

Lecture #16: Client-Side Programming

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In this lecture, we take a look at client-side processing. We take a look at some of the most common tasks used for client-side processing. We review the characteristics of JavaScript, the language used for client-side processing. We study the Document Object Model which is used to connect JavaScript programs to the internals of webpages. We consider Ajax a technology allowing client-side processing and server-side processing to work together – a critical factor in creating Single Page Applications (SPAs). Finally we take a look at some Frameworks built on top of JavaScript.

Client-Side Processing

Client-Side Processing can be used for a variety of purposes.

- Complex user interface interactions are done with Client-Side Processing including
 - o Dragging items around a webpage (e.g., Google Maps)
 - o Nested menus – while basic HTML form elements can provide a single level of pulldown menu, anything more complex such as a nested menu requires client-side processing.
 - o Search result refinement where typing into a text field results in a list of possible completions. In general if the webpage changes or reconfigures as the user interacts with it, that's client-side processing. This is sometimes done in conjunction with the server, but ultimately the server by itself can't change part of the webpage without client-side processing.
- Single Page Applications require Client-Side Processing
 - o SPAs use JavaScript programs to dynamically change a webpage adding and removing elements, as the user interacts with them.
- Client-Side Processing can also be used for basic calculations such as determining loan payments for a given interest rate or converting from metric to imperial units.

Client-Side Processing Languages

- The vast majority of Client-Side Processing is done with **JavaScript**
- Java can also run in a web browser, although most security experts recommend that you disable your web browser's ability to run Java, as this is a known vector for attacks on your computer.
- Adobe Flash is also used on the Client-Side, although it's no longer in favor, and Adobe is scheduled to end support for it in 2020.
- In addition, as we briefly discussed in the CPU lectures when talking about compilers and interpreters, there are some languages that will compile to JavaScript.
 - o Users of these language will use compilers to convert their code to JavaScript, and then their web server will serve out the converted JavaScript code to visitors.
 - o These languages include TypeScript, Google Dart, and Scala

About JavaScript

- While JavaScript is primarily used in the web browser, it can be used in other places as well.
 - o Node.js is a general purpose JavaScript interpreter and among other uses it is commonly used as a web server.
 - o The MongoDB database uses JavaScript's object model and supports JavaScript code.

- JavaScript can also be embedded in other applications as a scripting language.
- The official name for JavaScript is ECMAScript
 - Netscape Corporation passed control of the language to the European Computer Manufacturers' Association for standardization.
 - You usually will only hear the term ECMAScript in reference to specific versions of the language and the features they added. For example:
 - ECMAScript 6 added a considerable number of features including support for traditional classes.

JavaScript Language Characteristics

- Untyped variables, parameters, and return types.
- Limited range of primitive data types
 - Only one Number type which is used for both floats and integers
- Object system based on Prototypes, not traditional classes
- Interpreted

Integrating JavaScript into a Webpage

- JavaScript is put into a webpage very similar to how Cascading Style Sheets are.
- You can insert JavaScript directly into your HTML file by adding in a `<script>` start and `</script>` end tag and then just sticking your JavaScript code right there into the HTML file.

```
<script>
  var x = 1;
  x = x + 5;
</script>
```

- You can also keep your JavaScript file separately from your HTML, just as you can with CSS. In this case though we still use the `<script>` tag, except we add an `src` to our `<script>` tag:

```
<script src="basic.js">
</script>
```

Document Object Model (DOM)

The key to JavaScript working in the web browser is something called the Document Object Model or DOM.

- When a webpage loads the web browser creates a set of objects corresponding to all the HTML elements on the webpage.
- This set of objects is called the Document Object Model
- A client-side language such as JavaScript can access and modify the elements on the webpage via the DOM
 - Using the DOM a client-side program can retrieve and change the values in an HTML form: reading and modifying the values in text fields, checking and changing radio button settings, etc.
 - Changing the `src` property of an image causes the webpage to display a different image. This is how an image carousel or slideshow on a website works.
 - Style settings can be changed via the DOM.

- This might be used, for example, to change the location of an element on the webpage using CSS position properties. This is how something like Google maps allows the user to drag the map around.
 - This can also be used to make items visible or invisible.
- A client-side program can change the contents of existing elements on the webpage. For example, this could be used to change a div from displaying one email message to displaying another.
- Finally, a client-side program can add in new elements or remove existing ones.

The web browser also exposes other capabilities to the client-side programming.

- The client-side program can change the current webpage displayed by modifying the web browser's Location object.
- It can open and close windows using the Window object.
- It can go backwards and forward in the browser history using the History object.

Dynamic HTML and HTML5

- Client-side processing takes websites to a whole new level of sophistication over what can be provided with simply HTML and CSS.
- Client-side processing enhanced web technology is sometimes referred to as Dynamic HTML
 - Dynamic HTML is generally considered to consist of HTML, CSS, JavaScript, and the DOM. Ajax (see below) is sometimes added into this mix.
 - Sometimes the term HTML5 is used as a replacement for Dynamic HTML.
 - Although technically HTML5 only refers to the HTML specification itself.
- You'll see employment advertisements asking for Dynamic HTML or HTML5 developers
 - This is a shorthand way of saying you want someone with expertise on the full suite of client-side processing technology

Ajax

- Ajax allows Client-Side JavaScript programs to make an HTTP request to a webserver.
 - Normally, when we send a request to the server, the server responds with a new HTML file that replaces the current webpage. That's not how Ajax works.
 - Instead, the server's response is stored in program memory, where our Client-Side program can access it.
 - Our program analyzes the response and dynamically change the current webpage in response to the new information from the server.
- Ajax is a critical technology for making single-page applications (SPA).
 - An SPA is a website consisting of a single page.
 - The user visits that page, interacts with the page, the page changes and responds to the user's interactions, but never switches to a new page.
 - Google Maps and Gmail are both examples of Single Page Applications
 - If I type in an address, Google Maps does not switch to another webpage. Instead, it updates the current webpage.
 - Similarly if I click on mail message in Gmail, I don't go to a different webpage. Instead the mail message is returned from the server and part of the webpage is updated to show that mail message.
 - SPAs require Ajax's ability to get data from the server, without switching from one webpage to another webpage.
- The JSON and XML formats we discussed in the last lecture are commonly used as data formats for Ajax.

Vanilla JavaScript / JavaScript Libraries / JavaScript Frameworks

- There are a wide number of frameworks and libraries built on top of JavaScript. Some of these are very common. Some of the most common include:
 - o jQuery, Twitter Bootstrap, Angular, React, and Vue.
- JavaScript programs that just use the support provided by the web browser along with the standard JavaScript language libraries (i.e., without an accompanying framework) is sometimes referred to as *vanilla JavaScript*.
- Historically programming vanilla JavaScript has been somewhat challenging
 - o Unfortunately web browsers all acted differently, requiring vanilla JavaScript code to determine which features a web browser supported and which it didn't.
 - o Microsoft's Internet Explorer, in particular, did not follow standards, and vanilla JavaScript programs often had to have two sets of code in places, one for web browsers following the World Wide Web Consortium (W3C) standard, and one for Internet Explorer.
- This led to the rise of the very popular jQuery library, which we'll take a closer look at in a moment.
 - o jQuery handled cross-browser problems for the programmer.
- More recently, web browsers have done a better job of following the W3C standard, and the last few versions of Internet Explorer and Microsoft's new Edge web browser now support standard code.
- Recently more powerful, full featured frameworks have appeared.
 - o Frameworks often have a very specific view of the world and how programs should be written.
 - o If your project fits in with the framework's model, these can give tremendous advantages.

jQuery

- jQuery has become a very popular library since its introduction just over a decade ago.
- jQuery provided several important advantages over vanilla JavaScript.
 - o Foremost, as I mentioned previously, jQuery handled cross web browser issues. Programmers using jQuery were able to write just a single set of code, and jQuery would ensure that it ran on all web browsers.
 - o jQuery also supported more sophisticated ways of selecting elements on a webpage for processing.
 - jQuery users could use CSS style selectors to choose elements on the webpage for further processing.
 - o In addition, jQuery provided other advanced features such as easy animation of webpage elements.
- However, many of the advantages of jQuery are no longer applicable.
 - o As mentioned above, modern web browsers have become far more standardized. Ensuring a vanilla JavaScript program works across web browsers is no longer the chore it once was.
 - o Vanilla JavaScript now has the ability to choose elements for processing using CSS rules, just like jQuery.
 - o CSS Animation provides animation support.
- Plusses for using jQuery,
 - o jQuery has a huge installed code base. At this point, if you're working on a legacy project, there's a good chance it will be using jQuery.

- Some very popular and useful libraries are built on jQuery (most notably Twitter Bootstrap, which we'll explore further in a moment).
- Minuses for using jQuery
 - As previously mentioned, vanilla JavaScript has improved considerably; jQuery no longer provides the advantages it once did.
 - New powerful frameworks, such as Angular 4, React, and Vue have a very different view of the world from jQuery.
 - While it is often possible to combine jQuery with these frameworks, it is not recommended, as their world views and coding styles may clash with jQuery's, leading to code that is harder to understand and maintain.

jQuery UI

- jQuery UI provides a variety of user interface widgets built on top of jQuery.
- For example, if you need to create a fancy menu that includes sub menus on your webpage, it is possible to build one from scratch, but jQuery UI has one pre-built for you.
- jQuery UI also makes it easy to support a number of different commonly used abilities to your webpage elements such as making an element draggable or resizable.

Twitter Bootstrap

- Twitter Bootstrap is also built on jQuery and provides a set of user interface widgets similar to jQuery UI.
- In addition, however, Twitter Bootstrap provides pre-defined classes for CSS that allow us to easily layout a webpage into columns of different sizes.
- Twitter Bootstrap allows us to select different column rules depending on the size of the user's screen – easily setting up different webpage layouts for cell phones, tablets, and laptops or desktops with large monitors.

Angular

- Angular is a framework developed by Google.
- The first version of Angular uses JavaScript and is sometimes referred to as AngularJS.
- There are two newer versions of Angular – Angular 2 and Angular 4.
 - These are built for TypeScript, a superset of JavaScript that supports static typing.
- AngularJS provides support for a concept called Model View Controller (MVC)
 - Using MVC we distinguish between data (the model) and views of the data.
 - In AngularJS, I can associate different form elements on the webpage with underlying variables representing those form elements.
 - For example, I can associate a text field with a JavaScript variable.
 - If I change the variable, the text field automatically changes to match the variable. If the user changes the text field, the variable is automatically updated.
- AngularJS also allows provides the ability to auto-generate HTML based on JavaScript data structures.
 - For example, I could have an array of patient names, and a unordered list element. I could instruct angular to take that list of patient names and automatically generate list items in the unordered list for me.
 - If the list later changes, what appears on the webpage will automatically change as well.

React

- React is a relatively new framework that has been gaining a lot of popularity.
- React has a very declarative style.

- You can think of it as allowing us to define new types of HTML-like elements.
 - These elements can be parameterized to take display different data.
- For example, if I had a news website, I could define the following elements:
 - NewsItem elements for displaying different news items
 - A WeatherBox element for displaying the current weather.

 - I can combine these elements in different ways to create different looking news webpages.
 - I can take an array of news stories and combine it with my NewsItem element to populate my webpage.

- React is from Facebook.