if we send our requests without waiting for each response?



Beyond one Request per Connection

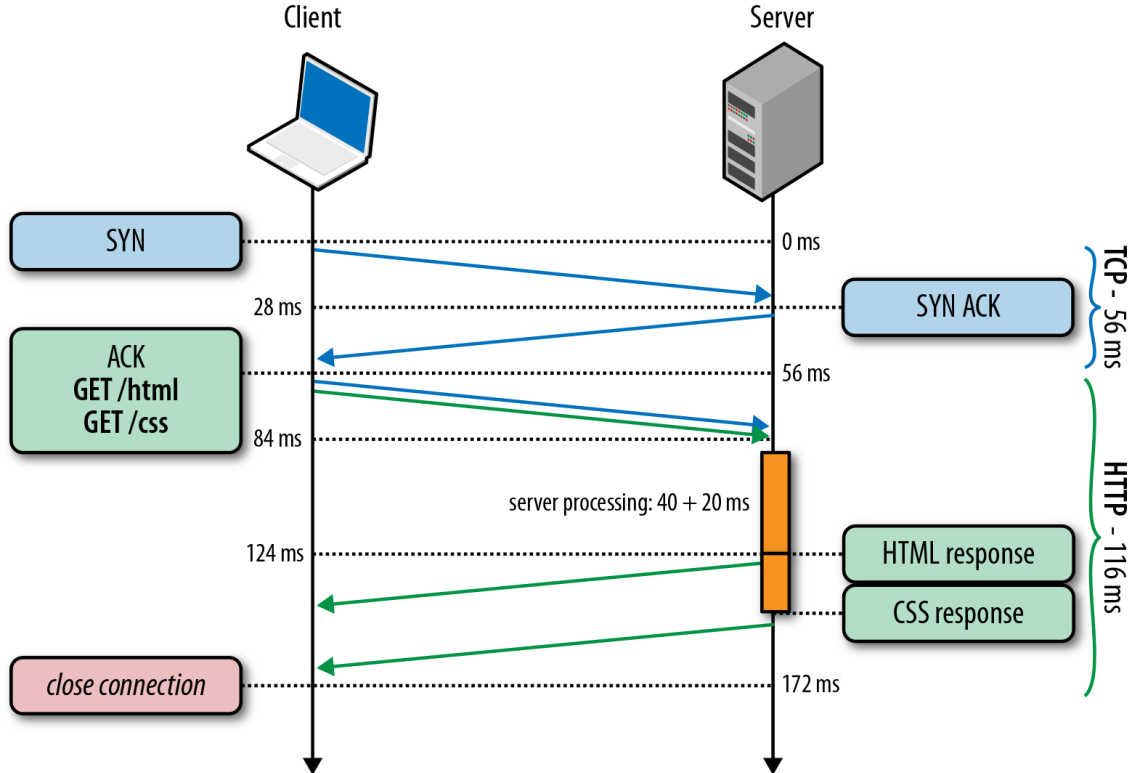


Image Source: "High Performance Browser Networking," by Ilya Grigorik



Beyond one Request per Connection

This is called “HTTP Pipelining”

- It works, but has lots of problems
 - Head of line blocking
 - Failure mechanics
- Due to problems, while support for it exists widely, it is generally not turned on.
- Expect to see this make a comeback in HTTP 2.0



Beyond one Request per Connection

So a browser that needs N resources can establish anywhere between 1 and N TCP connections to get these.

- How many should it use?
 - Too many and you can DoS the site
 - Too few and you prohibit any parallelism
- **Whats the answer?**



Beyond one Request per Connection

So a browser that needs N resources can establish anywhere between 1 and N TCP connections to get these.

- How many should it use?
 - Too many and you can DoS the site
 - Too few and you prohibit any parallelism
- **Whats the answer?**
 - **Six.**



Beyond one Request per Connection

Six connections per server is today's "standard"

- Not part of any actual standard.

If you want to have more, you can use a trick called "domain sharding"

- Set up `www1.foo.com`, `www2.foo.com`, `www3.foo.com`, that all point to the same server
- The browser will treat these as separate servers and open six connections per domain



HTML Explained

Overview of HTML

- Syntax
- Essential tags
- Relationship to CSS



HTML Explained: Syntax

- HyperText Markup Language
 - A markup language takes flat text and annotates it to add structure.
 - HTML uses SGML syntax:

```
<h1>Endangered Species</h1>
```

```
<p class="intro">Why we <i>need</i> to act.</p>
```

- Areas of text are marked up using tags enclosed in <tag>...</tag>
- Tags are nestable
- Tags have key-value attributes

(Markup languages aren't really "languages", rather they are structured data.)



HTML Explained: Essential Tags

HTML documents consist of an all-encompassing `<html>` tag. The logical tree of tags found inside this is referred to as the Document Object Model (DOM)

Within this, the document is divided into the `<head>` and the `<body>`:

```
<html>
  <head>
    <title>My HTML Page</title>
  </head>
  <body> Hello World </body>
</html>
```



HTML Explained: Essential Tags

The HTML header generally contains information about the page that isn't directly rendered:

- CSS
- JavaScript
- Metadata (`title`, `refresh`, etc.)

We will cover CSS in greater detail later this lecture.



HTML Explained: Essential Tags

The body includes most of the content that is seen by the user of the web browser. Tags can be used for formatting and styling, but this is increasingly the role of CSS.

- `h1` - Header
- `p` - Paragraph
- `ul`, `ol`, `li` - Unordered and ordered lists
- `table`, `tr`, `td` - Tabular information
- `span` - An inline grouping mechanism
- `div` - A block-level grouping mechanism



HTML Explained: Essential Tags

The body will also include Anchor tags. The anchor tag is one of the original, central innovations of the world wide web.

You can search `here`.

The links that are created by anchor tags make HyperText.



HTML Explained: Essential Tags

HTML forms

- Author specifies a series of input elements to be presented to the user
- The form is submitted to the specified action, generally as a POST
 - Method doesn't have to be POST
 - Encoding defaults "application/x-www-form-urlencoded"

```
<form action="/communities" method="post">  
  <label for="cn">Name</label><br>  
  <input type="text" name="community[name]" id="cn">  
  <input type="submit" name="commit" value="Submit">  
</form>
```



HTML Explained

HTML elements have some important attributes:

- `id` - A unique identifier can be assigned to a DOM element.
- `class` - Multiple classes can be assigned to DOM elements. There is a many-to-many relationship between classes and DOM elements.

```
<span class="alert,loud" id="flash_message">Error.</span>
```

Classes and IDs can be used to refer to DOM elements by CSS and JavaScript.



Intro to CSS

- Inside the HTML head, we can define styles using the `<style>` tag.
 - (As we will later see, we generally don't style with style tags)

```
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
  </head>
  <body>
    <h1> Hello World </h1>
  </body>
</html>
```



Intro to CSS

- We can style DOM elements in a variety of ways

```
<html>
  <head>
    <style>
      #header {color: blue;}
    </style>
  </head>
  <body>
    <span id="header"> Hello World </span>
  </body>
</html>
```



Intro to CSS

- We can style DOM elements in a variety of ways

```
<html>
  <head>
    <style>
      .alerting {color: red;}
    </style>
  </head>
  <body>
    <span class="alerting"> Hello World </span>
  </body>
</html>
```



Intro to CSS

- We can style DOM elements in a variety of ways

```
<html>
  <head>
    <style>
    </style>
  </head>
  <body>
    <span style="color: red;"> Hello World </span>
  </body>
</html>
```



Intro to CSS

- If we can style in many ways, we can style in contradictory ways
 - What color will the text be rendered below?

```
<html>
  <head>
    <style>
      span {color: blue;}
      .a {color: yellow;}
      #b {color: green;}
    </style>
  </head>
  <body>
    <span class="a" id="b" style="color: red;"> Hello World </span>
  </body>
</html>
```



Intro to CSS

- The precedence order is somewhat complex, but in general...
 - More specific has higher precedence than less specific
 - Example: A style applied to an id-specified `img` tag takes precedence over one applied to all `img` tags
 - Styles specified in the markup itself via the style attribute are higher than those specified in separate CSS files
 - The `!important` annotation can be used to increase the precedence of a CSS rule.



Intro to CSS

Styling is not generally done in-line, either on an element or elsewhere in the markup using the `<style>` tag

Instead, we serve these styles as separate resources and indicate their location to the browser with a link tag:

- `<link rel="stylesheet" href="styling.css" type="text/css" >`

Why is this better?



Intro to CSS

CSS styling can give you limitless control over the appearance of a web application.

While you will use CSS to style your project in this class, CSS really falls outside the core of the course

- Leaning on libraries like Twitter Bootstrap is recommended



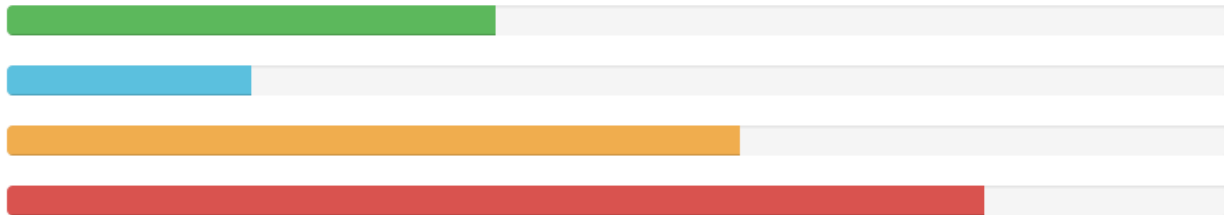
Intro to CSS

Learn more about Bootstrap: <http://getbootstrap.com/>

Contextual alternatives

Progress bars use some of the same button and alert classes for consistent styles.

EXAMPLE

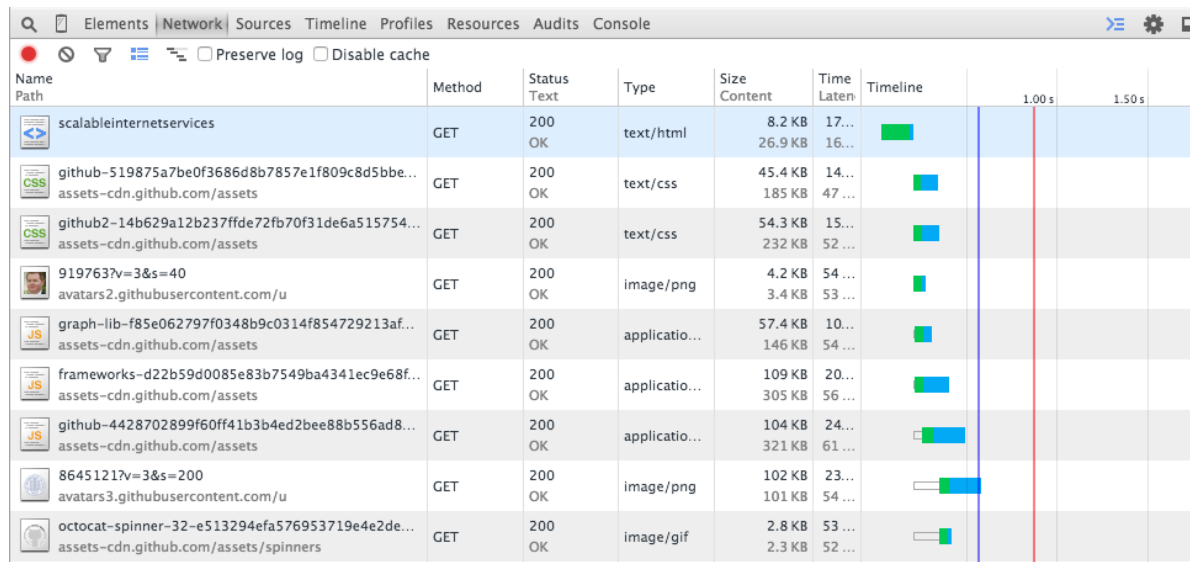


```
<div class="progress">
  <div class="progress-bar progress-bar-success" role="progressbar" aria-valuenow="40" aria-
    valuelmin="0" aria-valuemax="100" style="width: 40%">
    <span class="sr-only">40% Complete (success)</span>
  </div>
</div>
<div class="progress">
```

Copy



Conclusion



Name Path	Method	Status Text	Type	Size Content	Time Laten	Timeline
scalableinternetservices	GET	200 OK	text/html	8.2 KB 26.9 KB	17... 16...	
github-519875a7be0f3686d8b7857e1f809c8d5bbe... assets-cdn.github.com/assets	GET	200 OK	text/css	45.4 KB 185 KB	14... 47...	
github2-14b629a12b237fde72fb70f31de6a515754... assets-cdn.github.com/assets	GET	200 OK	text/css	54.3 KB 232 KB	15... 52...	
919763?v=3&s=40 avatars2.githubusercontent.com/u	GET	200 OK	image/png	4.2 KB 3.4 KB	54... 53...	
graph-lib-f85e062797f0348b9c0314f854729213af... assets-cdn.github.com/assets	GET	200 OK	applicatio...	57.4 KB 146 KB	10... 54...	
frameworks-d22b59d0085e83b7549ba4341ec9e68f... assets-cdn.github.com/assets	GET	200 OK	applicatio...	109 KB 305 KB	20... 56...	
github-4428702899f60ff41b3b4ed2bee88b556ad8... assets-cdn.github.com/assets	GET	200 OK	applicatio...	104 KB 321 KB	24... 61...	
8645121?v=3&s=200 avatars3.githubusercontent.com/u	GET	200 OK	image/png	102 KB 101 KB	23... 54...	
octocat-spinner-32-e513294efa576953719e4e2de... assets-cdn.github.com/assets/spinners	GET	200 OK	image/gif	2.8 KB 2.3 KB	53... 52...	

After today, you should have all the basic tools you need to understand output like this



For Next Time...

For Thursday:

- Read and do ch. 1 and 2 from AWDR, get Rails setup
- Continue Ruby Code Academy (finish it by next week)
 - <http://www.codecademy.com/en/tracks/ruby/>

