CSE 331
Software Design & Implementation

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Winter 2022

HTML + TypeScript Overview

Administrivia

- HW7 out yesterday – campus map pathfinder
  - Due next Thursday night
  - Lots of relevant things in sections yesterday
- Holiday Monday. We should have some office hours – watch calendar for updates.
- TypeScript tutorial video available on 331 course canvas panopto page & liked to today on lecture calendar
  - Followup to this lecture
  - Must watch this before next Wednesday's class (or else that will be *really* confusing/mysterious)
  - Sample code for this lecture and the TypeScript video linked to the course calendar for this lecture

The Weeks Ahead

- We’re going to build an application that can find walking paths on the campus (hw7)
- We’d like to add a graphical user interface front-end once that’s done
  - The web is a common way to build/distribute apps
  - Web programming uses the same concepts we're learning
  - So: We're going to make a webapp for this.
  - Therefore: Let's learn how to do this!
  - Note: There are *many* ways to approach web programming. We're doing just one…

Our Approach

- We're going to be using several different pieces:
  - HTML
    - The language that web browsers render
    - Describes the structure and content of the page
  - TypeScript (TS)
    - A version of JavaScript that adds type-safety
    - Used to create the bulk of our application
    - Adds interactivity to the webpage
  - React
    - A UI library – handles the interactions between TS and HTML, makes UI programming easier

Our Approach (2)

- We’re going to learn just enough to display a map, allow users to select endpoints, and draw a path
  - So we we’ll focus on the basics, particularly key differences between what we're doing and Java
  - But also realize our goal isn’t to exhaustively cover everything – don’t have time, so core ideas only
- Will probably be outside your comfort zone – this is new stuff!
  - Remember to ask questions ☺
- Last two assignments this quarter:
  - HW8 draw lines on a map image (using TS/React)
  - HW9: use HW8 framework to build campus path GUI, use the Java graph/pathfinding code from hw5-hw7

Credits

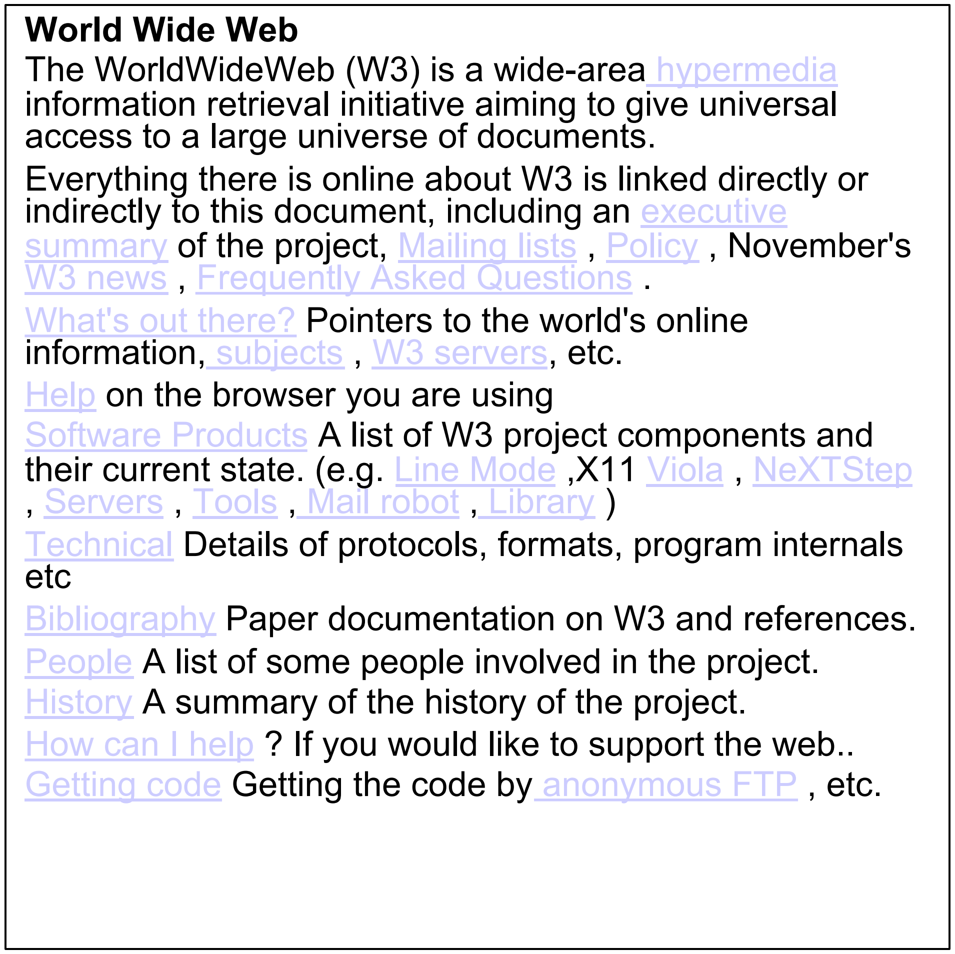
- CSE 331 JS/TS project originally due to Andrew Gies and Avi Bhagat, new version this quarter done by Bryan Lim and Ardi Madadi (& a host of others testing, etc.)
- Slides due to Andrew Gies, Hal Perkins & Kevin Zatloukal
- Thanks to Lauren Bricker and CSE 154 crew for some additional notes (but even if you took 154 recently this stuff probably will look different)
- And from wherever we can find useful things…

- Notes: JS = JavaScript. ECMAScript is the official standard version so you'll also see things like ES or ES6 or ES2015, etc. TS=TypeScript=JS with type declaration

A little history

In the beginning was the web page

- It was displayed in a browser
- It had links
- But it was static
- There was no way to update or compute content dynamically or interact with users
- Solution: add a scripting language to the browser
  - Users (page developers) should be able to write code
  - Code should be able to interact with the browser's data structures to read / update / modify the page contents



World Wide Web

The WorldWideWeb (W3) is a wide-area hypermedia information retrieval initiative aiming to give universal access to a large universe of documents.

Everything there is online about W3 is linked directly or indirectly to this document, including an executive summary of the project, Mailing lists , Policy , November's W3 news , Frequently Asked Questions .

What's out there? Pointers to the world's online information, subjects , W3 servers, etc.

Help on the browser you are using

Software Products A list of W3 project components and their current state. (e.g. Line Mode ,X11 Viola , NeXTStep , Servers , Tools , Mail robot , Library)

Technical Details of protocols, formats, program internals etc

Bibliography Paper documentation on W3 and references.

People A list of some people involved in the project.

History A summary of the history of the project.

How can I help ? If you would like to support the web..

Getting code Getting the code by anonymous FTP , etc.

Enter JavaScript

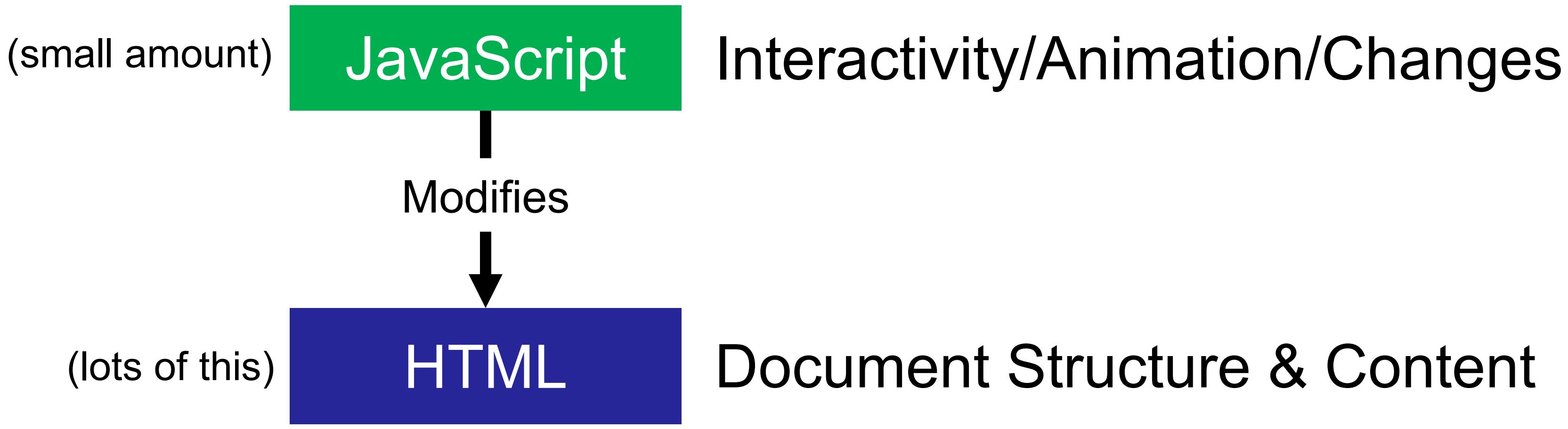
- Created in 1995 by Brenden Eich as a “scripting language” for Mozilla’s browser
  - Done in 10 days!
- Used to make web pages interactive:
  - Change the content/structure in HTML
  - React to events (page load, user clicks)
  - Discover info about local computer
  - Do local calculations
- No relation to Java other than trying to piggyback on all the Java hype at that time

Why JavaScript now?

- JavaScript is a web standard & ships in every browser
  - But not supported identically by all of them ☹
- De facto execution engine for dynamic code on web
  - If a website is doing something interesting, there's probably JavaScript inside
- We will try to stick to portable, generic stuff
  - We use tooling that "smooths out" the difference between browsers as much as possible (it's the wild west out there)
  - But for hw8/hw9 we're only supporting Chrome (at least this time around) to avoid cross-platform grief
    - Install and update to current version please

In Context…

The "Original" Model of (Dynamic) Web Development

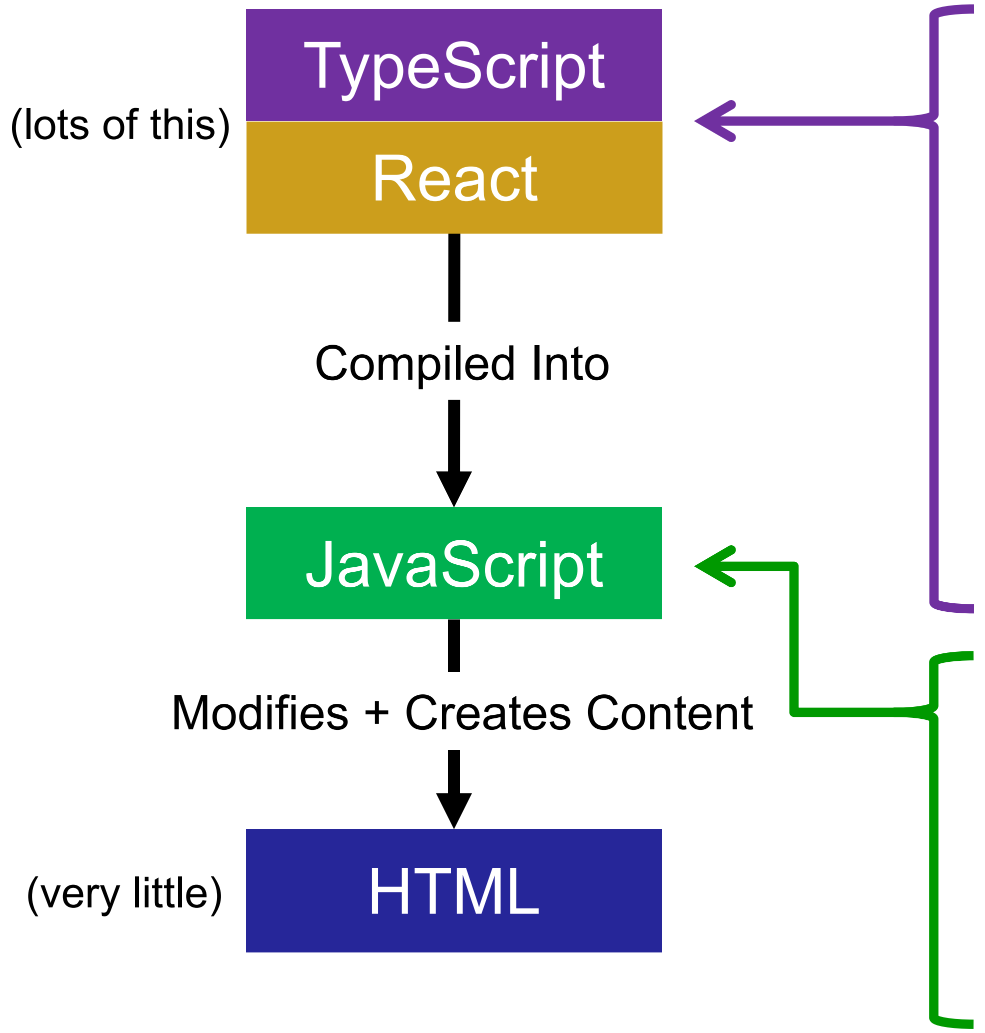


So that's what we're doing, right?

- Not quite…
- The original model was meant for simple things
  - click a button to submit a form, change a color, etc..
- The modern web now hosts full-fledged *applications* entirely using web technology
  - JS + HTML were never designed for this
- The "old" way:
  - Language + tooling doesn't help much, difficult to write big programs correctly/safely/efficiently
  - Managing large parts of the webpage with pure JS is difficult to get right

* There are a lot of ways to do things in modern web dev

One* Modern Alternative



- TS = JS with extra features
  - Type System (!)
  - The compiler is smart – helps you find bugs, just like Java
- React = UI Library
  - Main idea: users create the content with JS/TS
  - Uses data to create the web content – change the data to change the content

- Browsers don't speak TS
  - Need to convert to JS before running
- We don't need to read/write (we write TS), but you should know that this is what's happening

Resources

- Lectures will (try to) point out key things

- TypeScript is *mostly* JavaScript – only big difference is types
  - Wondering how to do something? Look for JavaScript answers
  - Wondering how to type something? Look for TypeScript answers

- For more…
  - Mozilla (MDN) tutorials are good
  - CodeAcademy JavaScript basics
  - React documentation – small doses, way more info than we need
  - TypeScript documentation – focused on the "new stuff" in TS vs JS

- Be ***very*** careful about web searches
  - There are 1000 ways to do anything, many of which may be different than what we're doing
  - Code snippets from the web may lead you ***way*** off.
  - When in doubt, make an Ed post!

Our plan…

- First, look at basic HTML on its own
  - No scripting, no dynamic content
  - Just how content/structure is communicated to the browser

- Second, look at basic TypeScript (& JavaScript) on its own
  - No browser, no HTML, just the language
  - Get a feel for what's different from Java

- Third, a quick look at very basic user interactions
  - Events, event listeners, and callbacks (just basic ideas now)

- Fourth, use TypeScript with React with HTML
  - Write TypeScript code, using the React library
  - Generates the page content using HTML-like syntax

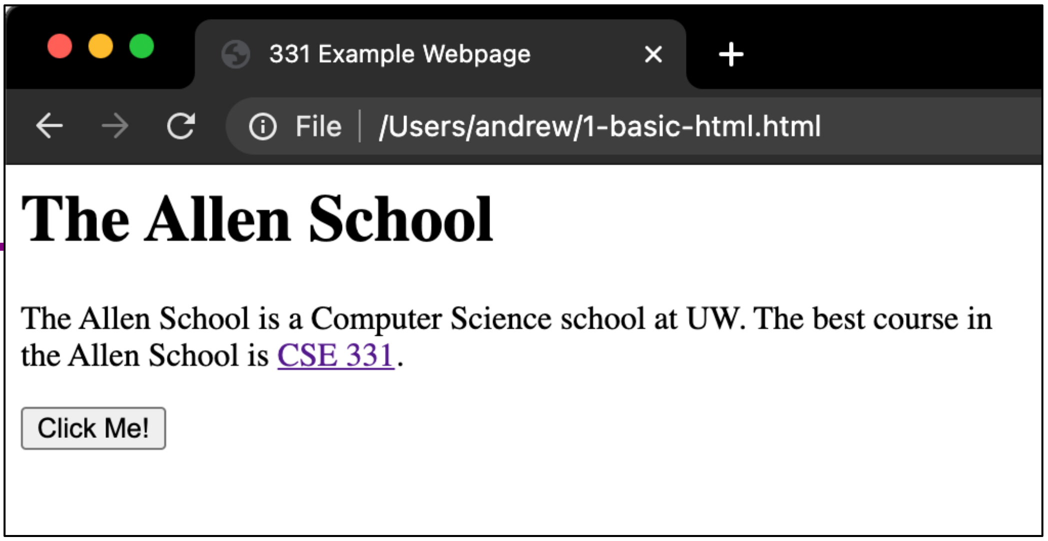
HTML, Formally

- HTML - HyperText Markup Language

- Consists of *tags* and their contents
  - Each tag has a different meaning
    - button, paragraph, link, etc…
  - Each one has a beginning and end.
  - Can contain text (content) and other tags. Optional attributes (organized as key-value pairs)
    - Can think of them like “constructor parameters”: pieces of data that specify extra info about the tag.

- Define document *structure and content*

Demo


331 Example Webpage

File | /Users/andrew/1-basic-html.html

The Allen School

The Allen School is a Computer Science school at UW. The best course in
the Allen School is CSE 331.

```
<html lang="en">
  <head>
    <title>331 Example Webpage</title>
  </head>
  <body>
    <h1>The Allen School</h1>
    <div>
      <p>
        The Allen School is a Computer Science school at
        UW. The best course in <br/> the Allen School is
        <a href="https://cs.uw.edu/331">CSE 331</a>.
      </p>
      <button>Click Me!</button>
    </div>
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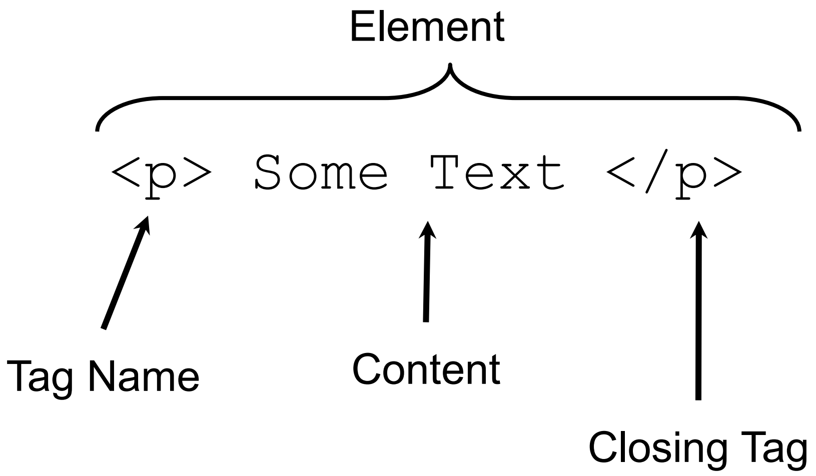
```

Anatomy of a Tag



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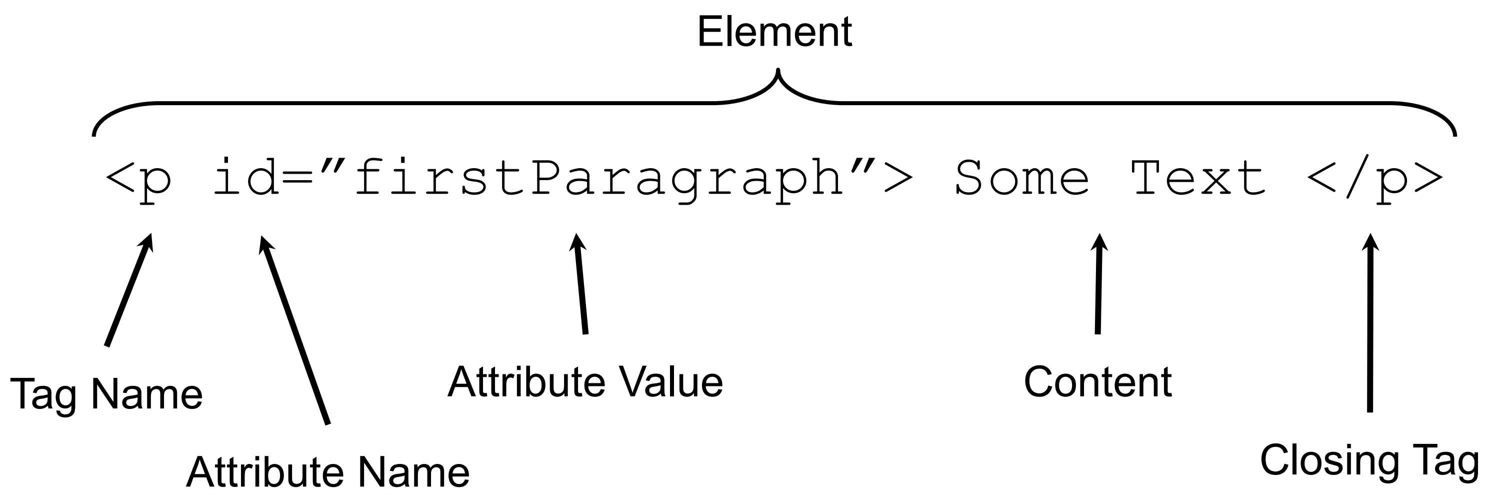
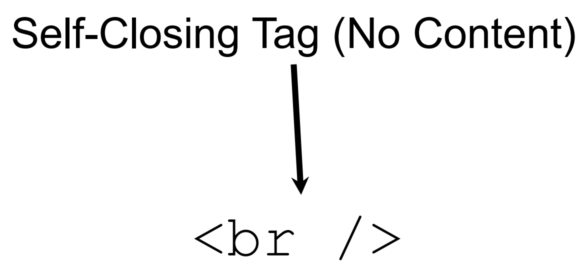


```
<p id=”firstParagraph”> Some Text </p>
```

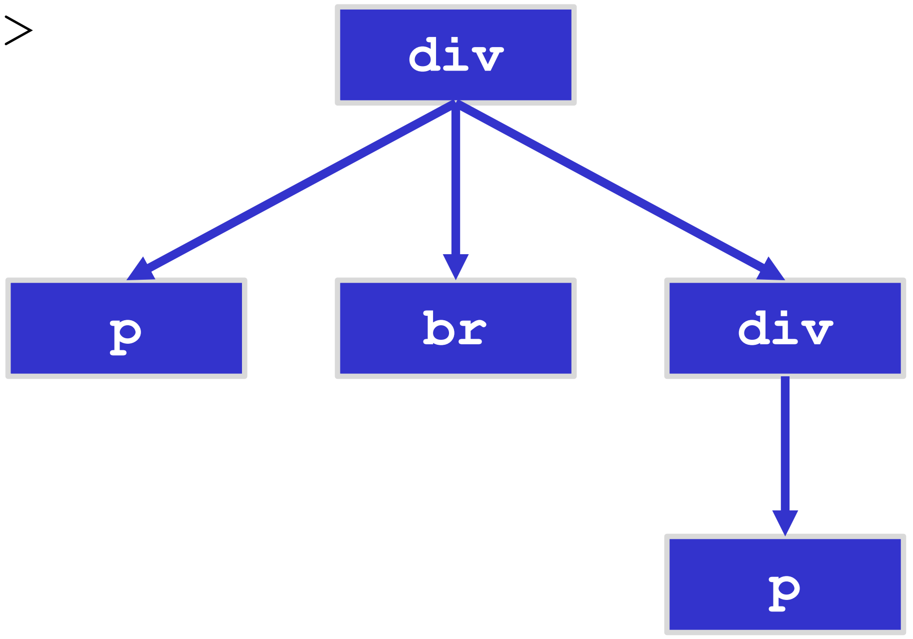


```
<br />
```

We’ll see what <p> and <br> mean soon...

Tags form a Tree

```
<div>
   <p id=”firstParagraph”> Some Text </p>
   <br />
   <div>
      <p>Hello</p>
   </div>
</div>
```



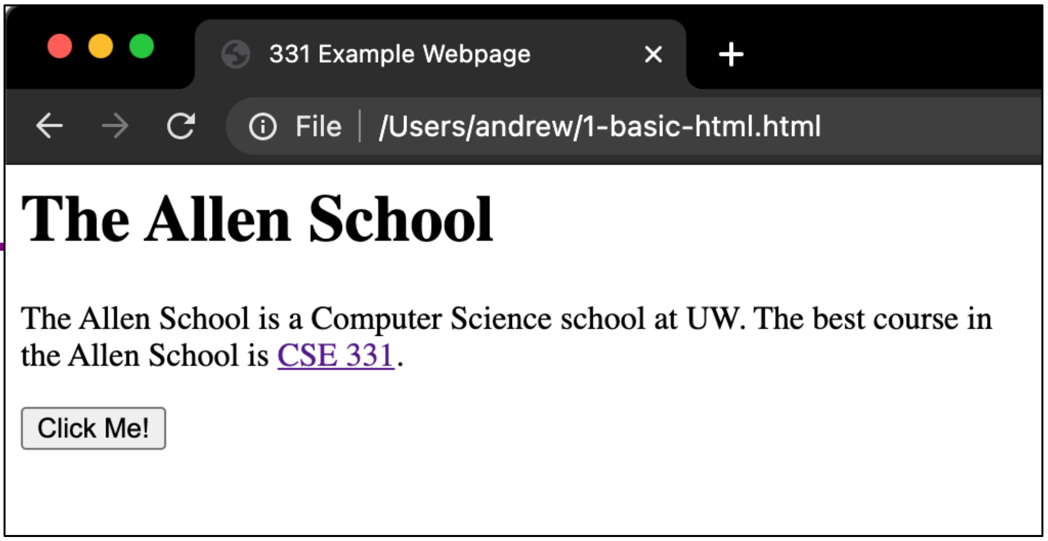
This tree data structure, which lives in the browser, is often called the "DOM" – *Document Object Model*

A Few Useful Tags

- A few worth mentioning here:
  - `<html>` and `<head>` and `<body>` - Used to organize a basic HTML document.
  - `<title>` - Sets the title of the webpage
  - `<p>` - Paragraph tag, surrounds text with whitespace/line breaks.
  - `<a>` - Link tag – links to another webpage.
  - `<div>` - "The curly braces of HTML" - used for grouping other tags. Surrounds its content with whitespace/line breaks.
  - `<span>` - Like `<div>`, but no whitespace/line breaks.
  - `<br />` - Forces a new line (like "\n"). Has no content.
  - `<button>` - Create a clickable button on the screen

- See the W3Schools HTML reference for a complete list, along with all their supported attributes.

Demo Again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What’s next?

Done:

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JavaScript (1)

Like Java in many ways:

- Variables:
  - `let` allows rebinding
  - `const` is like Java's final – can't change after creation

```
let something = "hello, world";
const pi = 3.1415;
```

- Types of values:
  - `number` – floating point only, no integer type
  - `boolean` – true/false
  - `string` – similar to Java's strings
  - `undefined` – "unset" values
  - `object` (includes `null`) – more info later

JavaScript (2)

- `if`/`else if`/`else` statements
  - Structurally identical to Java
  - *Any value* can be used as a boolean:
    - `false, 0, "", null, undefined, NaN` behave as `false`
    - Everything else (!) behaves as `true`
    - Values are described as "falsey" and "truthy"
- Loops
  - `for` & `while` – same as Java
  - for-in and for-of are like Java's for-each
    - Be careful with for-in and for-of, they're tricky
- Arrays
  - Can mix types in the array – `[123, "hello", false]`
  - No bounds checks, possible to access after the end
  - Versatile: behave as stacks/queues/lists

JavaScript (3)

- Functions
  - Can exist outside of classes/objects
  - Functions are *values*
    - Put them in variables
    - Pass them to functions
    - (more in demo)
- Objects
  - Similar to a Java HashMap
    - key/value pairs
  - The values can be functions
    - This is how we get methods!
  - Written using { and }
    - Recent JS/ECMAScript adds “class” syntax so it looks more familiar

```
let mul = function(x, y) {
  return x * y;
}

let add = function(x, y) {
  return x + y;
}

add(2, 3);   // result is 5
add = mul;
add(2, 3);   // result is 6
```

```
let simpleObj = {
  x: 8,
  y: "abc",
  z: true
};
simpleObj.x; // result is 8
```

Why TypeScript?

- JS variables are *dynamically typed*
  - The type of a variable can change based on its value
  - JS will attempt to convert values where it can
  - This leads to tricky bugs

```
let x = 5;   // x holds a number
x = "35";    // x now holds a string
x += 7;      // x = "357"
```

- TS = Mostly JS, but adds *static* types (like Java)
  - Can declare type when creating a variable
  - TypeScript compiler will enforce this – prevents bugs!

```
let x: number = 5;
x = "35";   // TypeScript error!
```

More TypeScript

- Longer online video tutorial
  - Please watch before next Wednesday (otherwise that class won’t make much sense)

- Some basic sample files in the typescript/ folder accompanying these slides (see calendar for link)

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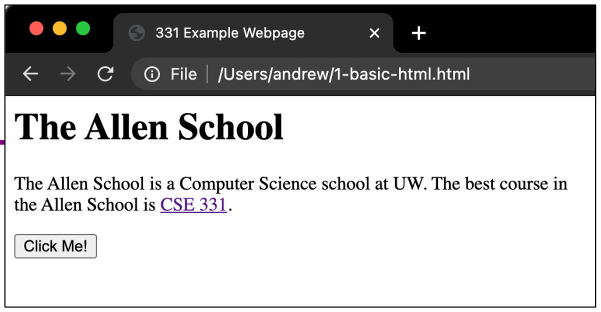
Demo Revisited

- Our first webpage was static
  - It even included a picture of a button, but nothing happened when it was clicked
- How do we add interaction?

Demo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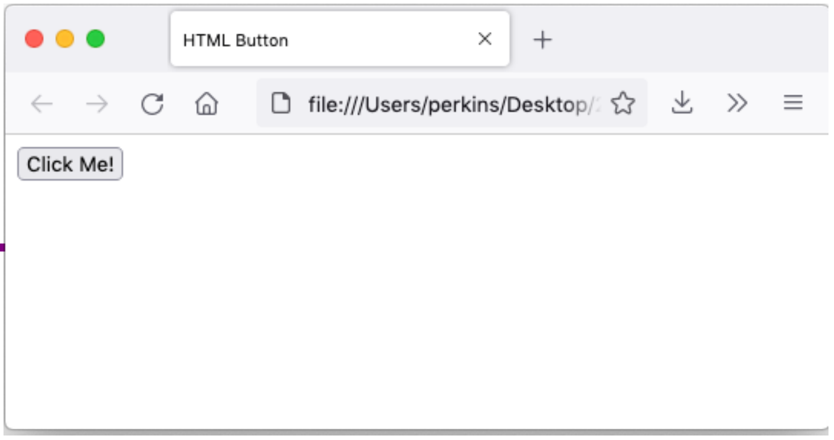
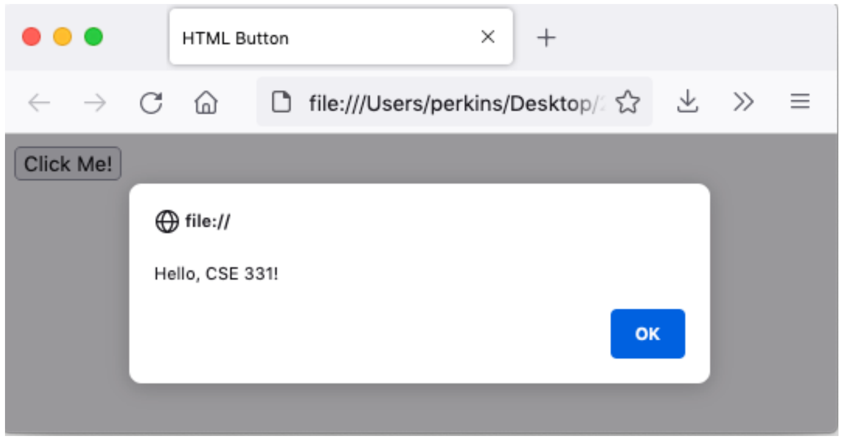
Demo 2





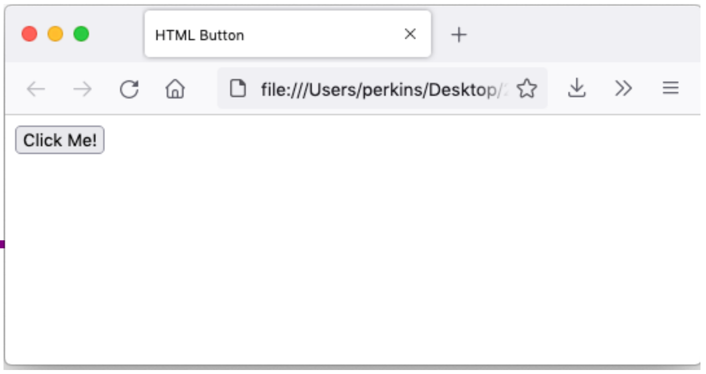
Hello, CSE 331!

```
<html lang="en">
  <head>
    <title>HTML Button</title>
  </head>
  <body>
    <script type="text/javascript">
        function sayHello() {
            alert("Hello, CSE 331!");
        }
    </script>
    <button onclick="sayHello()">Click Me!</button>
  </body>
</html>
```

What happened here?

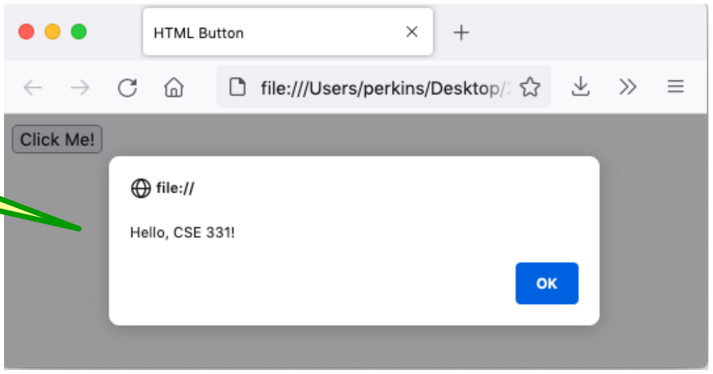
- This is the *callback pattern*
- The webpage is loaded into the web browser and it contains a JavaScript function and a button
- When the button is created, the JS function to be called on a button click is *registered* with the button
  - The function is not called at this time
- When the user clicks the button, it causes a user-interface *event* to happen
  - In response, the button calls the function that was registered to be called (notified) whenever there is a click event
    - This is a *callback*

Demo 2 revisited



0 – web page is loaded into browser

3 – when button is clicked function sayHello() is called and alert box is displayed



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        }
    </script>
    <button onclick="sayHello()">Click Me!</button>
  </body>
</html>
```

1 – JS sayHello function embedded in web page inside <script> tag

2 – Button created on page load; sayHello() function *registered* to be called on click event

Demo 2 Perspective

- This demo gives a very simple example using plain JavaScript – details will be different in React, but the core callback idea will be the same
  - On startup, register code to be activated when events happen
    - Multiple ways to do this: options in an html tag (basic JS), call a "register" function and pass to it the function to call when the event happens (react), similar things in other async systems
  - When an event happens (button press, text added to dialog, timer expires, data read, etc. etc.) the code that is registered ahead of time will be called

Up Next

- Watch the TS Demo video before Wednesday
  - On Canvas under "Panopto Recordings” & linked to lecture calendar for today
  - Details on how the language works
  - Sample code for the video is linked to this lecture in the code/typescript/ folder
- Wednesday class: Using React + TS to create websites
- Sections next week: HW8, TS + React