CSCI 571 Lecture Notes

Lec1 Course Introduction

Course objectives

Core technologies

- HTML and CSS
- HTTP
- Web servers
- Server-Side programming using JavaScript and Python
- Client-side programming using JavaScript and JS Frameworks
- Ajax Development Style

New technologies:

- Responsive Website Design (Bootstrap, etc.)
- JS Frameworks (Angular, React and Node.js)
- Web Services (REST)
- Web security, TOR, Dark web
- Native Mobile frameworks (Java / Android and Swift / iOS)
- React (native)
- Cloud computing (AWS, GCP, Azure)

- Serverless Applications, Containers, Docker
- AWS Lambda, Google Cloud Functions, Azure Functions

Sample Web Sites

1. Modest Size:

   www.fogdog.com:

   - Online sale of sporting goods

   Solution:

   - Commodity hardware
   - Linux server running Apache 2.0 web servers
   - Using MySQL data base
   - Move to www.ebay.com/str/fogdog:
     - F5 BIG-IP OS, Apache 2.0.64 web server
2. Medium Size:

   www.autobytel.com:

   - New/used car sale (now AutoWeb)

   Original Microsoft solution:

   - Microsoft Windows Server
   - Microsoft IIS 7.5 web server
   - Microsoft SQL server database
   - Akamai CDN

   Today:

   - Windows Server
   - Microsoft IIS/7.5 web server
3. Large Size:

   www.etrade.com

   - online investing services and resources

   Solution:

   - IBM 90 xSeries running Linux/**Citrix Netscaler**, **Apache** and Tomcat web servers, AWS Route 53 (DNS)
   - Hardware facility for load balancing and redundancy
   - Oracle database system
   - Proprietary programming systems

Web server farms

- Recently all serious web sites were maintained using web **server farms**:
  - A group of computers acting as servers and housed in a single location;
  - Internet Service Providers (ISP’s) provide web hosting services using a web server farm
- Hardware and software is used to load balance requests across the machines
- Other issues addressed:
  - Redundancy
    - Eliminate single point of failure
    - Backup and failover strategy
  - Security: secure areas behind firewalls which monitor web traffic, network address translation, port translation, SSL

Popular Web Hosting Services:

- For individuals and small business:
  - 1 & 1
  - GoDaddy.com
  - Yahoo
- For companies willing to pay MUCH higher cosets:
  - Rackspace
  - Network Solutions
- Reviews and price comparisons:

Cloud Computing

- **Cloud computing** is Internet-based computing, shared resources, software, and information are provided to computers and other devices **on demand**, like the electricity grid
- User does not need to be expert in the infrastructure
- Cloud computing providers applications online that are accessed from another Web service/software
  - software and data are stored on servers
- Major cloud service provider:
  - Amazon
  - Google
  - Microsoft
  - Salesforce
  - Skytap

    - HP
    - IBM
    - Apple iCloud

Example: Amazon's Elastic Compute Cloud

- A web service providing resizable compute capacity
- **elastic:** the service instantly scales to meet demand with no up-front investment
- user need to create Amazon Machine Image (AMI)
- Amazon’s Simple Storage Service (S3): large- scale, persistent storage

Example: Google Cloud Platform

- Basic compute, storage, big data services, massively scalable gaming solutions, mobile application backend, and Apache Hadoop
- App Engine: A platform for building scalable web applications and mobile backend, scales automatically in amount of traffic it receives
- Compute Engine: Offers predefined virtual machine configurations
- Google uses software-defined networking technology to route packets across the globe and enable fast edge-caching so that data is where it needs to be to serve users

Serverless Architecture

- Internet based systems, application development noes not use the usual server process
- rely on combination of:
    - 3-party services, or Backend as a Service (BaaS)
    - Client-side logic
    - Service hosted remote procedure calls, or Function as a Service (FaaS)
- **AWS Lambda** is implementations of FaaS

Web Browsers Use Standard Layout Engines

- **WebKit:** used to render web pages, open source
    - used by Chrome and Safari web browsers
- **Gecko:** layout engine of Firefox web browser
    - used to display web pages and application's user interface

- provide rich programming API
    - Originated with Netscape Communications Corporation
- Some web kits and the browsers that use them
    - **Gecko-based**: FireFox (Mozilla), Flock, Netscape
    - **Trident-shells**: Internet Explorer (Microsoft)
    - **EdgeHTML**: Edge (Microsoft), fork of Trident 7 Jan 2020 moves to Chromium
    - **WebKit-based**: Chrome and Android (Google), Midori, Safari and Mobile Safari (Apple), Symbian^3 (Nokia) and many others
    - **Chromium:** Chrome
    - **Presto-based**: Opera, Nintendo DS, Opera Mini, Opera Mobile
    - **Java-based**: HotJava, Lobo

Web Browsers can:

1. Mouse-driven graphical user interface
2. Display of
    - Hypertext documents (HTML standard)
    - Text with fonts/styles/point_size
    - Foreign-language character sets (ISO-8859)
    - Forms composed of edit boxes, check boxes, radio boxes, lists, text areas
    - Graphics in different formats
3. Invoke helper applications and plug-ins (Obsoleted in HTML5):
    - *Adobe Acrobat* (pdf files)
    - *Windows Media Player* (digital sound files)
    - *Adobe Flash Player* (video) Retired in 2020
4. Communicate over a secure channel (SSL)
5. Maintain/Exchange digital certificates
6. Run scripts in JavaScript
7. run Java applets and Active X components (**also obsoleted in HTML5**)

Browser rank: Chrome > Firefox > Edge/IE > Safari > Opera

85% of browsers use **WebKit** !!!!!

Internet Explorer Browser Caching:

- History: Links/URLs accessed before
- Disk cache: Temporary internet files
- Memory cache: Session-based information that is cached during the session

- Offline content: Web content is downloaded when online and viewed offline

Evolution of Web Sites

- 1st gen (1991):
  - Client-centric, Static
  - HTML, Scripts, CGI
- 2nd gen (1997):
  - Server Applications, Databases, Dynamic web pages
  - ODBC, JDBC ASP, Applets, ActiveX
- 3rd gen (2000):
  - Web services Multiple layers, Business and service Integration
  - XML, WML, SQL, .NET, COM+, Beans
- 4th gen (2005):
  - Service Oriented Arch (SOA), Client-centric
  - Ajax, Web 2.0, JSON
- 5th gen (2008):
  - Multi-platform (desktop, tablet, phone), Client-centric
  - HTML5, CSS3, JS, gestures navigation
- 6th gen (2014):
  - IoT, Wearables, Cloud computing, Serverless Arch (Baas, Faas)
  - JS Frameworks, AWS, GCP, Azure, Microservices containers

Lec2 Internet Trends and Web Basics

Internet Trends

- Internet:__ a global digital infrastructurethat connects computers
- **WWW:** a mechanism that unifies the retrieval and display of a subset of data on the Internet
- **Intranet:** a local/global information structure that connects an organization internally. (also use Web technologies now)
- **Extranet:** a private network that uses the public telecommunication system to securely share part of a business's information/operations

Recent trends in Internet Development:

- Growth:
  - number of users connected

    - Smartphone use (iOS/Android)
    - digital data (photo/video)
    - Social media
    - Internet use from Mobile/tablet (平板和移动端) over desktop/laptop
    - use of cloud
- Derease: dominance of Microsoft Windows

Host counts in 2019 > 1,012 million

IoT

IoT: the Internet of Things

IoT Protocols

- Device/thing to Gateway:
    - ZigBee: Wireless sensors
    - BLE: Wireless sensors
    - ModBus (Serial or TCP)
- Gateway to Server:
    - ModBus TCP: common
    - OPC: common for industrial assets
    - HTTP: JSON over HTTP
    - MQTT: Consumer oriented, promising

IoT platforms

- Amazon IoT
    - Physical/Shadow Device (Persisted JSON State)
    - MQTT Endpoint
    - Rules
    - AWS Connectivity
- GE Predix 2.0 (PaaS)
    - CloudFoundry, HDP
    - Asset Model, Machine Connectivity, Time Series DB, Analystics Plugin (BPMN)
- PTC ThingWorx
    - Originally HMI for TCP-connected devices
- Xively
    - Device connectivity, time series database, connectivity to applications

    - Popular with Arduino developers

Domain Name System (DNS)

DNS resolution:

- when visit a website, the computer need to perform DNS lookup
- Complex pages require multiple DNS lookups before loading
- DNS latency mainly from:
    - round-trip time to make the request and get the response, due to network congestion, overloaded servers, denial-of-service attacks
    - Cache misses which cause recursive querying of other name servers
- Google has introduced **Google Public DNS**
    - use 8.8.8.8 and 8.8.4.4
    - handles more than 70 billion requests ***a day!***
    - Google also has IPv6 addresses
- Another alternative is **opendns.com**
    - a global network of DNS resolvers to speed resolution
    - Free for basic service, but upgrades cost

Internet Domain Names

- DNS is a mapping to/from IP addresses to domain names
    - Defined in RFC 1034, 1035
- 13 top level root name services
- founded in 1998, ICANN is the organization in charge of maintaining the DNS system

Top Level Domain Names (TLDs)

- **In 1984**, **originally** divided into **6** logical categories
    - com
    - edu
    - gov
    - mil
    - net
    - org

- **In 2001** new top level domain added:
    - biz, info, name, musem, coop, aero, pro, xxx
- **In 2009** ICANN agreed to accept internationalized domain names, encoded as Unicode
- **In 2011** ICANN announced expansion of TLDs, giving requirements for anyone wanting to establish one

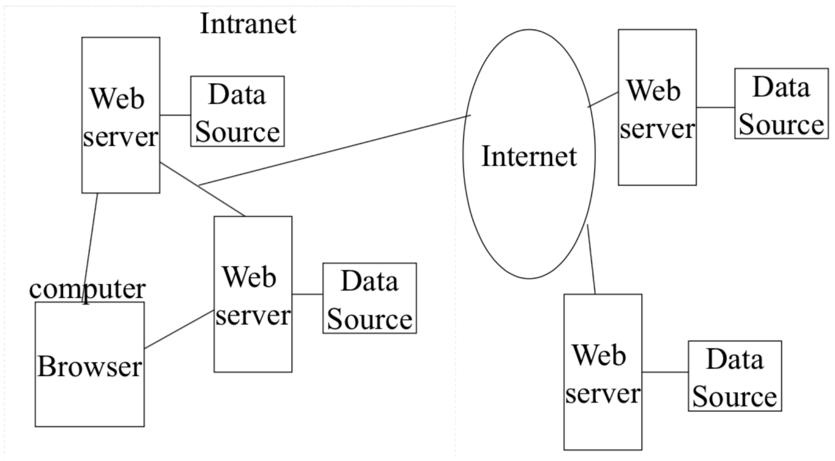
In 2019 `.com`, `.net` are the most popular top name domain.

World Wide Web

Define:

- A wide-area hypertext, multimedia information retrieval system that provides access to a large universe of documents
- A uniform way of accessing and viewing some information on the Internet
- WWW subsumes the capabilities of ftp, gopher, wars, and news

Graphical View of the WWW



Major Technology Components

- Client/server architecture: client programs interact with web servers
- Network protocol: HTTP understood by browsers and web servers
- Addressing system (Uniform Resource Locators)
- Markup Language: support HyperText and multimedia

WWW server

- Web browsers/servers communicate according to a protocol (HTTP)
    - current HTTP is version 1.1
- The Web server is a software system running on a machine often called the Web server
- A web server **can**
    - receive/reply to HTTP requests
    - retrieve documents from specified directories
    - run programs in specified directories
    - handle limited forms of security
- A web server **does not**
    - know about the contents of a document, links in a document, images in a document or whether a particular file, e.g. a *.gif file, is in the correct format

Uniform Resource Locator (URL)

- A mechanism whereby an Internet resource can be specified in a single line of ASCII text
- RFC 1738

General description of URL:

1. Scheme
    - http:, ftp:, news:, wais:
2. Double dash //
3. Internet domain name: usc.edu
4. Port number (optimal)
5. Path

Markup Languages

- HTML: hypertext markup language, specifies document layout and the specification of hypertext links to text, graphics and other objects
- Browsers display text and graphics using the markup as guidance

> HyperText: Regular text, with the additional feature of links to related documents

Lec3 HTML

What is HTML?

- hypertext markup language (HTML) can describe:
    - The display and format of text
    - The display of graphics
    - Pointers to other html files
    - Pointers to files containing graphics, digitized video and sound
    - Forms that capture information from the viewer
- HTML: by **Tim Berners-Lee** of CERN around 1990
- understand by WWW browsers

Version of HTML

- 1990 V0: original one
- V1: highlighting & images
- 1995 V2: V0 + V1 + forms
- 1997 V3.2: released by W3CW, tables
- 1999 HTML4.01
- 2014 HTML5: vocabulary & APIs
- 2017 HTML5.2
- 2019: **HTML Living Standard**
- W3C & WHATWG agreement

HTML General Structure

- HTML documents have a **head** and **body**
- A leading line indicates the version of HTML

  ```
  <!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0//EN" "http://www.w3.org/TR/REC-html40/strict.dtd">
  ```

- **comments in HTML:** `<!--this is comment-->`, cannot be nested

> IE/Firefox are tolerant browsers:
>
> - not insist that the HTML document begin and end with `<HTML>`
> - `<HEAD>` and/or `<BODY>` tags are not required

- HTML chracter set

    - HTML uses **Universal Character Set (UCS)**, defined in ISO10646
    - Character references:
        - **numeric**
        - character **entity**
- HTML anchor
    - to designate a **link to another document** or to a specific place in the **same document**
    - anchor `name`: **Unique** & **String matching**
    - anchor using `id` attribute: use `href=#id` where `id` is from other tag
    - `id` and `name` attributes share the same name space (cannot use same as each other)
- Universal Resource Identifier (**URI**):
    - **scheme** of the mechanism used to access the resource
    - name of the machine **hosting** the resource
    - name of the **resource** itself, given as a **path**

    > - *Fragment identifiers* are URIs that refer to a location within a resource
    >
    >   e.g. http://www.usc.edu/dept/cs/index.html**#section2**

- `link` element in `<head>` part: provide a variety of information to search engines
    - Links to **alternate versions** of a document, written in another human language
    - Links to alternate versions of a document, designed for **different media**
    - Links to the starting page of a collection of documents
    - Links to style sheets and "**media queries**" used in Responsive Web Design
- Create graphic:
    - image source:
        - digital camera/phone
        - graphic editor
        - scanner
    - image format:
        - **x-pixelmaps**: 256 colors
        - **GIP**
        - **JPEG**: includes image compression; for photographic images
        - **PNG** (portable network graphics): lossless compression; patent-free compared with GIF & TIFF
    - why `alt` attribute in `<img>` tag? replace an image with text, if the image is unavailable or a text browser is used
    - active image: with a border around it and the cursor changes shape when passed over
    - `usemap` attribute in `<img>` tag
- `<meta>` element: insert Name/Value pairs describing document properties
    - `<meta>` & robotic exclusion: `<meta name="robots" content="[no]index,[no]follow">`

        - index: whether the search engine can index the page
        - follow: whether the web crawler can follow links contained by the page
- Why validate HTML?
    - Browsers display HTML differently
    - Browsers treat HTML errors differently

Lec4 HTML: Style Sheets

- start from HTML4.x
- style sheets specify:
    - the amount of white space between text or between lines
    - the amount lines are indented
    - the colors for text/backgrounds
    - font size and text style
    - the precise position of text/graphics
- Style sheet language: `CSS`, `XSL`
- express style within HTML:
    - `<style>` element and `style` attribute
    - `<link>` to point to external style sheets
        - combining style information from multiple sources, called cascading

          > There is a defined order of precedence where the definitions of a style element conflict

> **Pre-defined color** names
>
> | | |
> |---|---|
> | Black="#000000" | Silver="#C0C0C0" |
> | Gray="#808080" | White="#FFFFFF" |
> | Maroon="#800000" | Red="#FF0000" |
> | Purple="#800080" | Fuschia="#FF00FF" |
> | Green="#008000" | Lime="#00FF00" |
> | Olive="#808000" | Yellow="#FFFF00" |
> | Navy="#000080" | Blue="#0000FF" |
> | Teal="#008080" | Aqua="#00FFFF" |

Use inline stle attribute

```
<HTML>
   <HEAD>
   <TITLE>Setting Body Attributes</TITLE>
   </HEAD>
   <BODY style="font-size: 20pt;background: green; color: fuchsia">
   The nine planets of the solar system ...
   </BODY>
</HTML>
```

Use `<style>` element

```
<HTML>
<HEAD>
  <TITLE>The Solar System</TITLE>
  <STYLE type="text/css">
    BODY {text-align: center}
  </STYLE>
</HEAD>

<BODY>
  <P>The nine planets of the solar system are <B>mercury, venus, earth, mars,
jupiter, saturn, uranus, neptune and pluto.</B></P>
  <P>The very nearest star is about <I>7,000</I> times farther away than pluto is
to our sun.</P>
</BODY>
</HTML>
```

- `ID` attribute can only be used once in the entire document
- `class` rule preceded by `.` and applied to multiple elements
- Values assigned to `ID` and `class` are case sensitive

Composite Styles

```
font-family: Verdana, Arial, Helvetica, sans-serif; font-size:small;
font-style:normal;
font-variant:small-caps;
font-weight:bold;
line-height:2em;
```

is equal to

```
font: normal small-caps bold small/2em Verdana, Arial, Helvetica, sans-serif;
```

`DOCTYPE` directive

- Instructs modern browsers to work in ‘standards compliant mode
  - Your web page will look the same in **all** browsers – Browsers turn off their proprietary extensions
  - Fonts are rendered in the same way
    - For example, **font-size: small**, is rendered the same size on all browsers
- **HOWEVER**, if you do not specify a `!DOCTYPE`, browsers work in `Quirks` mode
  - Internet Explorer will display fonts larger than standards mode
  - IE Uses the ‘broken box model’
    - Measures the dimensions of a box using the inner size, not the outer size as in standard mode

Style Sheet Media Types

- Enable authors to create documents for different media types:

```
<HEAD>
<STYLE type=text/css media=projection>
H1 {color:blue}
</STYLE>
<STYLE type=text/css media=print>
H1 {text-align:center}
</STYLE>
</HEAD>
```

- Used in CSS3 for **media queries**

```
<style>
@media all and (min-width:500px) { ... }
@media (min-width:500px) { ... }
</style>
```

```
<link rel="stylesheet" type="text/css" media="screen and (max-device- width:
480px)" href="min.css" />
```

- recognized media types:

  `all`, `braille`, `embossed`, `handheld`, `print`, `projection`, `screen`, `speech`, `tty`, `tv`, `3d-glasses`

Pseudo Elements and Classes

- pseudo-classes
  - **:link –** a normal, un-visited link
  - **:visited –** a link the user has visited
  - **:hover** - a link when the user mouses over it
  - **:active** - a link the moment it is clicked
  - **:lang** - selects every `<p>` element with a lang attribute
  - **:focus** - selects the input element which has the focus
  - **:first-child** - select every `<p>` elements that is the first child of its parent
- pseudo elements
  - **:first-line**, add a special style to the first line of a text
  - **:first-letter**, add a special style to the first letter of a text
  - **:before**, to insert some content before the content of an element
  - **:after**, to insert some content after the content of an element

Properties of Style Setting

1. Inheriting Style Properties

Some CSS property values set on parent elements are *inherited by their child elements*, and some aren't.

- `<DIV>` and `<SPAN>` tags have no initial presentation properties
  - **exception**, line break before and after a `<DIV>` tag – `<SPAN>` applies to **inline** elements (example: `<b>`)
  - `<DIV>` applies to **block** elements (example: `<p>`)
- With CSS, properties such as text-align are "inherited" from the parent element

2. Precedence (specificity)

Specificity is how the browser decides which rule applies *if multiple rules have different selectors* but could still apply to the same element.

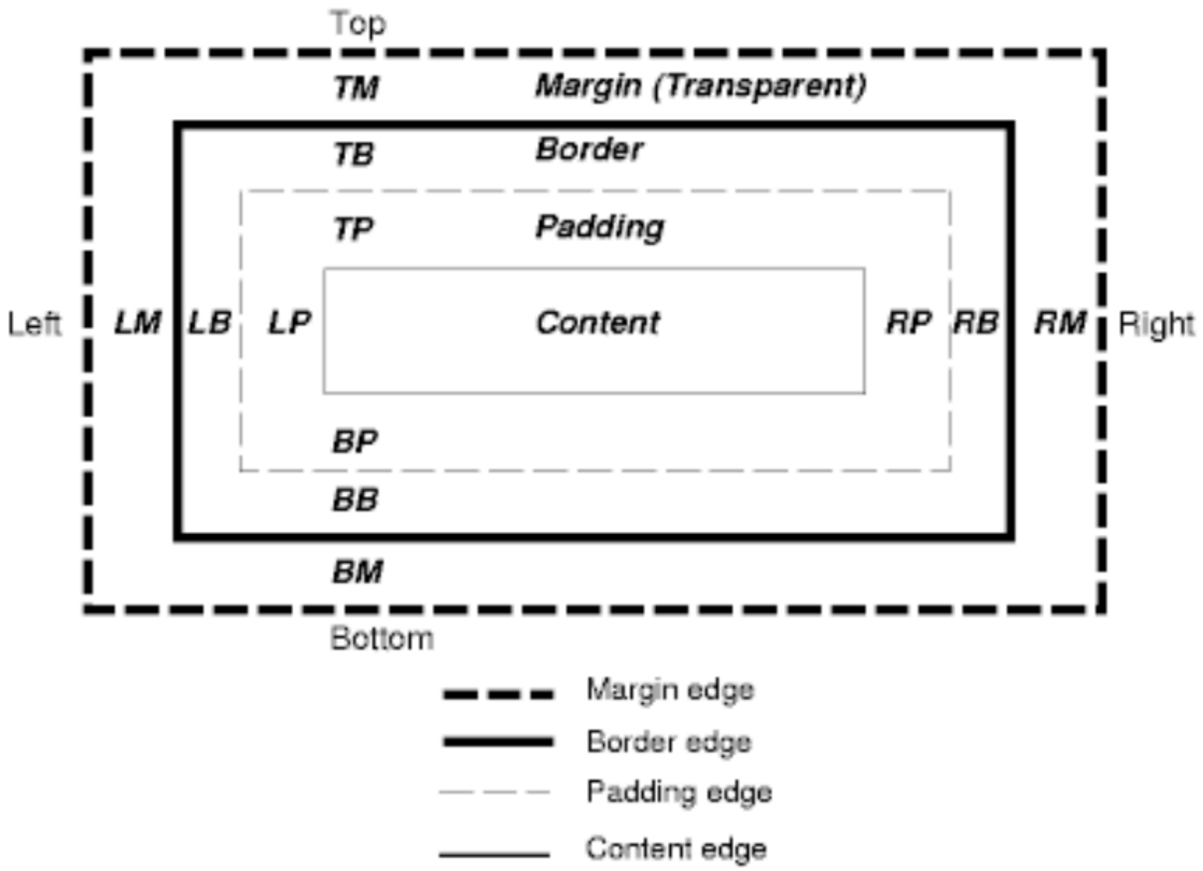
- The more precise a specification is, the higher the precedence
- a style for tag.class has higher precedence than one for .class, which has higher precedence than a style for the tag itself
- styles defined using a `style` attribute (inline) have highest precedence
- styles defined using `<STYLE>` element have next highest precedence
- styles defined in a separate file, e.g. special.css, have lowest precedence

3. Cascade

At a very simple level this means that the *order of CSS rules matter*; when two rules apply that have equal specificity the one that comes *last* in the CSS is the one that will be used.

Box Model

Each box has a **content** *area* (e.g., text, an image, etc.) and optional surrounding **padding**, **border**, and **margin** areas.



```
margin: 10px 5px 15px 20px;
```

means:

top margin is 10px
right margin is 5px
bottom margin is 15px
left margin is 20px

CSS Vendor Prefixes

The CSS browser prefixes are:

- – Android: -webkit-
- – Chrome: -webkit-
- – Firefox: -moz-
- – Internet Explorer: -ms-
- – iOS: -webkit-
- – Opera: -o-
- – Safari: -webkit-

Reset CSS

- A **CSS Reset** is a short, often compressed (minified) set of CSS rules that *resets* the styling of all HTML elements to a consistent baseline.
- The goal of a reset stylesheet is to reduce browser inconsistencies in things like default line heights, margins and font sizes of headings, and so on.

Lec5 JavaScript Basics

- JavaScript has 2 distinct systems
  - server-side JavaScript runs on Web servers
  - client-side JavaScript runs on Web browsers\
- JavaScript syntax resembles C, C++, and Java
- Developed in 10 days by **Brendan Eich**, in **May 1995**
- originally named as **Mocha**
- renamed as **LiveScript**, then **JavaScript**

JavaScript is embedded in HTML:

- in the body

```
<HTML>
<HEAD>
</HEAD>
<BODY>
<SCRIPT LANGUAGE="JavaScript">
document.write("Last updated on " + document.lastModified + ". ")
</SCRIPT>
</BODY>
</HTML>
```

- in the `<head>` as a deferred script

```
<HTML>
<HEAD>
<SCRIPT LANGUAGE="JavaScript">
//the Javascript here creates functions for later use </SCRIPT>
</HEAD>
<BODY>
</BODY>
</HTML>
```

Event Handlers

- Mouse events
  - `onclick`
  - `onblclick`
  - `onmouseover`
  - `onmouseout`
- Keyboard events
  - `onkeydown`
  - `onkeyup`
- Object events
  - `onload`
  - `onunload`
  - `onresize`
  - `onscroll`

What JavaScript can do?

Designed for **manipulating web pages**, but can also be general-purpose language.

- Control Web page appearance and content (intended)
- Control the Web browser, open windows, test for browser properties
- Interact with document content
- Retrieve and manipulate all hyperlinks
- Interact with the user, sensing mouse clicks, mouse moves, keyboard actions
- Read/write client state with cookies

Limitations of Client-side JavaScript:

- **was** difficult to draw graphics
  - has been dramatically improved in the latest versions
- No access to the underlying file system or operating system
- Unable to open and use arbitrary network connections
- No support for multithreading
- **was** not suitable for computationally intensive applications
  - has been improved in the latest versions

JavaScript

Basics of the Language

- **case-sensitive** (HTML is not case-sensitive)
- **ignores** spaces, tabs, newlines (can be **minified**)
- Semicolon is optional
- C and C++ style comments are supported

Literals

- **numbers**
- **boolean**
- **strings**: immutable (cannot be changed after created)
  - string properties: `str.length`, `str.tolowerCase`, `str.toupperCase`, `str.indexOf`, `str.charAt`, `str.substring`

Variables

- **scope**:
  - Any variable outside a function is a **global** variable and can be referenced by any statement in the document
  - Variables declared in a function as “var” are **local** to the function
    - if var is omitted, the variable becomes global

Arrays

- **array properties**: 1 dimensional, indexed from zero
- `arr.length`
- Arrays are **sparse**: most elements are not allocated after initiation
- loop
  - `for (i=0; i<len; i++) {}`
  - `for (x in person) {}`
  - `while (condition) {}`
- built-in methods:
  - `concat()`
  - `indexOf()`
  - `pop()`
  - `push()`
  - `reverse()`

Object

- Objects can be nested within objects
- predefined object:
  - `Array object`
  - `Date object`
  - `Function object`
  - `Math object`
  - `RegExp object`
  - `String object`

Popup Boxes

- `alert()`, `confirm()`, `prompt()`

Common mistakes

- **Undefined may not be null** : use `!==` to test, will fail if use `!=`
- **cannot overload a function**: the latest-defined version of function will be used
- **Undeclared variables are global** : if a variable is NOT declared using `var`, then it is global

ECMAScript

- JavaScript now controlled by the ECMA standard body
- **ECMA** stands for **European Computer Manufacturers**
- First language specification, ECMA-262, a.k.a. ECMAScript, approved in 1997, closely resembles Netscape JavaScript 1.1
- Current language specification is **ECMA-262, 10****th** **Edition, June 2019, ECMAScript © 2019**

Lec6 JavaScript Object Notation （JSON）

What is JSON?

- **JSON**, short for **JavaScript Object Notation**, is a lightweight data interchange format
- JSON format is often used for transmitting structured data over a network connection in a process called **serialization**

Brief History

- JSON was based on a subset of the JavaScript programming language

How to use the JSON format?

A JSON file allows one to load data from the server or to send data to it.

Working with JSON involves three steps:

1. the browser processing: the content of a JSON file or the definition of JSON data is assigned variavle, and this variable becomes an object of the program

2. the server processing: a JSON file on the server can be operate upon by various programming languages, and may even convert it into classes and attributes of the language
3. the data exchange between them:
    - loading JSON file from the server may be accomplished in JavaScript in several ways:
        - directly including the file into the HTML page, as a JavaScript .json external file
        - loading by a JavaScript command
        - using XMLHttpRequest
    - To convert JSON into an object, it can be passed to the JavaScript eval() function
    - Sending the file to the server may be accomplished by XMLHttpRequest. The file is sent as a text file and processed by the parser of the programming language that uses it

JSON Basic Data Types

- String
- Numbers
- Booleans
- Object: **unordered** containers of **key/value** pairs
- Array: **ordered** sequences of values, indexing is not mentioned in JSON (an implementation can start array indexing at 0 or 1)
- Null

> **Array vs Object**
>
> - Use objects when the key names are arbitrary strings
> - Use arrays when the key names are sequential integers

JSON is Not XML !!!

JSON uses less data to represent the same information than XML!!

Rules for JSON Parsers

- the decoder must accept all well-formed JSON text
- the decoder may also accept non-JSON text
- the encoder must only produce well-formed JSON text

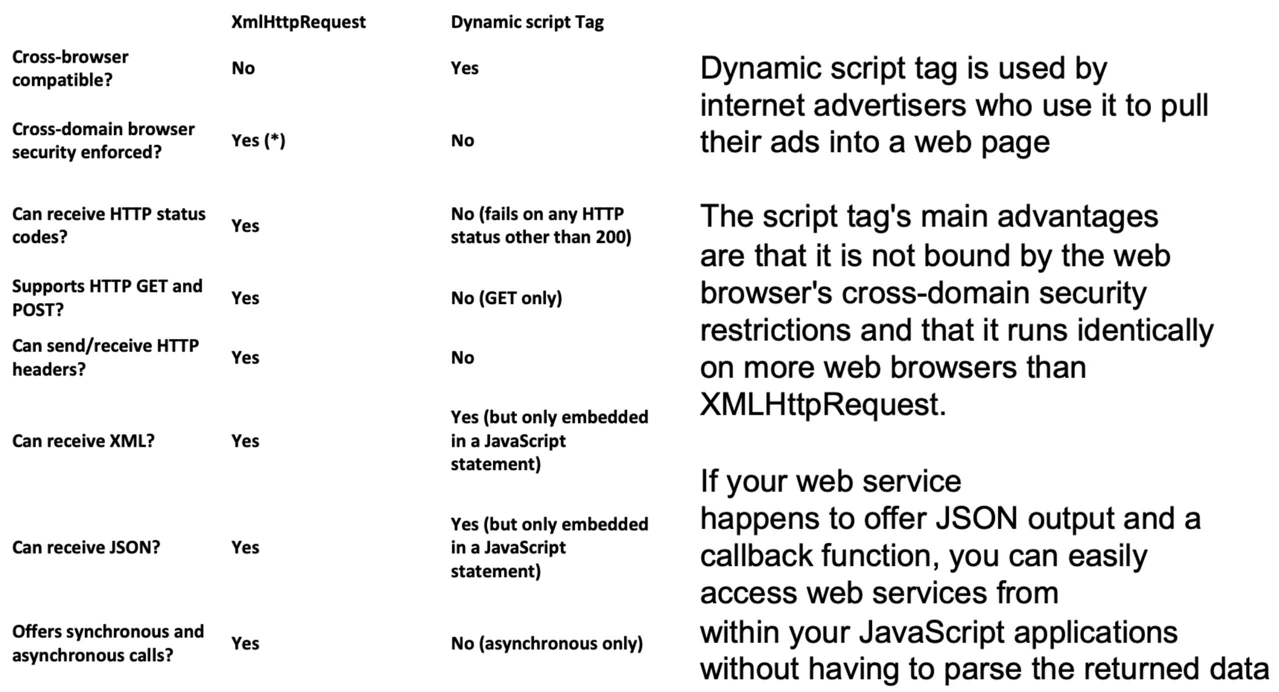
Same Origin Policy

- `same protocol` + `same host` + `same port`
- Same origin policy is a security feature that browsers apply to client-side scripts
- It prevents a document or script loaded from one “origin” from getting or setting properties of a document from a different “origin”

JSON: the Cross-Domain Hack

- JSON and the `<script>` tag provide a way to get around the Same Origin Policy
- The src attribute of a script tag can be set to a URL from any server, and every browser will go and retrieve it, and read it into your page
- So a script tag can be set to point at a URL on another server with JSON data in it, and that JSON will become a global variable in the webpage
- So JSON can be used to grab data from other servers, without the use of a server-side proxy
- available in HTML since 1994

XMLHttpRequest Compared to the Dynamic Script Tag



	XmlHttpRequest	Dynamic script Tag
Cross-browser compatible?	No	Yes
Cross-domain browser security enforced?	Yes (*)	No
Can receive HTTP status codes?	Yes	No (fails on any HTTP status other than 200)
Supports HTTP GET and POST?	Yes	No (GET only)
Can send/receive HTTP headers?	Yes	No
Can receive XML?	Yes	Yes (but only embedded in a JavaScript statement)
Can receive JSON?	Yes	Yes (but only embedded in a JavaScript statement)
Offers synchronous and asynchronous calls?	Yes	No (asynchronous only)

Dynamic script tag is used by internet advertisers who use it to pull their ads into a web page

The script tag's main advantages are that it is not bound by the web browser's cross-domain security restrictions and that it runs identically on more web browsers than XMLHttpRequest.

If your web service happens to offer JSON output and a callback function, you can easily access web services from within your JavaScript applications without having to parse the returned data

Arguments against JSON

- JSON doesn't have namespaces
- JSON has no validator
  - Every application is responsible for validating its inputs
- JSON is not extensible
- JSON is not XML
  - but a JavaScript compiler is a JSON decoder

`Eval()` is fast but very dangerous!

To help guard the browser from insecure JSON input, use **JSON.parse()** instead of `eval` ; e.g. `JSON.parse()` is used this way

```
var myObject = JSON.parse(JSONtext [, reviver]);
```

`eval()` will execute the string content but `json.parse()` will not.

JSONP

- "JSON with padding", a JSON extension wherein the name of a callback function is specified as an input argument of the call itself
- It is now used by many Web 2.0 applications such as Dojo Toolkit Applications or Google Toolkit Applications
- JSONP may be inappropriate to carry sensitive data (make use of script tags, and open to the world)
- supported by jQuery

Lec7 Python

- Variables assigned values inside a class declaration are **class variables**
- Variables assigned values in class methods are **instance variables**
- **Note:** Python **DOES NOT** support ‘++’ and ‘--’ notation for auto increments and decrement
- Strings are **immutable**

Flask

- Flask is a lightweight **WSGI** (**Web Server Gateway Interface**) web application framework
- WSGI specifies a standard interface between web servers and Python web applications or frameworks
- Flask offers suggestions but doesn't enforce any dependencies or project layout
- `render_template()`
- `send_static_file()`

Lec8 Document Object Model (DOM)

- **DOM** : programming interface for XML documents (access & manipulate), includes HTML documents
- XML DOM is designed to be used with **any programming language** and any **operating system**
- DOM represents an XML file as a tree
  - top-level: `documentElement`

Useful DOM Functions

- `document` **is the root element**
- `document.getElementById("sample")`
- `document.getElementsByTagName("font")`
- `innerHTML`:
  - first introduced as non-standard extension in IE
  - widely used in Ajax-based site
  - Elements that do not have both an opening and closing tag cannot have an `innerHTML` property
  - `innerHTML` has been added to the HTML5 specification
- `style.left`, `style.color` properties
- Newer browsers use “Synchronous” XMLHttpRequest

`XMLHTTPRequest` Object

- an XMLHttpRequest object can
  - Update a web page without reloading the page
  - Request data from a server after page has loaded
  - Receive data from a server after page has loaded
  - Send data to a server in the background
- "Synchronous" XMLHttpRequest is in process of being removed from web platform (will take many years)

> **Firefox and I.E. Represent DOM Structures Differently**
>
> Firefox view space as nodes in DOM tree too!

Lec9 Forms and Common Gateway Interface Mechanism

Forms

- `AUTOCOMPLETE`: input history
- `ONRESET=Script`
- `ONSUBMIT=Script`
- `<input>` tag
    - type: `submit`, `reset`, `text`, `textarea` (multiline input), ...
- `<select>` tag
    - `<option>` tag

Form Control Group: `fieldset`

```
<FIELDSET> <LEGEND ACCESSKEY=O>...</LEGEND>
...
</FIELDSET>
```

Common Gateway Interface (CGI)

Purpose of CGI

- used to create dynamic Web documents
    - Scripts are placed in a server directory often named cgi-bin
    - Scripts can deliver information that is not directly readable by clients
    - Scripts dynamically convert data from a non- Web source (e.g. DBMS) into a Web-compatible document
- **common gateway** : programs act as gateways between the `WWW` and other type of data/service

CGI Script Environment Variables

- a set of pre-defined dynamic values that can affect a running program
- part of the operating environment
- `UNIX`/`Windows` use these as a means of passing information about the environment of a process

- created by the web server and set before web server executes a gateway script
- Can be classified into two major categories
    - **Non-request-specific**: `SERVER_NAME`, `SERVER_PORT`, `SERVER_SOFTWARE`, `SERVER_PROTOCOL`, `GATEWAY_INTERFACE`
    - **Request-specific**: `PATH_INFO`, `REQUEST_METHOD`, `SCRIPT_NAME`, `QUERY_STRING`

Lec12 HTTP Protocol

What does WWW server do?

- Enables browser requests
- Provides
    - Support for retrieving hypertext documents
    - Manages access to the Web site
    - Provides several mechanisms for executing server-side scripts
        - Common Gateway Interface (CGI)
        - Application Programmers Interface (API)
    - produces log files and usage statistics

How does a Web server communicate?

- Web browsers and servers communicate using the **HyperText Transfer Protocol** (HTTP)
- HTTP is a **lightweight** protocol
    - FTP protocol: FTP session is long lived and there are 2 connections (1 for control, 1 for data)
- Current HTTP is version 1.1
- HTTP 2.0 under the IETF httpbis working group

HTTP History

- application-level protocol for distributed, collaborative, hypermedia information systems
- first version of HTTP: **HTTP 0.9**, a simple protocol for raw data transfer across the Internet
- HTTP 1.0 is defined by RFC 1945, messages containing meta-information about the data reansferred and modifiers on the request/response semantics
- HTTP 1.1 is defined by RFCs 7230-7237, being able to handle the handle

    - the effect of hierachical proxies
    - caching
    - the need for persistent connections
    - virtual hosts
- HTTP 2 worked by IETF working group
    - started as a copy as a copy of Google SPDY (SPeeDY)
    - speed up websites far larger than 10 years ago, using hundreds of requests/connections
    - uses **header compression**
    - Google has dropped SPDY from Chrome and adopted HTTP 2
    - Dozens of implementations (server) already available, including **Apache (2.4+)**, Apache-Tomcat (8.5+), **Nginx (1.9.5+)**

MIME Media types

- HTTP tags all data that it sends with its MIME type
- HTTP sends the MIME type of the file using the line

  ```
  Content-Type: [mime type header]
  ```

  for example:

  `Content-type: image/jpeg`, `Content-length: 1598`
- MIME types:
    - `text/plain`, `text/html`
    - `image/gif`, `image/jpeg`
    - `audio/basic`, `audio/wav`, `audio/x-pn-realaudio`
    - `model/vrml`
    - `video/mpeg`, `video/quicktime`, `video/vnd.rn- realmedia`, `video/x-ms-wmv`
    - `application/*`, `application-specific` data that does not fall under any other MIME category, e.g. application/vnd.ms-powerpoint
- MIME: **Multipurpose Internet Mail Extensions**, an Internet standard for **electronic mail**
    - Traditional e-mail was limited to ASCII text, limited line length, and limited size
- MIME has extended Internet e-mail to include
    - Unlimited text line and message length
    - Messages with multiple body parts or objects enclosed
    - International character sets in addition to US-ASCII
    - Formatted text including multiple font styles
    - Images
    - Video clips
    - Audio messages

    - Application-specific binary data
- was formalized in RFC 2046
- converts 8-bit data into 7-bit ASCII, sends it, and reconverts it at the other end

HTTP Scenario

An HTTP 1.0 "default" Scenario

Communication takes place over a TCP/IP connection, generally on **port 80**.

Client action	Server response
1. client opens a connection	server response with an acknowledgement
2. Client sends HTTP request for HTML document	server responses with the document and closes the connection
3. Client parses the HTML document and opens a new connection; it sends a request for an image	server responds with the inlined image and closes the connection
4. Client opens a connection and sends another request for another image	server sends the inlined image and closes the connection

A more Complicated HTTP Scenario

- communication can go between one or more **intermediaries**
- Common forms of intermediary:
    - **proxy:** a forwarding agent, receives requests for a URL in its absolute form, rewrites all or part of the message, and forward the reformatted request toward the server identified by the URI
    - **gateway:** a receiving agent, acts as a layer above some other servers and, if necessary, translating the requests to the underlying server's protocol
    - **tunnel:** acts as a relay point between two connections without changing the messages; tunnels are used when the communication needs to pass through an intermediary (firewall for example) even through an intermediary cannot understand the contents of the messages (no caching)

Caching Proxies

A **web cache** or **caching proxy** is a special type of HTTP proxy server that keep copies of popular documents that pass through the proxy (“forward” proxy). The next client requesting the same document can be served from the cache's personal copy.

Forward proxy hides the clients, backward proxy hides the servers.

Gateways

Gateways are special servers that act as intermediaries for other servers, used to convert HTTP traffic to another protocol. A gateway always receives requests as if it was the origin server for the resource. The client may not be aware it is communicating with a gateway.

> **Example**
>
> an HTTP/FTP gateway receives requests for FTP URIs via HTTP requests but fetches the documents using the FTP protocol. The resulting document is packed into an HTTP message and sent to the client.

Tunnels

Tunnels are HTTP applications that, after setup, blindly relay raw data between two connections. HTTP tunnels are often used to transport non-HTTP data over one or more HTTP connections, without looking at the data.

the Most General HTTP Scenario

Communication between browser and server should be regarded as a **request chain** goes left to right, and a **response chain** goes right to left:

`UA`-->`A`-->`B`-->`C`-->`O`

- `A`, `B` and `C` are three intermediaries between the user agent and origin server. A request or response message that travels the whole chain will pass through four separate connections
- `UA` stands for User Agent, typically a browser
- `O` stands for the origin server; the server that actually delivers the document

Connections

Persistent Connections

- In the original HTTP protocol each request was made over a new connection
    - an HTML page with n distinct graphic elements produced **n+1** requests
- TCP uses a three-way handshake when establishing a connection
    - client sends SYN
    - server replies ACK/SYN
    - client responds with ACK
- HTTP 1.0 introduced a **keep-alive** feature
    - the connection between client and server is maintained for a period of time allowing for multiple requests and responses
    - a.k.a. **persistent connection**
- Persistent connections are now the default
- request header to set timeout (in sec.) and max. amount of requests, before closing:

```
Keep-Alive: timeout=5, max=1000
```

- client and server must explicitly say they do NOT want persistence using the header

```
Connection: close
```

- HTTP permits multiple connections in parallel, but generally browsers severely limit multiple connections and servers do as well

Example of a `GET` request

- Suppose the user clicks on the link:

```
<A HREF="http://www.usc.edu/html/file.html">click here </A>
```

- The request from the client may contain the following lines

```
GET /html/file.html HTTP/1.1
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
User-Agent: Mozilla/5.0 (Windows NT 5.1; rv:15.0) Gecko/20100101
Firefox/15.0.1
Referer: http://www.usc.edu/html/prevfile.html If-Modified-Since: Wed, 11 Feb
2009 13:14:15 GMT {there is a blank line here which terminates the input}
```

- the server responds with the following

  ```
  HTTP/1.1 200 OK
  Date: Monday, 29-May-09 12:02:12 GMT Server: Apache/2.0
  MIME-version: 1.0
  Content-Type: text/html
  Last-modified: Sun, 28-May-09 15:36:13 GMT Content-Length: 145
  {a blank line goes here }
  {the contents of file.html goes here }
  ```

Client HTTP request

The general form of an HTTP request has four fields:

- `HTTP_Method`: to be done to the object specified in the URL; some possibilities include `GET`, `HEAD`, and `POST`
  - `GET`: retrieve whatever information is identified by the request URL
  - `HEAD`: identical to `GET`, except the server does not return the body in the response
  - `POST`: instructs the server that the request includes a block of data in the message body, which is typically used as input to a server-side application
  - `PUT`: used to modify existing resourses or create new ones, contained in the message body
  - `DELETE`: used to remove existing resourses
  - `TRACE`: traces the requests in a chain of web proxy servers; used primarily for diagnostics
  - `OPTIONS`: aloows requests for info about the server's capabilities
- `identifier`: the URL of the resourse or the body
- `HTTP_version`: the current HTTP version, e.g. HTTP/1.1
- `Body`: optional text

HTTP Headers

- HTTP/1.1 divides headers into four categories:
  - `general`: present in requests or responses
  - `request`: present only in requests
  - `response`: present only in response
  - `entity`: describe the content of a body

Byte Range Headers

- Requests
  - `If-Range`: `entity-tag`
  - `Range`: `bytes=1-512`, `2046-4096`

  used to request a byte range
- Responses
  - `Accespt-ranges`: `bytes`

  indicates the server can respond to range requests
- Entity
  - `Content-Range`: `0-399/2000`

  response to byte range request giving the byte ranges actually returned, e.g. the first 400 bytes of a 2000 byte document

> - HTTP/1.1 introduces Vary: `accept-language`, `user-agent` the header specifies acceptable languages and browsers.
> - if a French version is requested and cached, then a new request may fail to retrieve the English version
>
> > **request:**
> >
> > ```
> > GET http://www.myco.com/ HTTP/1.1
> > User-agent: Mozilla/4.5
> > Accept-language: en
> > ```
> >
> > **response:**
> >
> > ```
> > HTTP/1.1 200 OK
> > Vary: Accept-language
> > Content-type: text/html
> > Content-language: en
> > ```

> **Response Header Status Code**

> ```
> 10    Response is stale
> 11    Revalidation failed
> 12    Disconnected operation
> 13    Heuristic expiration
> 14    Transformation applied
> 99    Miscellaneous warning
> ```

Entity Tags

- used for web cache validation, and which allows a client to make conditional requests
- assigned by a web server to a specific version of a resource found at a URL
  - If the resource content at that URL ever changes, a new/different ETag is assigned
  - ETags are similar to **fingerprints**, and they can be compared to determine whether two versions of a resource are the same
- An ETag is a serial number or a checksum that uniquely identifies the file
  - caches use the **If-None-Match** condition header to get a new copy if the entity tag has changed
  - if the tags match, then a `304 Not Modified` is returned
- ETag is determined by the server, sent as response

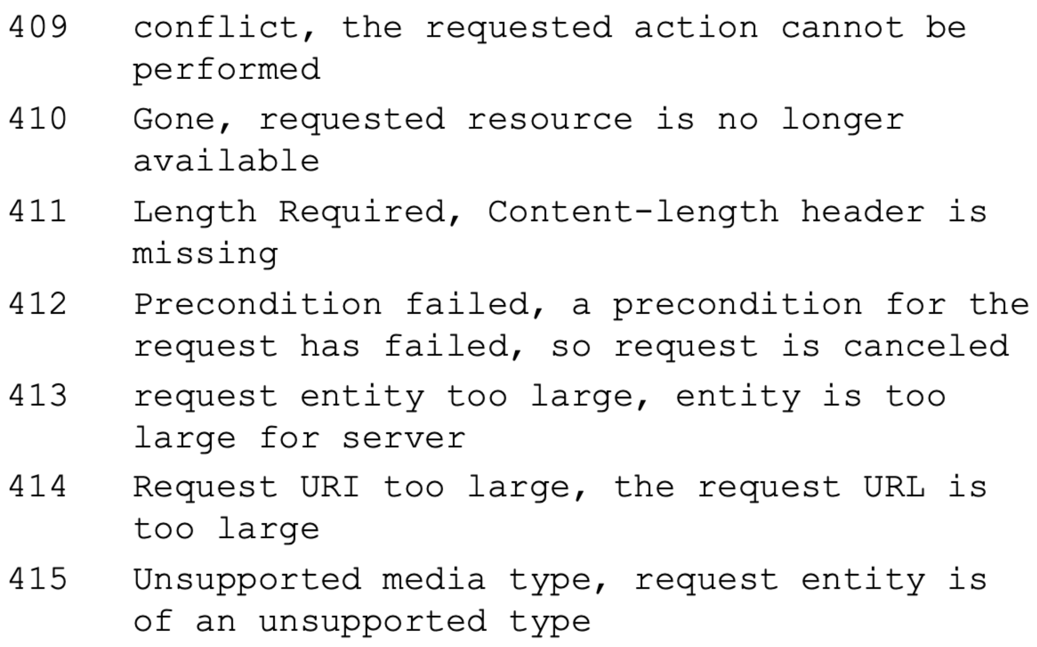
HTTP Status Codes

- Informational
  - `100`: Continue, the client may continue with its request; used for a PUT before a large document is sent
  - `101`: Switching Protocols, switching either the version or the actual protocol
- Successful
  - `200`: OK, request succeeded
  - `201`: Created, result is newly created
  - `202`, Accepted, the resourse will be created later
  - `203`: Non-authoritative information, infor returned is from a cached copy and may be wrong
  - `204`: No content, response is intensionally blank, so client should not change the page
  - `205`: Reset Content, notifies the client to reset the current document, e.g. clear a form field
  - `206`: Partial content, e.g. a byte range response
- Redirection

300	Multiple choices, the document has multiple representations
301	Moved permanently, new location is specified in Location: header
302	Moved temporarily: similar to above
303	See Other: used to automatically redirect the client to a different URL
304	Not Modified: the client or proxy copy is still up-to-date
305	Use Proxy: make the request via the proxy
306	Proxy Redirection: a proposed extension to HTTP/1.1 still not specified
307	Temporary Redirect

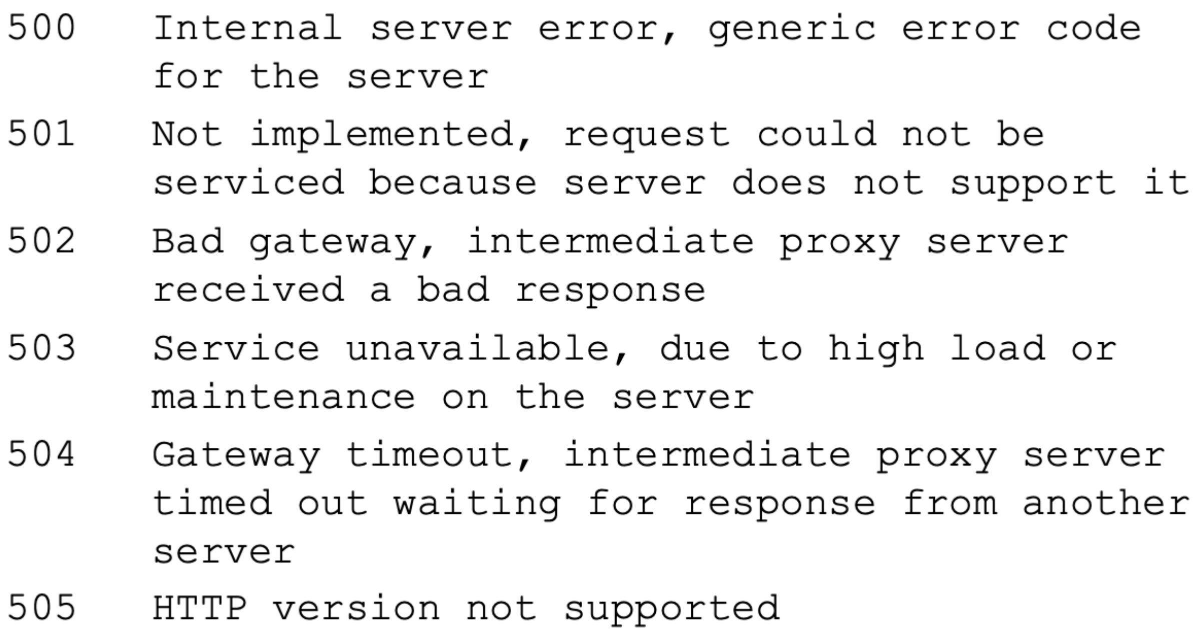
- Client Error

400	Bad request, server could not understand
401	unauthorized, authorization challenge
402	Payment Required, reserved for future use
403	forbidden, server refuses to fulfill request; e.g. check protections
404	Not found, document does not exist
405	Method not allowed, request method is not allowed for this URL
406	Not Acceptable, none of the available representations are acceptable to the client
407	Proxy Authentication Required, authentication is being challenged
408	Request Timeout, client did not send a request within a time given by server



409	conflict, the requested action cannot be performed
410	Gone, requested resource is no longer available
411	Length Required, Content-length header is missing
412	Precondition failed, a precondition for the request has failed, so request is canceled
413	request entity too large, entity is too large for server
414	Request URI too large, the request URL is too large
415	Unsupported media type, request entity is of an unsupported type

- Server Error



500	Internal server error, generic error code for the server
501	Not implemented, request could not be serviced because server does not support it
502	Bad gateway, intermediate proxy server received a bad response
503	Service unavailable, due to high load or maintenance on the server
504	Gateway timeout, intermediate proxy server timed out waiting for response from another server
505	HTTP version not supported

HTTP Authentication

- The web server can maintain secure directories and request authentication when someone tries to access them
- Procedure:
  - web server receives a request without proper authorization
  - web server responds with `401 Authentication Required`
  - client prompts for username and password and returns the information to the web server

META HTTP-EQUIV (meta tag)

- a mechanism for authors of HTML documents to set HTTP headers, in particular HTTP responses
- Two common used:
  - set the **expiration time** of a document
  - cause a **refresh** of a document
- `<meta http-equiv="refresh" content="5, http://csci571.com/index.html">`

`X-Frame-Options: sameorigin`

Indicate whether or not a browser should be allowed to render a page in a `<frame>` or `<iframe>`. Sites can use this to avoid clickjacking attacks, by **ensuring that their content is not embedded** into other sites;

- `deny`
- `sameorigin`
- `allow-from uri`

HTTP Strict-Transport-Security (HSTS)

- HSTS is a security feature that lets a web site tell browsers that it should only be **communicated with using HTTPS**, instead of using HTTP

```
Strict-Transport-Security: max-age=expireTime [; includeSubdomains]
```

Cross-origin resourse sharing (CORS)

- CORS allows allows many resources (e.g, fonts, JavaScript, etc.) on a web page to be requested across domains
- **AJAX calls can use XMLHttpRequest across domains**
- If the server does not allow the CORS request, the browser will deliver an error instead of the asked URL response.

Lec14 Secure Web Communication & Web Server Performance

Secure Web Communication

Public & private key encryption

- Private key encryption: sender/receiver share private key
- Public key encryption: for **authentication**
- Receiver has private & public keys: for **privacy**

Cryptographic Hash functions:

- Given data X and hash function H, H(X) is called **message digest** or **digital signature** of X under hashing algorithm H
- famous hash functions: **MD5**, **SHA**

Bulk Cipher Methods:

- public/private key encryption methods are not suitable for general purposes:
  - RSA can only encrypt blocks of data which are 11 bytes less than key size, and each decryption involves complex calculation
- secure communication on the web uses a combination of **public-key encryption** and **conventional one way ciphers**
- **bulk cipher**: the same key are used for encrypt/decrypt the data, fast and can encrypt files of any sizes
- famous bulk ciphers: **RC2**, **RC4-40**, **RC4-56**, **DES40-CBC**,

Digital Certificates & Certifying Authorities

- A **message digest** is the number produced by applying a cryptographic hash function to a message
  - Message will be sent with message digest together to receiver for later certification
  - Systems combining public key cryptography and message digests are called **digital signatures**

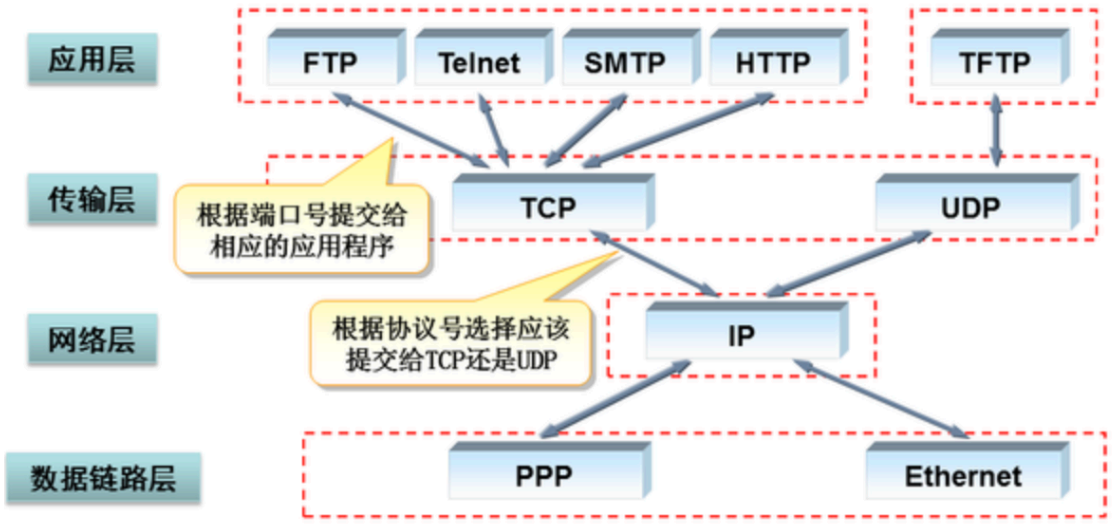
How do we guarantee that the organizations that we are dealing with are legitimate?

- A certificate authority (**CA**) is an organization that both parties involved in a secure communication, trust

- CA will verify the identity of an entity (client/server)
- once CA verifies the entity, it issues a digitally signed electronic certificate with CA's **private key**
- Web browsers are usually pre-configured with a list of CAs that are trusted

Secure Sockets Layer Protocol (SSL) and https

- **SSL**: a protocal establishes an encrypted link between server & client, using **authentication/encryption** of transactional data
    - original designer for SSL: Netscape
    - SSL is also called **TLS**, transport layer security protocol
    - SSL is transparent to users, except for the https that appears
        - HPPTS = HTTP + SSL/TCP
    - the SSL protocol fits between the TCP layer and the HTTP layer
        - SSL can be used to encrypt other application level protocols such as FTP and NNTP
- provides end-to-end security between client/server
- **authentication** of both parties is done using digital certificates
- **privacy** is maintained using encryption
- **message integrity** is accomplished using message digests
- SSL for HTTP is referred to as HTTPS and operates on port 443



Web Server Performance

What needed to be considered when selecting a Web Platform? Capacity, Cost/investment, Maintenance, Security, Development support.

Popular platforms

- Microsoft
  - Windows Server 2012 or 2016, Microsoft Nano Server – Internet Information Services (IIS) version 8 or 10 – MS SQL Server
  - Active Server Pages or ASP.NET applications
  - Develop with VB, COM, C++, C#, or HTML/CSS/JS
  - PHP Manager for IIS 7
  - Available on Cloud
- Linux
  - Ubuntu / Red Hat / SuSe or any other distribution
  - Apache web server
  - Oracle mySQL
  - HTML preprocessor (PHP 7)
  - JAVA serverlets & JSP (Tomcat 8/9)
  - available on Cloud
- UNIX
  - Oracle Solaris 11
  - Oracle WebLogic 12c
  - IBM WebSphere

Estimate Server Performance Requirements:

- Estimate
  - # of clients that will connect each second (connection per sec)
  - # of bytes the client will send to the server during each transaction
  - # of bytes the server will send to the client during each transaction (bytes transferred)
  - how much of link the web server is allowed to use

$$\frac{\#\text{connects\_per\_sec} \times (\#\text{bytes\_from\_client\_each\_trans} + \#\text{bytes\_from\_server\_each\_trans})}{\#\text{links\_allow\_by\_server}}$$

- **General rules:** <u>the link should have at least twice the bandwidth as the average above</u>

Web Server Farms

- A web server farm consists of **multiple server** machines and **load balancing** hardware that distributes web requests across the servers
- Web servers have a relatively **small amount of static data**, and an application server (behind the firewall) provides **dynamic content** from information stored in a database or exiting applications
- if storage is shared across all servers, then there is a single point of failure
  - mirroring is one possible solution using a DBMS feature to push new data to all servers

Load Balancing

Load balancing (using round Robin DNS) can detect the event of a failure, and route the request elsewhere. Persistent data must be fuilly replaced and all nodes are identical.

Two possible approach: **switches** & **DNS redirection**.

Switches

- Load balancing hardware exists to prevent requests going to servers that have failed; e.g.
  - Cisco Content Switching Module, Cisco Catalyst 6500; RADware appDirector
- can perform an HTTP redirect to a different location upon failure of a real or virtual IP address
- Supports Cookie, HTTP redirect, and SSL session ID persistence features guaranteeing that a specific client gets the correct content

DNS redirection

- This form of load balancing has problems because
  - web browsers will cache the IP address for a given domain
  - some operating systems cache IP addresses for given domains
- However, some DNS servers use algorithms other than round robin, e.g.
  - load-balancing: they check the load on many web servers and send the request to the least loaded
  - proximity-routing: they send the request to the nearest server, when the servers are geographically distributed
  - fault-masking: check for down web servers and avoid them

Web Server Performance Testing

Benchmarking

Web server benchmarking: process of estimating a web server performance in order to find if the server can serve sufficiently high workload.

- *Number of requests that can be served per sec*
- *Latency response time in ms for each new connection or request*
- *throughput in bytes per sec*

> ### Other Web Servers
>
> - `lighttpd`
> - `Nginx`
> - `Apache`
>
> **Memory Usage:** `lighttp` < `Nginx` < `Apache`
>
> **Requests Per Second:** `Apache` < `lighttpd` < `Nginx`

Improving Apache Web Server Performance

- `Additional RAM`
- Load `only the required modules`: reduce the memory footprint
- `HostnameLookups` directive enables DNS lookup
- Do not set `MaxClients` too low (may causes requests queue and lost);

  Do not set `MaxClients` too high (may causes server to start swapping and response time will degrade)
  - `MaxClients = (Total RAM dedicated to Web Server)/Max child process size`
- Tune `MinSpareServers` and `MaxSpareServers`
- HTTP compression can been abled using `mod_gzip` or `mod_deflate`; the payload is compressed only if the browser requests it
- `mod_fastcgi` uses FastCGI rather than normal CGI to connect to the CGI scripts
- Use `direct modules`: `mod_perl`, `mod_php5`, `mod_python`, etc
- Use two versions of Apache, one “tiny version” to serve static content and forward requests for dynamic content to the “larger version”
  - Alternatively use **Nginx** as **“reverse” proxy** (tier-1) and Apache as App Server (tier-2)

Web Server as Proxy Server

Proxy Server: An intermediary server that accepts requests from clients and either forwards them or services the request from its own cache. Also called `forward proxy`.

- The protocol between client and proxy server, or between proxy servers is HTTP, even if the request is for ftp, telnet, mailto

Why a forward Proxy Server?

- runs on client side
- **prevent access** to restricted sites
- **control access** to a restricted site (proxy server can request name/password)
- enhance security by **controlling** which application level **protocols** are permitted
- improve performance by maintaining a **cache**
- modify content before delivery to the client
- act as an **anonymizer**, removing identifying information from HTTP messages

HTML Meta Tags vs. HTTP Headers

- HTML authors can put tags in a document's `<HEAD>` section that describe its attributes. These *Meta tags* are often used that they can mark a document as uncacheable or expire it at a certain time
- Meta tags are easy to use but **aren't very effective**. They are never honored by proxy caches and they are honored by browser caches only together with HTTP Headers

Using Apache as a proxy server

Lec15 Web Service and REST

Implementation of Web Services is roughly divided into three categories:

- Big Web Services which involve XML messages that are communicated by the Simple Object Access Protocol (SOAP); the API is formally described using the Web Services Description Language (WSDL). These services are normally used for server to server communication, using additional protocols like XML Security and XML Encryption
- REST (Representational State Transfer) *Services* which use HTTP methods PUT, GET, POST and DELETE
- Cloud Services which provide cloud storage, application hosting, content delivery, and other hosting services

All three types of Web Services provide access through APIs.

REST Service

Introduction

- REST service ca be used to access sites that perform the following function
    - Web Search
    - Geolocation
    - Photo sharing
    - Social Networking
    - Mapping
- Access is provided using one or both methods:
    - **Direct URL**: return a response in one or more formats (XML, JSON, PHP)
    - **Library-based APIs**: embedded in JavaScript, Java, C#, Object-C and others
- Many of these services now require or include **OAuth user authentication**
    - Oauth is a standard for clients to access server resources on behalf of a resource owner

REST (Representational State Transfer)

- REST is a style of software architecture for distributed hypermedia systems
    - The World Wide Web is an example of REST
- There are three fundamental aspects of the REST Design Pattern
    - **client**, **servers**, **resources**
    - Resources are typically represented as documents
    - Systems that follow Fielding's REST principles are often referred to as **RESTful**

REST vs Other Approaches

- REST
    - Software architectural style for distributed hypermedia systems like WWW
    - Quickly gained popularity through its **simplicity**
- SOAP
    - Protocol for exchanging XML-based message, normally using HTTP
    - Much more robust way to make requests, but more robust than most APIs need
    - More **complicated** to use
- XML-RPC
    - RPC protocol with XML as a encoding and HTTP as a transport
    - More complex than REST but much simpler than SOAP
- JSON-RPC
    - RPC protocol encoded in JSON instead of XML
    - Very simple protocol (and very similar to XML-RPC)

REST as Lightweight Web Services

- a REST service is:
  - Platform-independent
  - Language-independent
  - Standard-based (runs on top of HTTP)
  - Can be used in the presence of **firewalls** (port80/443alwaysopen)
- Like Web Services, REST offers no built-in security features, encryption, session management, QoS guarantees, etc. But also as with Web Services, these can be added by building on top of HTTP:
  - For security, username/password tokens are often used
  - For encryption, REST can be used on top of **HTTPS**(secure sockets)
- REST *requests* rarely use XML
- Newer REST Services use JSON in their responses

Cloud Service

- Cloud Services covers a variety of hosting services:
  - Application Hosting
  - Backup and Storage
  - Content Delivery
  - E-commerce
  - Media Hosting
  - DNS Protection Services
  - Consumer Cloud Storage
- Access is provided using one or both of these methods:
  - Dashboard
  - Library-based APIs: embedded in Java, C#, Objective-C and other binary library formats

Lec16 Ajax: Asynchronous JavaScript + XML

Ajax incorporates:

- standards-based presentation using XHTML
- CSS, dynamically manipulated using JavaScript
- dynamic display and interaction using the Document Object Model (DOM). Web page exposed as DOM object
- data interchange using XML

- asynchronous data retrieval using XMLHttpRequest, a JavaScript object, a.k.a “Web remoting”
- JavaScript binding everything together
- Server no longer performs display logic, only business logic

History & Browsers Supporting Ajax:

- first Ajax-enabled browser: IE5

Characteristics of Ajax Applications:

- applications (or Apps), not just web sites
- allow for smooth, continuous interaction
- "Live" content
- Visual Effects
- Animations, dynamic icons
- Single keystrokes can lead to server calls
- New Widgets (selectors, buttons, tabs, lists)
- New Styles of Interaction (drag-and-drop, keyboard shortcuts, double-click)

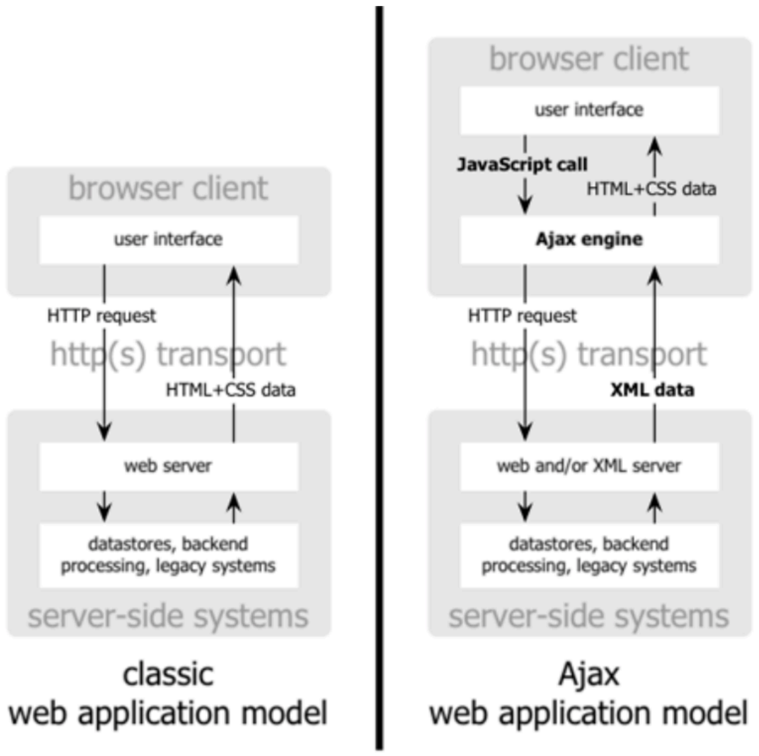
Traditional vs. Ajax Websites

Traditional	Ajax
Interface construction is mainly the responsibility of the server	Interface is manipulated by client-side JavaScript manipulations of the Document Object Model (DOM)
User interaction is via form submissions	User interaction via HTTP requests occur ‘behind the scenes’
An entire page is required for each interaction (bandwidth)	Communication can be restricted to data only
Application is unavailable while an interaction is processing (application speed)	Application is always responsive

Ajax:

- Cuts down on user wait time
- Uses client to offload some work from the server

- Asynchronous operation



Ajax Engine Role

- Every user action that normally would generate an HTTP request takes the form of a JavaScript call to the Ajax engine instead
- Any response to a user action that doesn't require a trip back to the server, such as:
    - simple data **validation**
    - **editing** data in memory
    - even some **navigation**

  the engine handles on its own
- If the engine needs something from the server in order to respond, such as:
    - **submitting** data for processing
    - **loading** additional **interface** code
    - **retrieving** new **data**

  the engine makes those requests asynchronously, retrieving results in JSON or XML, without stalling a user's interaction with the application

transaction completion state code: `4`

`xhr.responseText` is JSON format, `xhr.responseXML` is XML data.

Security Issues

- When the XMLHttpRequest object operates within a browser, it **adopts the same-domain security policies** of typical JavaScript activity (sharing the same "sandbox," as it were)
- **Everything must come from the same domain**

Ajax Cross Domain Security

image doesn't need to worry about cross domain issues.

Cross-domain solutions

- install web proxy on the server
- CORS: work on all recent browsers

Fetch API

- no cross-site cookie
- do not sent cookie

Lec17 Responsive Web Design

The Need: Mobile Growth

Websites must be designed to make sure the mobile viewer has an excellent experience.

Mobile devices offer:

- Use of **geo-location** to optimize the experience.
- Require **Switch layouts** depending on the way they're held.
- Need to support rich, **multi-touch** interfaces
  - input devices that recognize two or more simultaneous touches – e.g. two finger tap, two finger scroll, pinch, zoom
  - some devices also recognize differences in pressure and temperature

Design for Mobile Web

3 main approaches:

1. Build an entirely separate mobile **.mobi site**
    - The domain name **mobi** is a top-level domain. Its name is derived from the adjective *mobile*, indicating it is used by mobile devices for accessing Internet resources via the Mobile Web
    - The domain was approved by ICANN on 11 July 2005, and is managed by the mTLD global registry
    - To date only 0.06% of web TLDs
2. Host the mobile site within your current domain (a **subdomain**) (**mobile.**mycompany.com)
3. Configure your current website for mobile display using *Responsive Web Design* (**RWD**) techniques

Why not use mobile.mycompany.com webs?

1. Redirects can hinder/annoy search engines
2. Redirects take lots of time
3. If you offer a mobile.website for iPhone, what about for iPad, Android, etc.
4. Sharing a mobile.website will not work for people on laptops, as they will end up with a site designed for a small screen
5. Philosophical: every web resource should live at one URL!

What is Responsive Web Design

- **RWD** is the concept of developing a website in a way that **allows the layout to automatically adjust** according to the user's screen resolution (called its *viewport*).
- The viewport meta tag lets you set the width and initial scale of the viewport.
- For example

```
<meta name=“viewport” content="width=590">
```

- Responsive web design (RWD) is a web design approach that tries to achieve an ideal viewing experience
    - easy reading and navigation with a minimum of resizing, panning, and scrolling
    - across a wide range of devices (from mobile phones to desktop monitors)
- A site designed with RWD adapts the layout to the viewing environment by using
    - **fluid**, proportion-based **grids**
    - **flexible images**
    - **CSS3 media queries**

Major Technology Features

Media queries

```
<link rel="stylesheet" type="text/css" media="screen and (color)"
href="example.css" />
```

- Enhanced media types allows targeting of specific physical characteristics of the device

  ```
  <link rel="stylesheet" type="text/css" media="screen and (max-device- width:
  480px)" href="min.css" />
  ```

Fluid grids

- In "*adaptive grids*", we define pixel-based dimensions
- In "*fluid grids*" we define relative-based dimensions
- In fluid grids we
  1. Define a maximum layout size for the design.
  2. The grid is divided into a specific number of columns to keep the layout clean and easy to handle.
  3. Then we design each element with proportional widths and heights instead of pixel- based dimensions.
- So whenever the device or screen size is changed, elements will adjust their widths and heights by the specified proportions to its parent container

Scalable images

- To avoid having an image deformed due to the screen size one should avoid specific definitions of width and height and instead use CSS's max-width property setting it to 100%:

  ```
  img { max-width: 100%; }
  ```

- With the maximum width of the image set to 100% of the screen or browser width, if the screen becomes narrower, so does the image
- The browser will resize the images as needed using CSS to guide their relative size

Bootstrap

- Bootstrap is a powerful front-end framework for faster and easier responsive web development.
- includes HTML and CSS based design templates for common user interface components as well as optional JavaScript extensions
- Bootstrap responsive features make your web pages to appear more appropriately on different devices and screen resolutions without any change in markup

`.col-xs-`: grid columns for extra small devices, like smartphones.

`.col-sm-`: small screen devices, like tablets.

`.col-md-`: for medium size devices, like desktop.

`.col-lg-`: for large desktop screens.

Lec18 JS Frameworks

Node.JS

- a JavaScript runtime built on Chrome V8 JavaScript engine
- use an event-driven, non-blocking I/O model, lightweight & efficient

AngularJS

Basic functionality

- control of the app
  - Data binding
  - controller
  - Plain JavaScript
- Wire up a backend
  - Deep linking
  - Client-side Form Validation
  - Server Communication
- Create Components
  - Directives: invent new HTML syntax
  - Reusable Components
  - Localization

Goals

- doubles DOM manipulation from application logic
- decouple client side of an application from the server side
- provide structure for building an application
    - designing the UI
    - writing business logic
    - testing
- support dynamic content through two-way data-binding
    - allow for the automatic synchronization of models and views

Features of Angular 4

- small and faster
- View engine with less code
- Improved `*ngIf` directive: a new "else" statement is added
- animation
- TypeScript 2.1 and 2.2 Compatibility
- Source Maps for Templates

Angular 2+ doesn’t support *FilterPipe* or *OrderByPipe*.

RxJS

- RxJS is a library for reactive programming
- Reactive programming is an asynchronous programming paradigm concerned with data streams and the propagation of change
- RxJS uses **Observables** for asynchronous or callback-based code

Lec19 jQuery

What is jQuery?

- framework for client-side JavaScript
- provide useful alternatives for common programming tasks
- open source project
- it simplifies
    - HTML document traversing
    - Event Handling

    - Animating
    - AJAX interactions

How Does jQuery Change How You Write JavaScript?

- jQuery adds a JavaScript object called **$** or **jQuery** to your JavaScript code
    - Example: Instead of

      ```
      var myButton = document.getElementById("myButton");
      ```

      In jQuery, it's just `$("#myButton");`

jQuery Basic Selectors

- All Selector ("*"): selects all elements, sets css properties and returns the number of elements found

  ```
  var elementCount = $("*").css("border", "3px solid red" ).length;
  ```

- Class Selector (".class"): selects all elements with a given class and sets css properties

  ```
  $(".myClass").css("border", "3px solid red");
  ```

- Element selector ("element"): selects all elements with the given tag name, e.g. div, and sets css properties

  ```
  $("div").css("border", "9px solid red");
  ```

- ID selector ("#id"): selects a single element with the given id attribute

  ```
  $("#myDiv").css("border", "3px solid red");
  ```

- Multiple selector ("selector1, selector2, selectorN"): selects a combined result of all the specified selectors

  ```
  $("div, span, p.myClass").css("border", "3px solid red");
  ```

- Attribute: selects elements that have the specified attribute and changes the associated text

  ```
  $("input[value='Hot Fuzz']").text("Hot Fuzz");
  ```

- Basic Filter, e.g. selects all elements that are h1, h2, h3, etc and assigns css properties

```
$(":header").css({background: "#ccc", color: "blue"});
```

- Child Filter, e.g. finds the first span in each div and underlines the text

```
$("div span:first-child").css("text-decoration", "underline");
```

- Content Filter, e.g. finds all div containing “John” and underlines them

```
$("div:contains('John')").css("text-decoration", "underline");
```

- Form, e.g. finds all buttons and adds the css class “marked” to their properties

```
var input = $(":button").addClass("marked");
```

jQuery Functions

- Either **attached to the jQuery object** or **chained off of a selector statement**
  - Run a function when the page is fully loaded

```
$(window).load(function() {
               //run code
        } );
```

- Most functions return the jQuery object they were originally passed, so you can perform many actions in a single line.
  - Add the class *bigImg* to all images with height > 100 once the image is loaded

```
$("img.userIcon" ).load(function() {
    if ( $( this ).height() > 100 ) {
           $( this ).addClass("bigImg");
    }
});
```

jQuery & AJAX

- jQuery has a series of functions which provide a common interface for AJAX
- `load()` method: load data from a server and puts the returned data into the selected element

```
$(selector).load(URL,[data,callback]);
```

jQuery Event

- jQuery way of a mouseover event that shows a submenu when menu is selected:

  ```
  $('#menu').mouseover(function() { // Anonymous function
         $('#submenu').show();
  });
  ```

- Stopping a normal **event** action: Suppose we want to stop the action of following a URL when a link is clicked

  ```
  $('#menu').click(function(evt){ //JS code here
        evt.preventDefault();
  });
  ```

- Form selectors
  - selects all text fields:

    ```
    $(":text")
    ```

  - Set the value of a form element

    ```
    var fieldvalue = $('#total').val(YOURVALUE);
    ```

- Attribute: determining if checkbox is checked

  ```
  if ($('#total').attr('checked')) {
    // if check part
  }
  else {
    // if not checked part
  }
  ```

- Form event: submit

```
$(document).ready(function() {
  $('#signup').submit(function() {
    if ($('#username').val() =='') {
        alert (‘Please supply name to name
        field’);
        return false;}
  })
});
```

- click: if any radio button is clicked

```
$(':radio').click(function() {
  // do stuff
});
```

- add focus to the first element of the form

```
$('username').focus;
```

Cross Browser Support – no need extra code for browser compatibility using jQuery.

Lec20 High Performance Websites

The Performance Golden Rule:

- 80-90% of the end-user response time is spent on the front-end

The initial 14 rules:

1. Make fewer HTTP requests
    - combine scripts
    - combine stylesheets
    - combine images into an image map (images must contiguous)
    - combine images using "sprites"
2. Use a CDN (content distribution network): have servers around the world
3. Add an Expires header
4. Gzip components
    - gzip
    - deflate

5. Put stylesheets at the top
    - Stylesheets block rendering in IE
    - use `<link>`
6. Move scripts to the bottom
    - **loading of JavaScript** can cause the browser to **stop rendering** the page until the JavaScript is fully loaded

      ```
      <script type="text/javascript" defer="defer"> some script .... </script>
      ```

      also works
7. Avoid CSS expressions
8. Make JS and CSS external
    - **External JS and CSS can be cached**, HTML will not be cached
9. Reduce DNS lookups
    - DNS lookups will block parallel downloads
10. Minify JS
11. Avoid redirects
12. Remove duplicate scripts
    - Extra HTTP requests (IE only)
    - Extra executions
13. Configure Etags
14. Make AJAX cacheable

Some new rules:

- avoid empty src or href
- Use GET for AJAX requests
- reduce the number of DOM elements
- avoid HTTP 404 (not found) error
- reduce cookie size
- use cookie-free domains
- do not scale images in HTML
- make favicon small and cacheable

PageSpeed is available in **Google Analytics**.

Lec24 Serverless Application

Overview of Serverless

1. The need for Virtual Machine
2. Vitual Machines are expensive and slow
3. new solutions:
    - **Serverless Architectures**
    - **Containers**: Operating System Level virtualization, a lightweight approach to virtualization that only provides the bare minimum that an application requires to run and function as intended

Serverless Architectures

Serverless Architectures: applications that depend on

- third party-services (**Baas**)
- custom code that’s run in ephemeral containers (**FaaS**)

Features of Serverless Architectures

- No compute resource to manage
- Provisioning/scaling handled by the service itself
- You write code and the execution environment is provided by the service
- Core functionality (e.g. database, authentication and authorization) is provided by at-scale Web Services

Faas

- Origin:
    - **AWS Lambda:** first web service of it's kind that completely abstracted the execution environment from the code
    - **API Gateway:** critical ingredient for building service endpoints with Lambda
    - combined with existing back-plane services like DynamoDB, Cloudformation and S3 and the "serverless " development was born
- How does it work?
    - You write a function and deploy it to the cloud service for execution

Baas

- Type:
  - Data storage:
    - NoSQL database
    - BLOB storage
    - Cache (CDN)
  - Analytics
    - Query
    - Search
    - IoT
    - stram processing
  - AI
    - machine learning
    - image recognition
    - NLP
    - Speech to text / Text to Speech

AWS Lambda

AWS Lambda Example Architecture

- Search
- Location-Awareness
- Machine-learning powered recommendations
- NoSQL
- Microservices
- API Management
- Static website with CDN
- Not a single server to manage!

Overview of Containers

- Virtualization at the OS level
- based on **Linux kernel** features
- **Docker** has brought containers mainstream

Key features:

- Light-weight:

    - container images no need for full OS install like a VM
    - all containers run on the same host share one Linux kernel
- Portable:
    - Execution environment abstracts the underlying host from the container
    - No dependency on a specific virtual machine technology
    - Container images can be shared using GitHub-like repositories, such as **Docker Hub**

Container Architectures: Docker

- **Docker** allows developers to deploy Apps in a sandbox (containers) to run on the host operating system i.e. Linux
- **Benefit:** Allows users to **package an application** with all its **dependencies** into a standardized unit for software development
- Unlike virtual machines, Containers do **no**t have the **high overhead** and enable more efficient usage of the system/resources
- **efficient sharing of resources**
- Provides standard and minimizes software packaging
- **Decouples software** from underlying **host** w/ no hypervisor

Container Issues:

- Security
- Less Flexibility in OS, Networking
- Management of Docker and Container in production is challenge

Where we go from here

1. Serverless
    - BaaS
        - AI
            - Fraud detection
            - Latent sematic analysis
        - Geospatial
            - Satellite imagery • Hyper-Locality
        - Analytics
            - Query
            - Search
            - Stream Processing
        - Database
            - Graph

        - HPC
    - FaaS
        - Polyglot language support (each function written in a different language)
        - Stateful endpoints (Web Sockets)
        - Remote Debugging
        - Enhanced Monitoring
        - Evolution of CI/CD Patterns (Continuous Integration / Continuous Depoyment)
        - IDE’s
2. Container
    - Networking
        - Overlay networks between containers running across separate hosts
    - Stateful Containers
        - Support for container architectures that read and write persistent data
    - Monitoring and Logging
        - Evolution of design patterns for capturing telemetry and log data from running containers
    - Debugging
        - Attach to running containers and debug code
    - Security
        - Better isolation at the kernel level between containers running on the same host
        - Secret/Key management – Transparently pass sensitive configuration

AWS Lambda + AWS API Gateway

GCP Functions

- No servers to provision, manage, or upgrade
- Automatically scale based on the load
- Integrated monitoring, logging, and debugging capability
- Built-in security at role and per function level based on the principle of least privilege
- Key networking capabilities for hybrid and multi-cloud scenarios

Mobile app developers can use Cloud Functions directly from **Firebase**, Google Cloud’s mobile platform.

Google Cloud Functions Use Cases:

- Mobile Backend
- API & Microservices
- Data Processing / ETL
- Webhooks
- IoT

Features:

- Cloud Pub/Sub Triggers
- Cloud Storage Triggers
- Firebase Triggers
- HTTP/S Invocation
- GitHub/Bitbucket
- Logging, Monitoring & Debugging

Lec25 HTML5: the Next Generation

Major New Elements in HTML5

- New semantic elements like `<header>`, `<footer>`, `<article>` and `<section>`
- `<video>` and `<audio>` that you can embed on your web pages without resorting to third-party plug-ins
    - MPEG4 compressed video (mp4 or m4v)
    - QuickTime (.mov)
    - Flash Video (.flv) from Adobe
    - Ogg (.ogv) open source
    - WebM (VP8/VP9 video + Vorbis audio), from Google
    - Audio Video Interleave (.avi), invented by Microsoft
    - Audio:
        - MP3: 2 channels, encode bitrates 64/128/192 kbps
        - AAC & AAC+: 48 channels

```
<video src="pr6-1.webm" width="320" height="240" preload></video>
<video src="pr6-2.webm" width="320" height="240" preload="none"></video>
```

`pr6-1.webm` will start downloading as soon as the pages loads, while `pr6-2.webm` will not.

```
<video src="pr6.webm" width="320" height="240" autoplay></video>
```

`pr6.webm` will start downloading and playing as soon as possible after the page loads.

- `<canvas>` element, a two-dimensional drawing surface that you can program with JavaScript (No support for event handlers)
- Scalable vector graphics (**SVG**): a container for SVG graphics (support for event handlers)
- **Geolocation**, whereby visitors can choose to share their physical location with your web application
- **Persistent local storage** without resorting to third-party plug-ins `localStorage`
  - data is stored in the users browser and remains there **even across sessions** (open/close browser)
  - data is only available when on that machine and in that browser
  - localStorage is per browser not per computer
  - only supports storing of strings
  - The `sessionStorage` object is equal to the `localStorage object`, **except** that it stores the data for only one session. **The data is deleted when the user closes the specific browser tab**
- **Offline web applications** that work even after network access is interrupted
- Improvements to HTML web forms
- **Microdata**, which lets you create your own vocabularies beyond HTML5 and extend your web pages with custom semantics
- **New APIs** for complex web applications including support for mobile devices

Lec26 Cookies and Privacy

What is a Cookie?

- Short pieces of text generated during web activity and stored in the user’s machine by the user’s web browser for future reference
- Cookies are created by website authors who write software for reading and writing cookies
- Cookies were initially used so websites would remember that a user had visited before, allowing customization of sites without need for repeating preferences

Elements of a Cookie

- A cookie is associated with a website’s domain and contains: **name**, **value**, **path**, and **expiration date**
- Such cookies are sometimes referred to as HTTP cookies because they are placed there using the HTTP protocol as the delivery mechanism

Cookie Scope

- **What They Can Do?**
    - **Store** and manipulate any **information** you explicitly provide to a site
    - **Track** your interaction with the **site** such as pages visited, time of visits, number of visits
- **What They Cannot Do?**
    - Have automatic access to Personal Identifiable Information (PII) like name, address, email
    - Read or write data to disk
    - Read or write information in cookies placed by other sites
    - Run programs on your computer
    - As a result they
        - Cannot carry viruses
        - Cannot install malware on the host computer

Cookie Types and Taxonomy

- **By Lifespan**
    - *Session* Cookies (stored in RAM)
        - exist only while the user is reading and navigating the website; browsers normally delete session cookies when the user exits the browser
    - *Persistent* Cookies (stored on disk)
        - a.k.a. tracking cookies have an expiration date
- **By Read-Write Mechanism**
    - *Server-Side* Cookies (included in HTTP Headers)
    - *Client-Side* Cookies (manipulated with JavaScript)
- **By Structure**
    - *Simple* Cookies
    - *Array* Cookies
- **Secure cookies** have the secure attribute enabled and are only used via **https**, so the cookie is always encrypted
- **Third-party cookies** are not from the “visited” site: are cookies set with a different domain than the one in the browser’s address bar
    - can be placed by an **advertisement** on the page or an image on the page
    - Advertisers use third party cookies to **track a user** across multiple sites

Cookie Processing Algorithm

> **Cookie & Browser Cache**
>
> - Cookie:
>   - 2 way transfer: server --> client, client --> server
>   - only text information
> - Browser Cache:
>   - one-way transfer (from server to local cache)
>   - images can also be cached

Additional Facts about Cookies

- **Scope:** by default, cookie scope is limited to the current host name. Scope may be limited with the **path=** parameter to specify a specific path prefix to which the cookie should be sent, or broadened to a group of DNS names, with **domain=**.
- **Time to live:** by default, each cookie has a lifetime limited to the duration of the current browser session. Alternatively, an **expires=** parameter can specify the cookie dropping date
- **Overwriting cookies:** if a new cookie with the same **NAME**, **domain**, and **path** as an existing cookie is encountered, the old cookie is discarded
- **Deleting cookies:** no specific mechanism for deleting cookies, coomonly overwrite a cookie with a bogus value as outlined above, plus a backdated or short-lived **expires=**
- **"Protected" cookies:** as a security feature, some cookies set may be marked with **secure** keyword, which causes them to be sent over HTTPS only

Client-Side Cookies

- JavaScript can use `document.cookie` (a string variable that can be read and written using the JavaScript string functions)
- need to define 3 js functions for handling cookies:
    - `setCookie(name, value, expiry)`
    - `getCookie(name)`
    - `removeCookie(name)`

- **Canvas fingerprinting** is one of a number of browser fingerprinting techniques for tracking online users that allows websites to uniquely identify and track visitors **without** the use of browser cookies

Cookie-based marketing

Opt-Out

Anyone who prefers not to see ads with this level of relevance can opt out.

- select "do not track" in browser setting
- download opt-out cookies
- use the cookie management tools in web browser
- view current cookie and delete what you don't need
- check account preferences on registration sites
- use browser Add-ons

Lec27 Web Security - Hacking the Web

General Introduction

> **Why secure the Web?**
>
> Web has been used for the following types of criminal activities:
>
> - Chaos
> - Deceit
> - Extortion
> - Identity Theft
> - Information Warfare
> - Monetary Loss
> - Physical Pain
> - Political Defacements
> - Chinese Gaming sites hacked

- Cross-Site Scripting (XSS) is #1 vulnerability
- PHP Apps have highest risk of exposing vulnerabilities

Common ways that websites get infected

- **Cross-site scripting** attacks(XSS)
- **SQL injection** attacks
- Search Engine result **Redirection**
- Attacks on **backend virtual hosting** companies
- Vulnerabilities in web-server or forum-hosting software
- Using **social networks** to infect users (these are a combination of social engineering and above attacks)

How users get the malware planted by hackers?

- By installing “**fake codecs**” embedded with Trojans
- By viewing malicious **advertisements**
- By installing **fake scanners** or misleading applications (shareware/rogueware)
- by visiting malicious P2P sites and download malicious content
- By visiting websites sent as email links by the hacker
- By bisiting websites posted on **Blog Sites** under Blog Comments
- By installing **privated software** from wares sites which are maliciously modified by hackers

The Damage Caused by Hackers

- On client machine
  - Stealing users cookies and thus gaining access to users accounts on websites like email/banking.
  - Logging users keystrokes
  - Showing defaced/altered websites to the user (phishing)
  - User credential stealing and misuse
  - Stealing browser history and compromising privacy of user
  - Evading or disabling phishing filters and thus opening up new avenues for attacks
  - Circumvent other security controls like bypassing HTTPS
  - Installing malicious software (like Trojans/ Rootkits)
  - Spamming …..
- On the server
  - Defacing pages / Altering content
  - Injecting malicious content in dynamically served pages and thus infecting all users who visit the site
  - Denial of service on the server resulting in downtime and hence loss of business
  - Phishing
  - Scanning intranet for vulnerable machines
  - Spamming …

Authentication Attacks

Brute-forcing Attacks

Two types of Brute Force attacks:

- Normal: Uses a single username against many passwords
- Reverse: Use many usernames against a single password

Brute-forcing is easy when websites don't implement any form of account lockout policy.

Insufficient Authentication

- Happens when a website allows users to access sensitive content or functionality **without proper authentication**
- eBay hacked and many users accounts got suspended by hacker

Weak Password Recovery Validation

- when a web site permits an attacker to illegally obtain, change or **recover another users credentials**
- **bad recovery methods:**
  - information verification
  - password hints
  - secret question + answers
- Weak password: like `123456`

PassPhrases

- a password but longer and more secure. It is an encryption key that you memorize
- use **Diceware**
- **Recommendation:** use a password database (KeePassX) locked up with a master diceware passphrase

Client-Side Attacks

Cross-site Scripting (XSS)

- XSS enables attackers to **inject client-side script into Web pages** viewed by other users.
- A cross-site scripting vulnerability may be used by attackers to **bypass access controls** such as the same origin policy
- including other modes of code injection, including persistent and non-JavaScript vectors (including **Java, ActiveX, VBScript, Flash**, or even pure HTML, and SQL Queries)
- 2 types of XSS attacks:
  - **non-persistent (reflected) XSS:** the most common type
  - **persistent (stored) XSS:** saved by server
- Reduce the threat:
  - **contextual output encoding/escaping**
  - **HttpOnly Flag** allows a web server to set cookie that is unavailable to client-side scripts
  - tie session cookies to IP address of the user who originally logged in

Browser and plugin vulnerabilities

in the client browser software or client plugins (Java/ActiveX/Flash/Acrobat)

Clickjacking

- trick users into **clicking something without them knowing what they have clicked**
- can be achieved through CSS alone, no JavaScript is required

Injection Attacks

- Injection Attacks occurs when an application **does not properly validate user supplied input** and then includes that input blindly in further processing
- **SQL**/LDAP/XPATH/SOAP/**JSON Injection** are all types of Injection Attacks that are enabled by improper input validation
- **SQL Injection:**
    - Normal SQL injection
    - Blind SQL injection
- **JS Hijacking:** allows an unauthorized attacker to read confidential data from a vulnerable application using a technique similar to the one commonly used to create mashups, allows an attacker to bypass the Same Origin Policy
    - **JSON array is directly vulnerable to JavaScript Hijacking**.
- **Search Worms:** automate finding of vulnerable web servers by sending carefully crafted queries to search engines

Recent Attacks

- Worms: stuxnet
- Email Hacks
- account breaches
- the NSA
- Distributed Denial-of-Service (DDoS) Attacks

Privacy Tools

TOR

- web
  - Surface Web
  - Invisible Web
  - Dark Web: accessible only to those who use software called TOR (The Union Router)