CSE 331
Software Design & Implementation
Topic: HTML and TypeScript

💬 Discussion: What can you do to make a team work smoothly?
Reminders

• I’m out this weekend – make sure to email course staff
• Watch TS Introduction video

Upcoming Deadlines

• Prep. Quiz: HW7 due Monday (8/01)
• HW7 due Thursday (8/04)
Last Time…

- Generic Methods
- Generics and Subtyping
- Arrays
- Type Bounds
- Wildcards
- Type Erasure
- Callbacks

Today’s Agenda

- Event-driven Programming
- A Short History of Web
- HTML
- TypeScript
A sorting example...

Consider the following sorting method:

```java
public static void sort(List<Integer> lst) {
    for (int i = 0; i != n; i++) {
        for (int j = 0; j != n - 1; j++) {
            if (lst.get(j) > lst.get(j + 1)) {
                swap(lst, j, j + 1);
            }
        }
    }
}
```

What could we improve about this?
Consider the following sorting method:

```java
public static void sort(List<?> lst) {
    for (int i = 0; i != n; i++) {
        for (int j = 0; j != n - 1; j++) {
            if (lst.get(j) > lst.get(j + 1)) {
                swap(lst, j, j + 1);
            }
        }
    }
}
```

But wait - this doesn’t compile! Why?
Achievement unlocked: Callbacks

- Even though we are the implementer, we may need the client to help us
  - previously, we have seen clients provide **data** that we can process
  - now, we will see how clients can provide **code** that can be executed

**Callback pattern**: “Code” provided by client to be used by library
  - In JS etc., pass a function as an argument
  - In Java, pass an object with the “code” in a method

**Synchronous** callbacks:
  - Useful when library needs the callback result immediately

**Asynchronous** callbacks (i.e. event-driven programming):
  - Useful for performing an action when some interesting event occurs later
A sorting example...

First, we can define:

```java
public interface Comparable<T> {
    public int compareTo(T other);
}
```

Every object that implements this interface must provide some code that informs us which of two objects is bigger.

- returns -1 if this is smaller than other
- returns 0 if this is equal to other
- returns 1 if this is bigger than other
A sorting example...

```java
public static <T extends Comparable<T>> void sort(List<T> lst) {
    for (int i = 0; i != n; i++) {
        for (int j = 0; j != n - 1; j++) {
            if (lst.get(j).compareTo(lst.get(j + 1)) > 0) {
                swap(lst, j, j + 1);
            }
        }
    }
}
```

We can use the callback pattern to ask the client how to compare to objects.

Relying on client code to sort
How are callbacks used in practice?

- Clients sit around waiting for events like:
  - mouse move/drag/click, button press, button release
  - keyboard: key press or release, sometimes with modifiers like shift/control/alt/etc.
  - finger tap or drag on a touchscreen
  - window resize/minimize/restore/close
  - timer interrupt (including animations)
  - network activity or file I/O (start, done, error)
    - (we will see an example of this shortly)
Achievement unlocked: Observers

This is the **observer pattern**
- Objects can be *observed* via *observers/listeners* that are *notified* via *callbacks* when an *event* (of interest) occurs
- **Pattern**: Something used over-and-over in software, worth recognizing when appropriate and using common terms
  - Widely used in public libraries
  - Useful for “visual” programs like web applications

More examples of “observers” coming later...
Event-driven programming

An *event-driven* program is designed to wait for events:
- program initializes then enters the *event loop*
- abstractly:
  ```java
do {
    e = getNextEvent();
    process event e;
  } while (e != quit);
```

Contrast with most programs we have written so far
- they perform specified steps in order and then exit
- that style is still used, just not as frequently
  - example: computing Page Rank or other Big Data work
Event-driven programming

Register Event
public void myFunction() {
    System.out.println("I was here");
}
button1.addOnClickListener(myFunction);

Event loop:
do {
    e = getNextEvent();
    process event e;
} while (e != quit);
Event-driven programming

Register Event
public void myFunction() {
    System.out.println("I was here");
}
button1.addOnClickListener(myFunction);

Event loop:
do {
    e = getNextEvent();
    process event e;
} while (e != quit);
Event-driven programming

Register Event

```java
public void myFunction() {
    System.out.println(“I was here”);
}
button1.setOnClickListener(myFunction);
```

Event loop:

```java
do {
    e = getNextEvent();
    process event e;
} while (e != quit);
```
Event-driven programming

Register Event
public void myFunction() {
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Looking Ahead

• We’re going to build an application that can find walking paths on the campus

• 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

• Note: There are many ways to approach web programming. We're doing just one...
Looking Ahead

- We're going to need to learn a few 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
Looking Ahead

• We’re going to learn just enough to display a map, allow users to select endpoints, and draw a path
  – Focus on the basics, i.e. key differences between what we're doing and Java
  – Our goal isn't to 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 will draw lines on a map image (using TS/React)
  – HW9 connects the HW8 UI to the implementation of Dijkstra’s from HW7
Credits

• CSE 331 JS/TS project originally due to Andrew Gies and Avi Bhagat, new version in 22wi done by Bryan Lim and Ardi Madadi (& a host of others testing, etc.)

• Slides due to Andrew Gies, Hal Perkins, and 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...
A little history

In the beginning, there 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 hypertext 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
  - Use tooling that "smoothes 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 issues
In Context...

The "Original" Model of (Dynamic) Web Development

JavaScript

Modifies

HTML

Interactivity/Animation/Changes

Document Structure & Content
So that's what we're doing, right?

- 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
One* Modern Alternative

TypeScript

React

Compiled Into

JavaScript

Modifies + Creates Content

HTML

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

- 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 data to change the content

- Browsers don't speak TS
- We only write TS, but you should know that this is what's happening

(lots of this)

(very little)
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 are 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*
<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 the Allen School is <a href="https://cs.uw.edu/331">CSE 331</a>.</p>
      <button>Click Me!</button>
    </div>
  </body>
</html>
Anatomy of a Tag

Element

<p> Some Text </p>

Tag Name

Content

Closing Tag
Anatomy of a Tag

Element

Tag Name

Attribute Name

Attribute Value

Content

Closing Tag

Self-Closing Tag (No Content)

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Tags form a Tree

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.
The Allen School

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What’s next?

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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 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

• Objects
  − Key/Value pairs
    • Similar to a Java HashMap
  − 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

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

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

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

```javascript
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 Monday (otherwise that class won’t make much sense)

- Some basic sample files in the TypeScript/ folder accompanying these slides (see calendar for link)
What’s next?

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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?

```html
<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 the Allen School is CSE 331.
    </p>
    <button>Click Me!</button>
  </div>
</body>
</html>
```
<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*
<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>
Demo 2 - Takeaway

- 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
Before next class...

1. Watch the **TS Introduction** video posted on Panopto before next lecture

2. Start on the **Prep. Quiz: HW7** to get practice with generics
   - Will need to apply generics and implement Dijkstra’s algorithm

3. If you are uncomfortable with generics, start **HW7 early**
   - Will need to apply generics
   - Useful for implementing Dijkstra’s algorithm on a `Graph<Double>`