Principles of Software Construction: Objects, Design, and Concurrency

Basic GUI concepts, HTML

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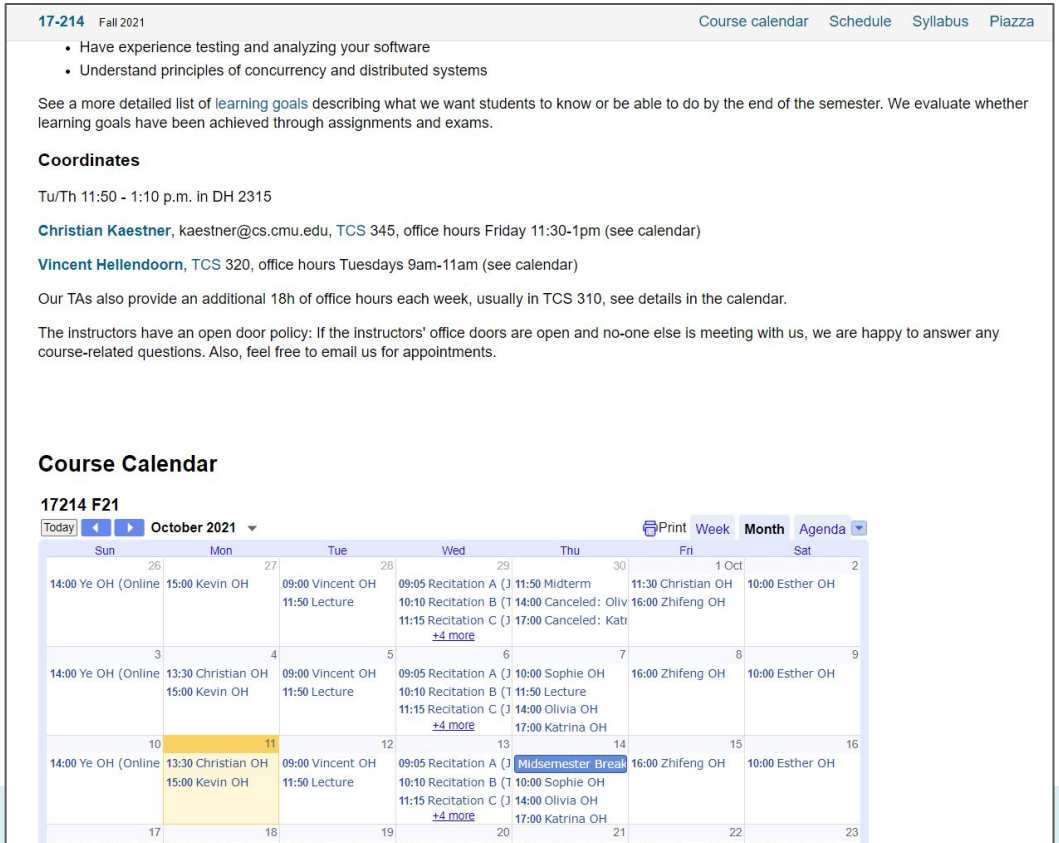
HW3 Reflections

Today

- GUI Design
  - Concepts, strategies
  - Practical application in HTML, CSS, JS
- Dynamic Web Pages
  - Client/Server communication
  - Backend architecture

How To Make This Happen?



17-214 Fall 2021 Course calendar Schedule Syllabus Piazza

- Have experience testing and analyzing your software
- Understand principles of concurrency and distributed systems

See a more detailed list of learning goals describing what we want students to know or be able to do by the end of the semester. We evaluate whether learning goals have been achieved through assignments and exams.

Coordinates

Tu/Th 11:50 - 1:10 p.m. in DH 2315

Christian Kaestner, kaestner@cs.cmu.edu, TCS 345, office hours Friday 11:30-1pm (see calendar)

Vincent Hellendoorn, TCS 320, office hours Tuesdays 9am-11am (see calendar)

Our TAs also provide an additional 18h of office hours each week, usually in TCS 310, see details in the calendar.

The instructors have an open door policy: If the instructors' office doors are open and no-one else is meeting with us, we are happy to answer any course-related questions. Also, feel free to email us for appointments.

Course Calendar

17214 F21

Today October 2021 Print Week Month Agenda

Sun	Mon	Tue	Wed	Thu	Fri	Sat
26 14:00 Ye OH (Online	27 15:00 Kevin OH	28 09:00 Vincent OH 11:50 Lecture	29 09:05 Recitation A (J 10:10 Recitation B (T 11:15 Recitation C (J +4 more	30 11:50 Midterm 14:00 Canceled: Oliv 17:00 Canceled: Katı	1 Oct 11:30 Christian OH 16:00 Zhifeng OH	2 10:00 Esther OH
3 14:00 Ye OH (Online	4 13:30 Christian OH 15:00 Kevin OH	5 09:00 Vincent OH 11:50 Lecture	6 09:05 Recitation A (J 10:10 Recitation B (T 11:15 Recitation C (J +4 more	7 10:00 Sophie OH 11:50 Lecture 14:00 Olivia OH 17:00 Katrina OH	8 16:00 Zhifeng OH	9 10:00 Esther OH
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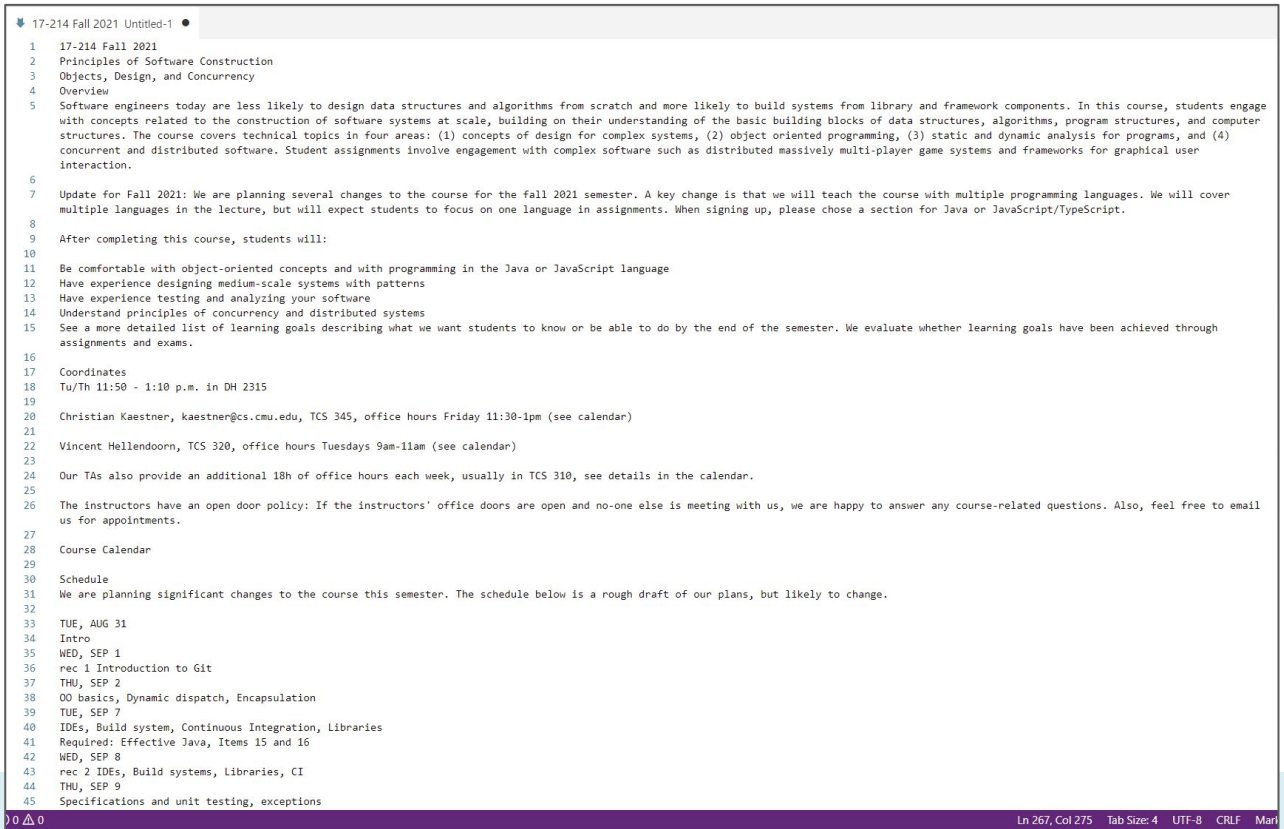
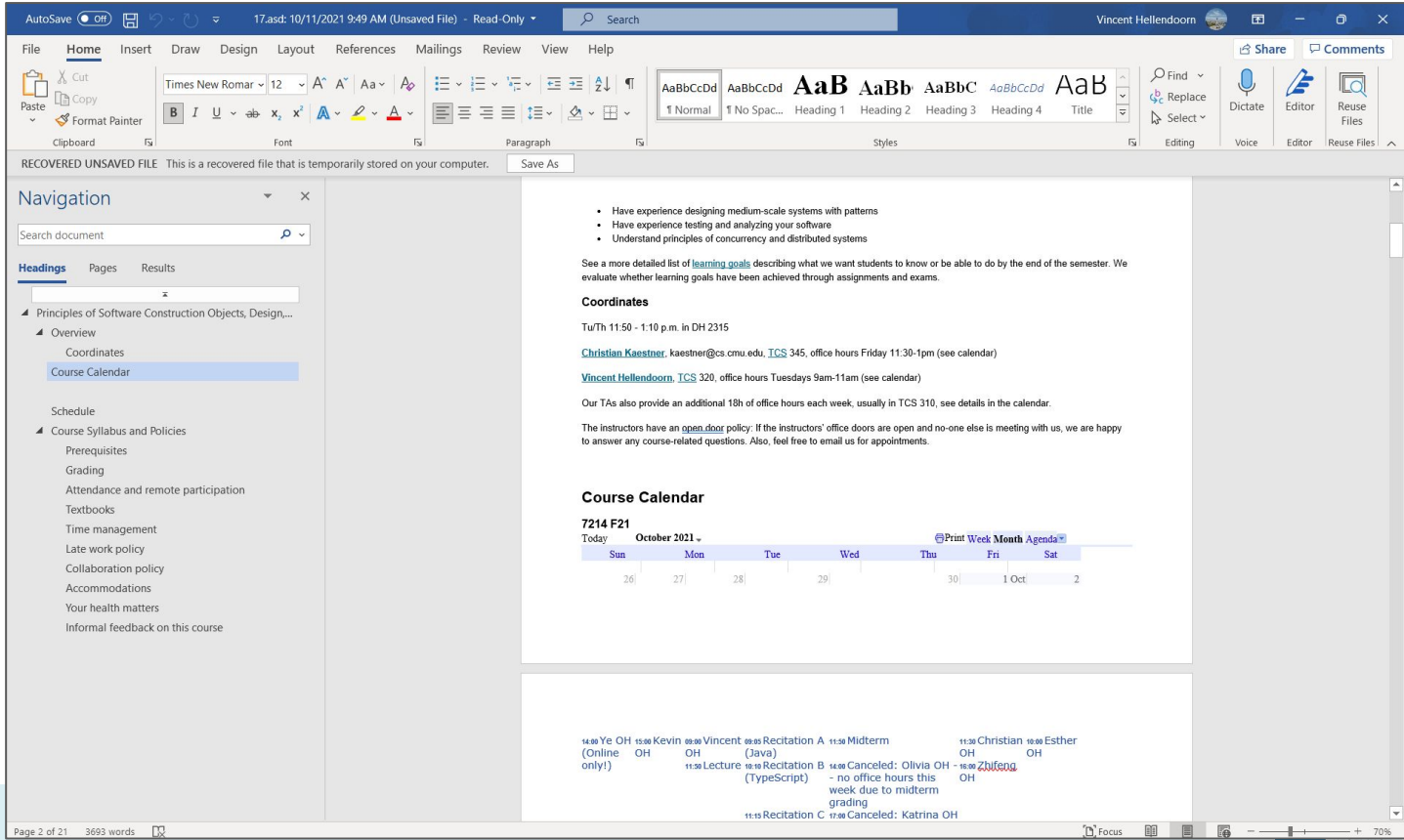
17	18	19	20	21	22	23

Why not plaintext?



Why not a Doc?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Search
Vincent Hellendoorn
File Home Insert Draw Design Layout References Mailings Review View Help
Share Comments
Paste Cut Copy Format Painter
Times New Roman 12
Clipboard Font Paragraph Styles Editing Voice Editor Reuse Files
Normal No Spac... Heading 1 Heading 2 Heading 3 Heading 4 Title
Find Replace Select
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RECOVERED UNSAVED FILE This is a recovered file that is temporarily stored on your computer. Save As
Navigation
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Principles of Software Construction Objects, Design,...
Overview
Coordinates
Course Calendar
Schedule
Course Syllabus and Policies
Prerequisites
Grading
Attendance and remote participation
Textbooks
Time management
Late work policy
Collaboration policy
Accommodations
Your health matters
Informal feedback on this course
Have experience designing medium-scale systems with patterns
Have experience testing and analyzing your software
Understand principles of concurrency and distributed systems
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09:05 Recitation A (Java)
10:10 Recitation B (TypeScript)
11:15 Recitation C
11:30 Midterm
14:00 Canceled: Olivia OH - no office hours this week due to midterm grading
17:00 Canceled: Katrina OH
11:30 Christian OH
10:00 Esther OH
16:00 Zhifeng OH
Page 2 of 21 3693 words
Focus
70%

GUI Design: what do we want?

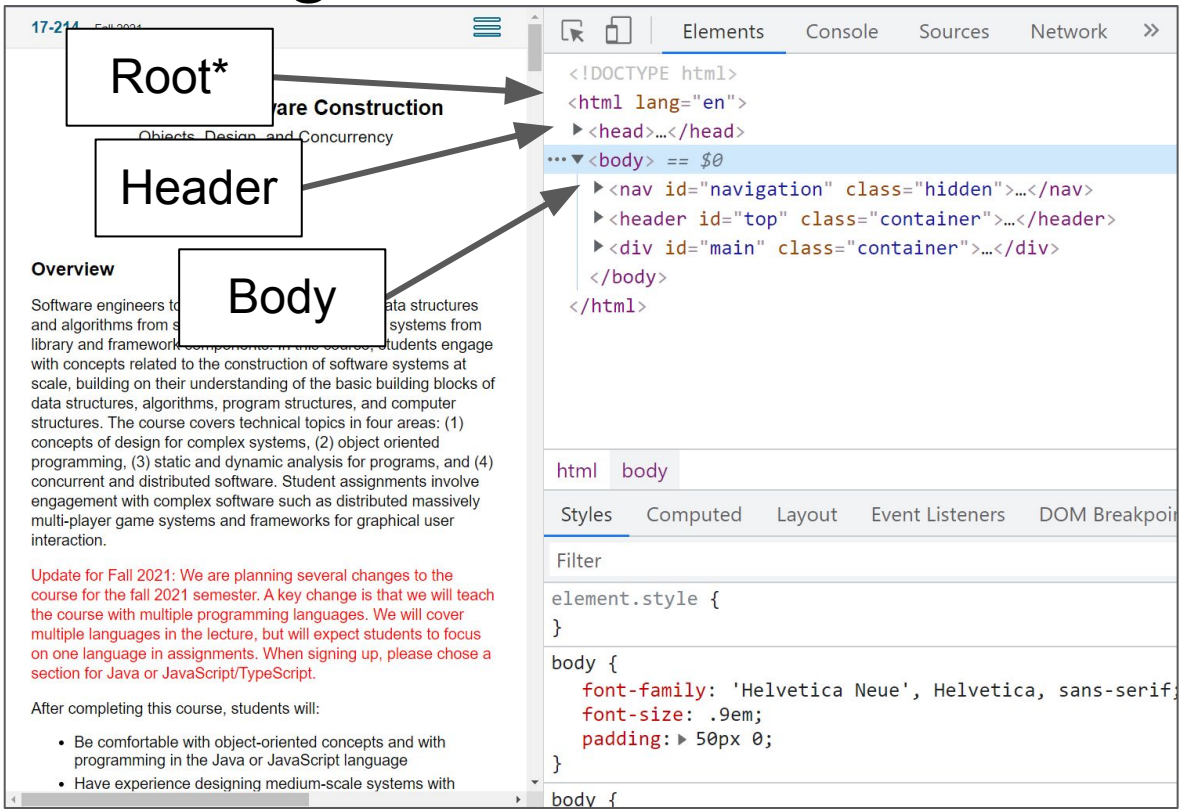
- Nested Elements
- Style Vocabulary
- Interactivity

GUI Design: what do we want?

- Nested Elements
  - HTML
- Style Vocabulary
  - CSS
- Interactivity
  - JavaScript

Anatomy of an HTML Page

Predefined elements

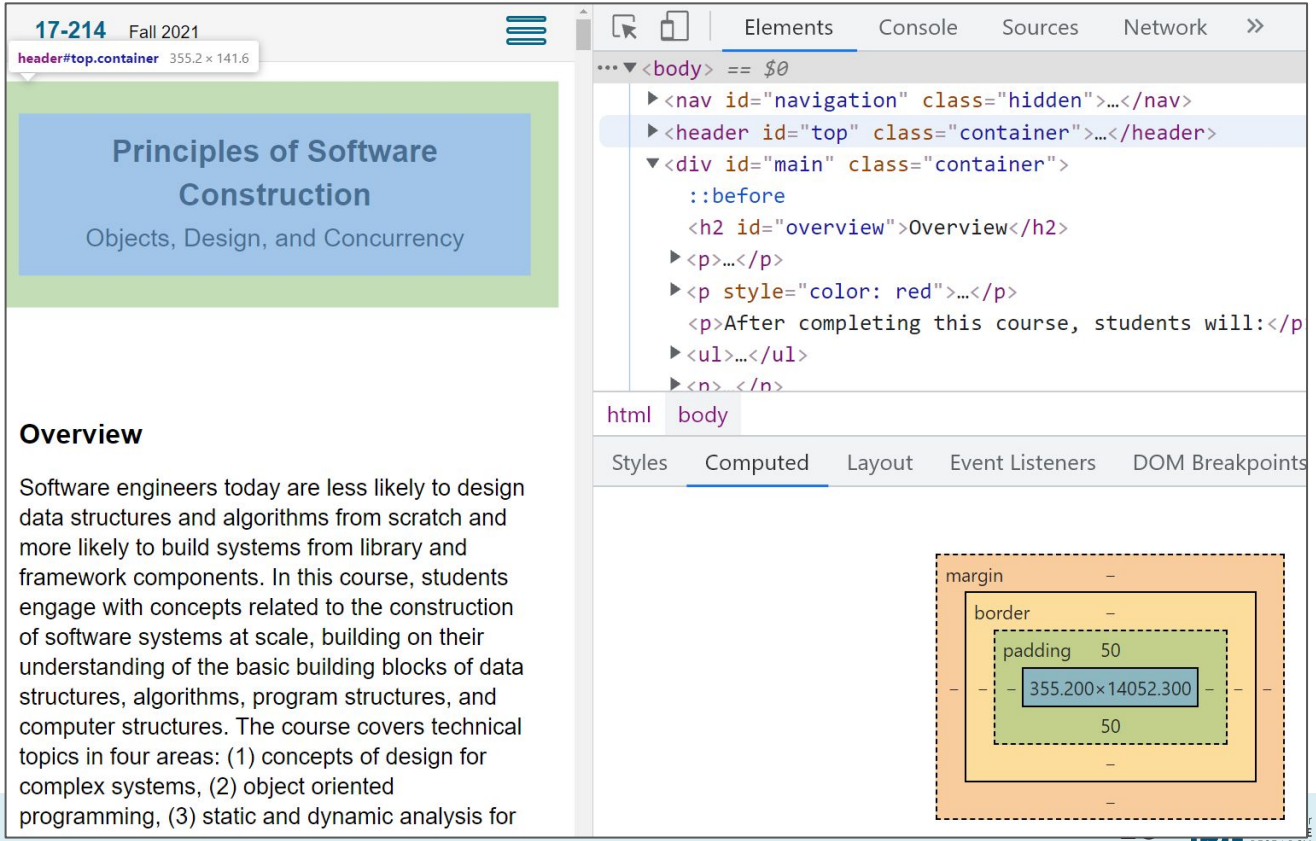


Technically, ‘document’ is the root with HTML its only child

Anatomy of an HTML Page

Nested elements

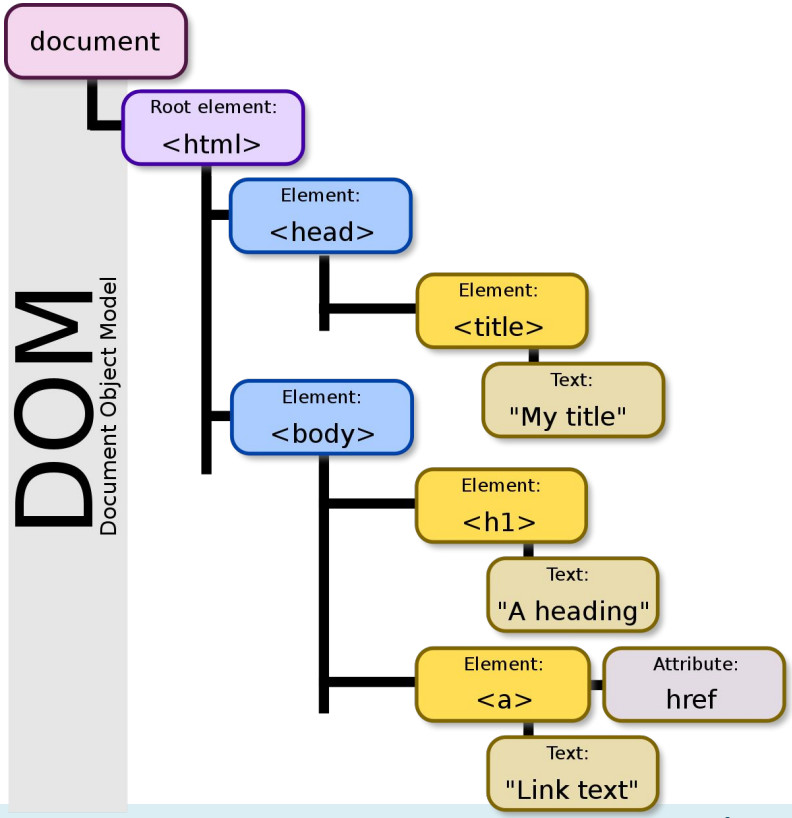
- Sizing
- Attributes
- Text



Anatomy of an HTML Page

Many GUIs are trees

- Nested elements, recursively
- Some fixed positions (html, body)



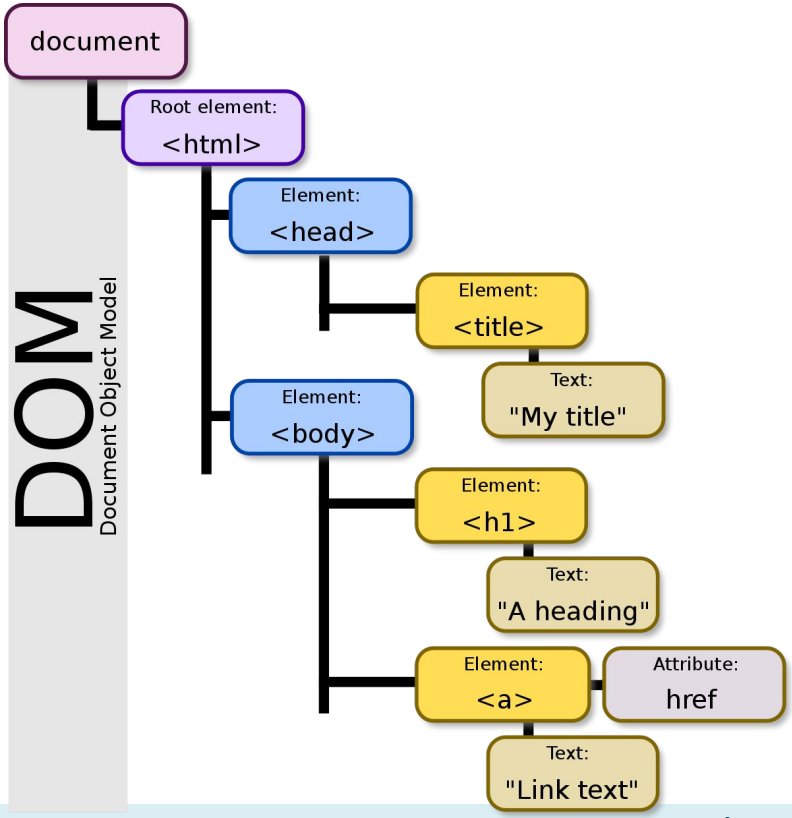
https://en.wikipedia.org/wiki/Document_Object_Model

Anatomy of an HTML Page

Many GUIs are trees

- Nested elements, recursively
- Some fixed positions (html, body)

How to implement this?



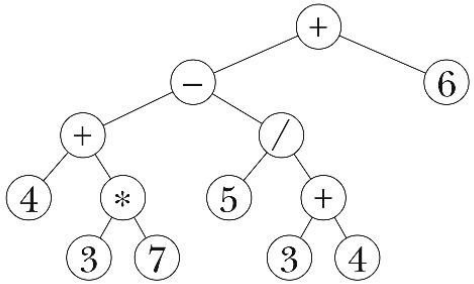
https://en.wikipedia.org/wiki/Document_Object_Model

The composite pattern

- Problem: Collection of objects has behavior similar to the individual objects
- Solution: Have collection of objects and individual objects implement the same interface
- Consequences:
  - Client code can treat collection as if it were an individual object
  - Easier to add new object types
  - Design might become too general, interface insufficiently useful

Another composite pattern example

```
public interface Expression {
    double eval();     // Returns value
}
```




```
public class BinaryOperationExpression implements Expression {
    public BinaryOperationExpression(BinaryOperator operator,
            Expression operand1, Expression operand2);
}

public class NumberExpression implements Expression {
    public NumberExpression(double number);
}
```

Composite

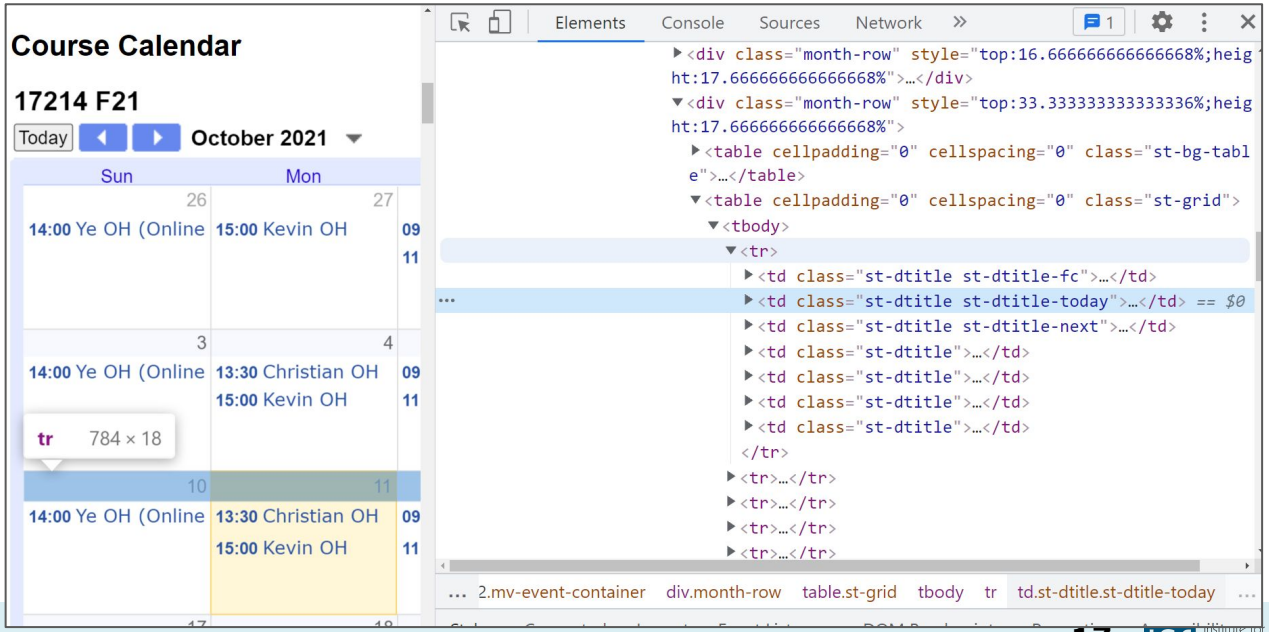
- Elements can contain elements
  - With restrictions
  - Need to deal with style, interaction
- In JS: HTMLElement
  - With child-classes e.g. HTMLDivElement, HTMLBodyElement
  - Navigation:
    - getElement*: locate by tag name, id, class, etc.
    - next/prev(Element)Sibling
    - childNodes, parent

A few Tags

- <html>
  - The root of the visible page
- <head>
  - Stores metadata, imports
- <p>
  - A paragraph
- <button>
  - Attributes include `name`, `type`, `value`
-
  - Generic section -- very useful
- <table>
  - The obvious
- Many more; dig into a real page!

Style

Not only leaf-nodes have an appearance



Style

Tags come with inherent & customizable style

- Inherent:
  - is a `block` (full-width, with margin)
  - is in-line
  - <h1> is large
- Customizable: add and override styles
  - Change font-styles, margins, widths
  - Modify groups of elements

Style: CSS

- Cascading Style Sheets
  - Reuse: styling rules for tags, classes, types
  - Reuse: not just at the leafs!

```
<span style="font-weight:bold">Hello again!</span>
```

vs.

```
<style type="text/css">
    span {
        font-family: arial
    }
</style>
```

Style: CSS

- Cascading Style Sheets
  - Reuse: styling rules for tags, classes, types
  - Reuse: not just at the leafs!
- What if there are conflicts?

```
<div style="font-weight:normal">
  <span style="font-weight:bold">Hello again!</span>
</div>
```

  - Lowest element wins*

*Technically, there's a whole scoring system

Style: CSS

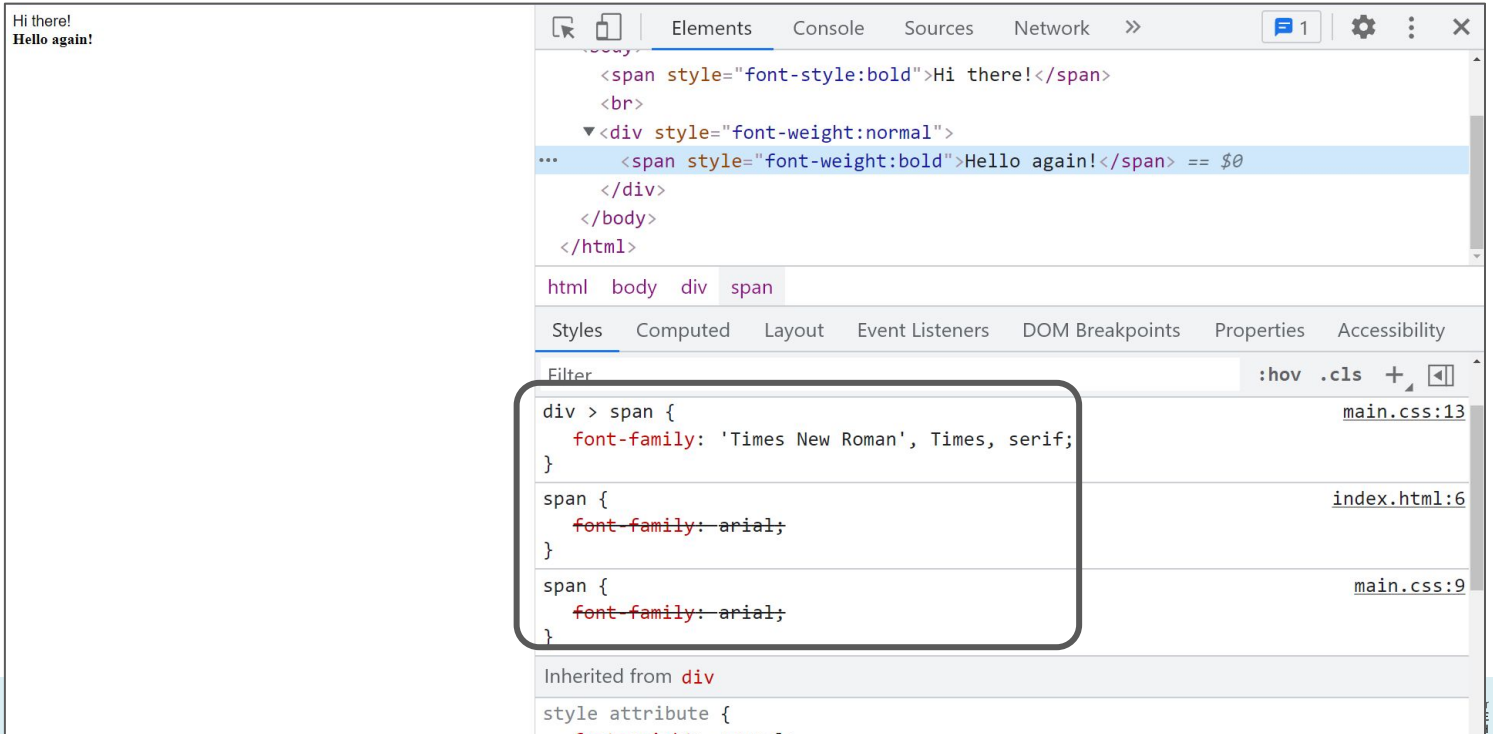
- Cascading Style Sheets
  - Reuse: styling rules for tags, classes, types
  - Reuse: not just at the leafs!
- What if there are no conflicts?

```
<div style="font-family:arial">
  <span style="font-weight:bold">Hello again!</span>
</div>
```

  - How would you implement this?

Style: CSS

What is happening here?



Decorator

What is happening here?

- To compute the style of an element:
  - Apply its tag-default style
  - **Wrap** in added style rules (tag-specific or general)
    - Text: font-family, weight, etc.
  - Inherit parents' style
    - Conflicts lead to overrides
- Makes *themes* really powerful

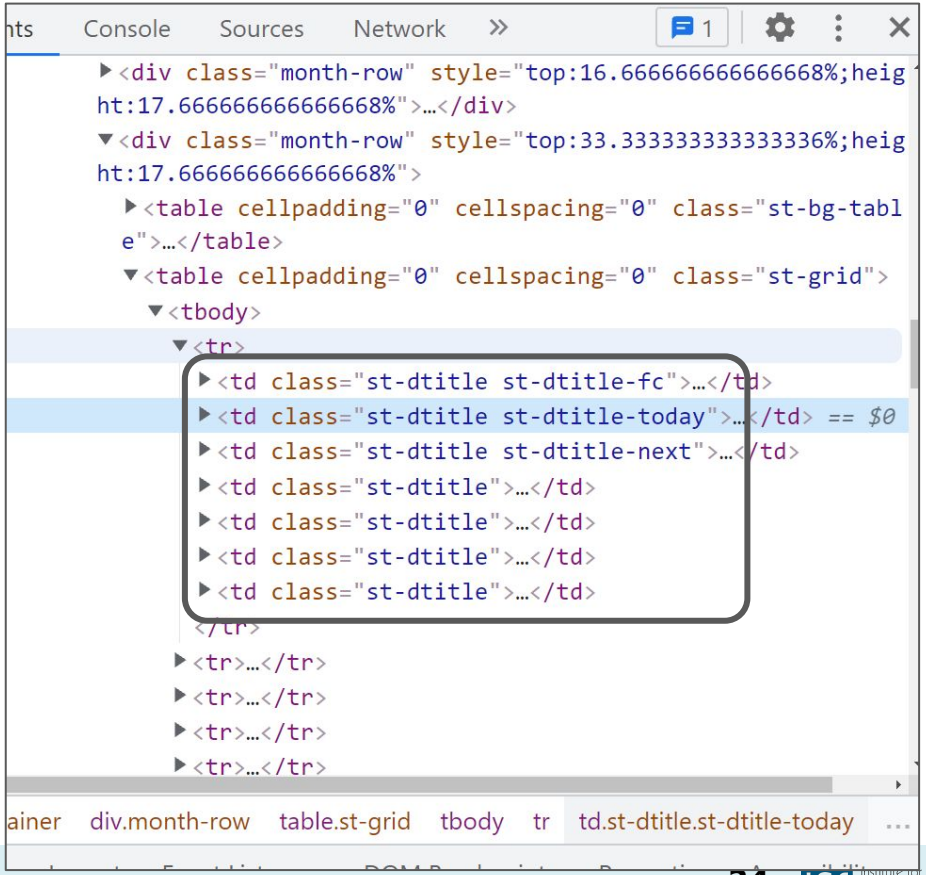
Technically, HTML is streamed top-to-bottom; CSS works bottom-up

CSS: classes

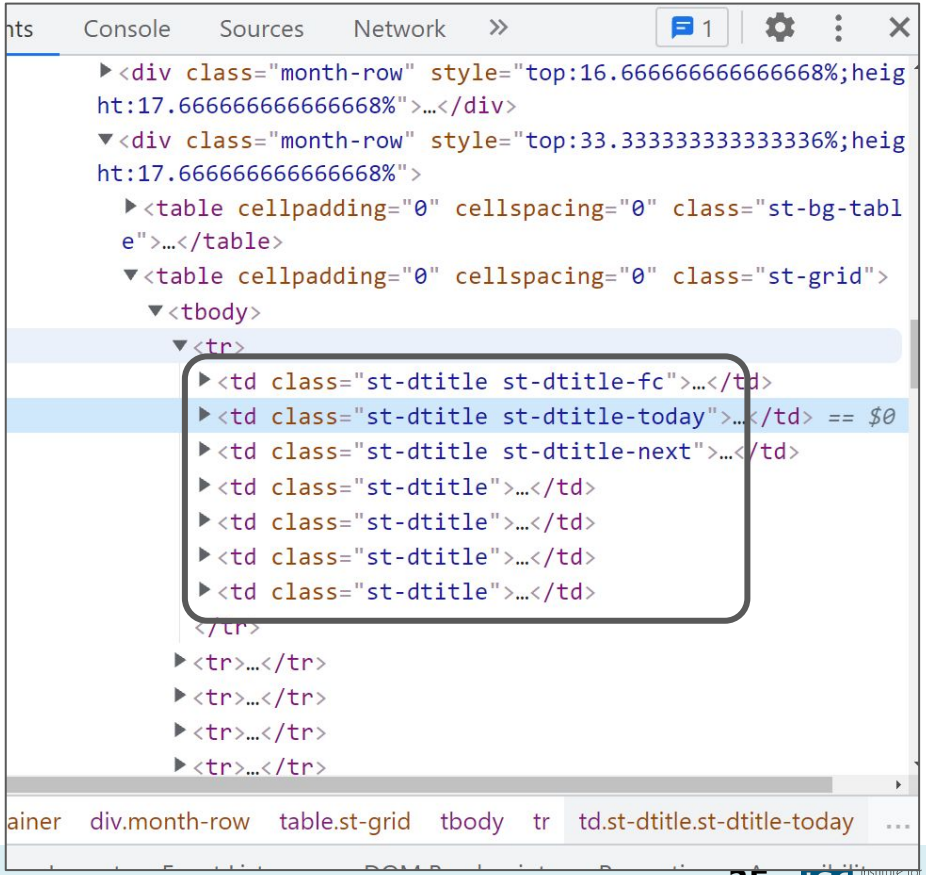
Let's not repeat custom style

- Use any nr. of class label(s)
- Class styles get added
- Facilitates reuse

How would you implement this?



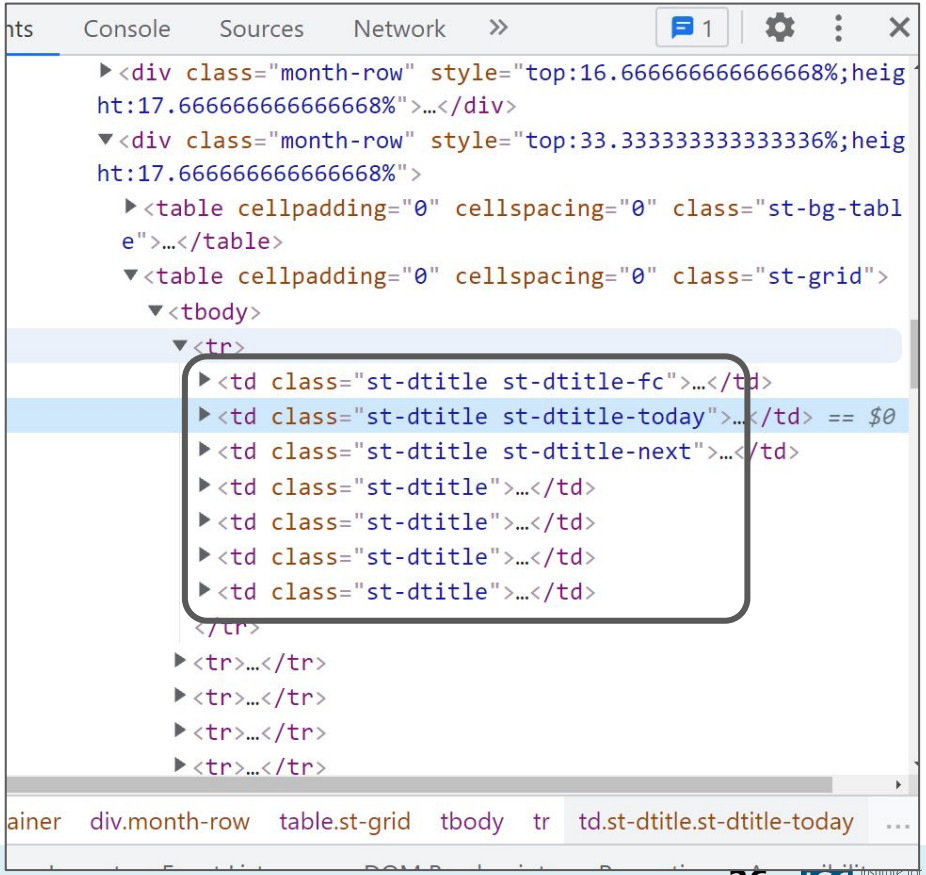
Strategy or Observer?



Strategy or Observer?

Either could apply

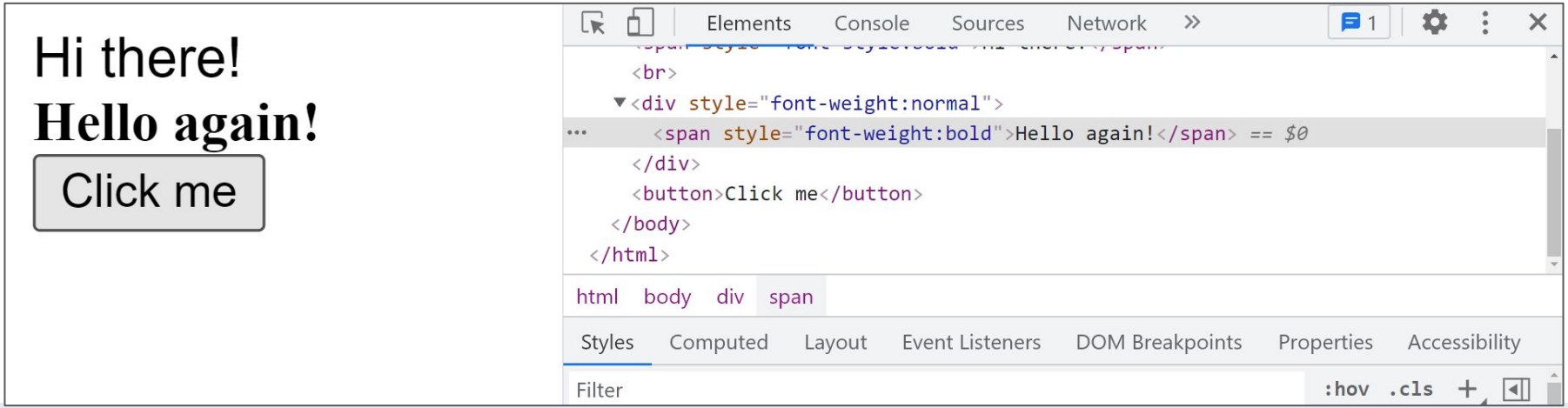
- Both involve callback
- Strategy:
  - Typically single
  - Often involves a return
- Observer:
  - Arbitrarily many
  - Involves external updates



Interactivity

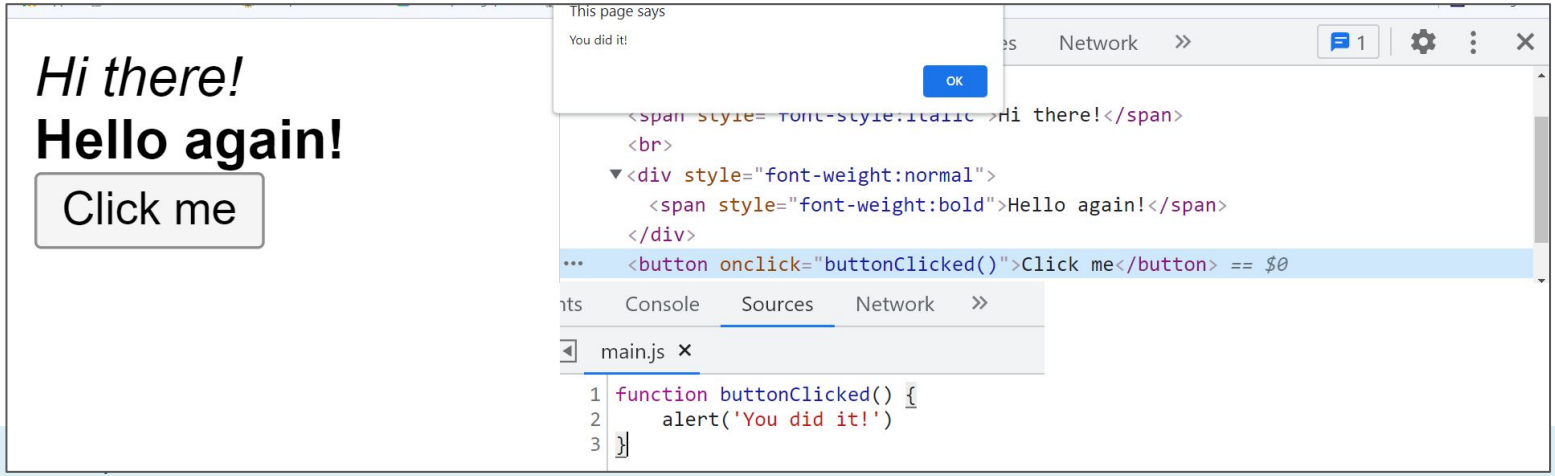
A GUI is more than a document

- How do we make it “work”?



Actions: JavaScript

- Key: event listeners (what's that pattern?)
- (frontend) JS is highly event-driven
  - Respond to window `onLoad` event, content loads (e.g., ads)
  - Respond to clicks, moves



Observer Pattern

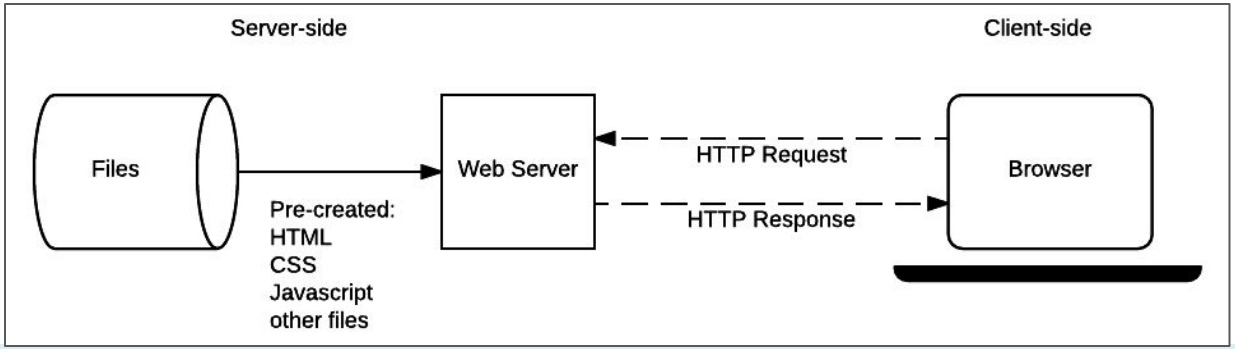
- Manages publishers and subscribers
  - Here, button publishes its ‘click’ events
  - `buttonClicked` subscribes to 1+ updates
- Flexibility and Reuse
  - Multiple observers per element
  - Shared observers across elements

Step Back

- What is our website now?
  - Layout, style, interaction
  - What is missing?

Static Web Pages

- Delivered as-is, final
  - Consistent, often fast
  - Cheap, only storage needed
- “Static” a tad murky with JavaScript
  - We can still have buttons, interaction
  - But it won’t “go” anywhere -- the server is mum



https://developer.mozilla.org/en-US/docs/Learn/Server-side/First_steps/Client-Server_overview#anatomy_of_a_dynamic_request

Static Web Pages

- Delivered as-is, final
  - Consistent, often fast
  - Cheap, only storage needed
- Maintain with *static website generators*
  - Or you'll be doing a lot of copying
  - Coupled with themes => rapid development, deployment
  - Quite popular, e.g. hosting on GH Pages

Static Web Pages

- But …
  - No persistence (at least, not obviously)
  - No customizability (e.g., accounts)
  - No communication (payment, chat, etc)
  - Realistically, no intensive jobs

Dynamic Web Pages

- Client/Server
  - Someone needs to answer the website's calls
    - Doesn't need to be us!
  - Host a webserver
    - Serves pages, handles calls
    - For static pages too!
- We'll show you more tomorrow (Wednesday)

Web Servers

- Communicate via HyperText Transfer Protocol
  - URL (the address)
  - Method:
    - GET: retrieve data. Parameters in URL `...?key=value&key2=value2` and message body
    - POST: store/create data. Parameters in request body
    - Several more, rarely used
  - Responses:
    - *Status Code*. We all know 404. 2XX family is OK.
    - And possible data. E.g., entire HTML page.

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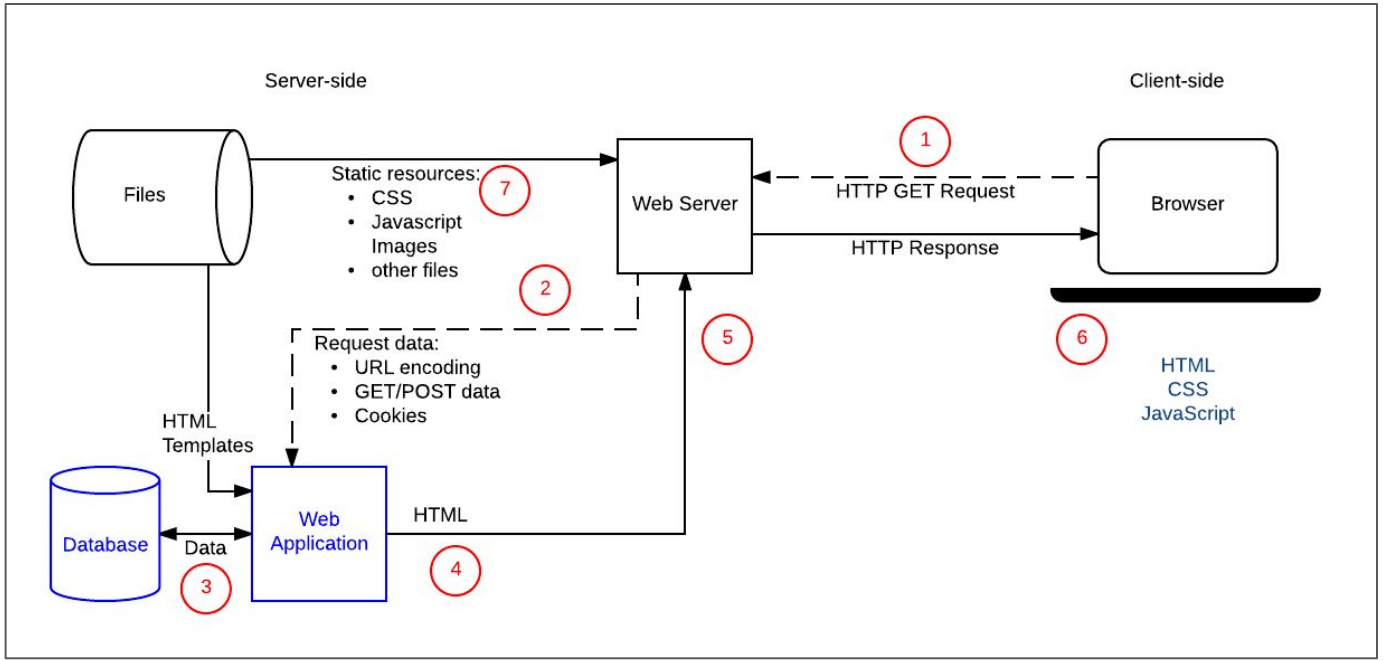
  - Responses:
    - *Status Code*. We all know 404. 2XX family is OK.
    - And possible data. E.g., entire HTML page.
  - POST makes no sense for static sites!
  - As do GETs with parameters

Web Servers

Dynamic sites can do more *work*



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AJAX

- Originally: “Asynchronous JavaScript and XML”
  - Updates parts of a page dynamically
  - Sends XMLHttpRequests with a callback
  - On return, check the code; handle success and failure.
  - Asynchronous, naturally decouples backend from UI

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  - Updates parts of a page dynamically
  - Sends XMLHttpRequests with a callback
  - On return, check the code; handle success and failure.
  - Asynchronous, naturally decouples backend from UI
- Slowly being phased out
  - Replace with `fetch`, which uses… Promises
    - More next week

How to Web App?

- Let’s avoid generating HTML from scratch on every call
  - Map requests to handler code
    - Fetch data, process
  - Generate and return HTML
- Historically: PHP
  - Modifies HTML pages server-side on request; strong ties to SQL

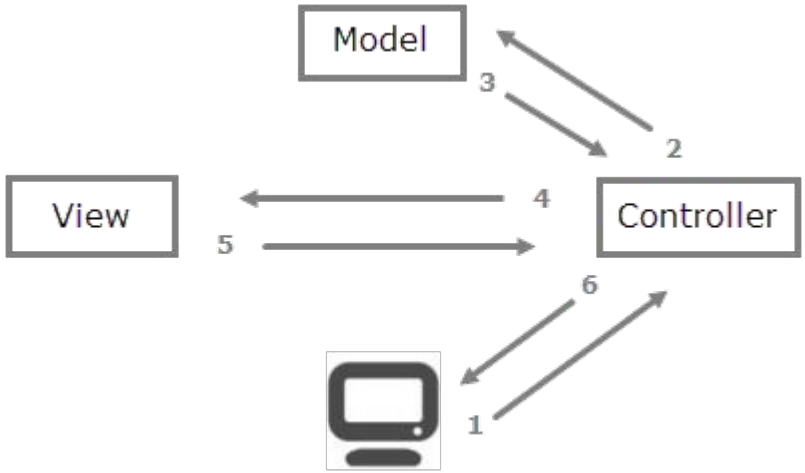
```php
<?php
  // The global $_POST variable allows you to access the data sent with the POST method by name
  // To access the data sent with the GET method, you can use $_GET
  $say = htmlspecialchars($_POST['say']);
  $to  = htmlspecialchars($_POST['to']);

  echo  $say, ' ', $to;
?>
```

How to Web App?

- Let’s avoid generating HTML from scratch on every call
  - Map requests to handler code
    - Fetch data, process
  - Generate and return HTML
- Or use a framework
  - Python: Flask, Django
  - NodeJS: Express
  - Spring for Java
  - Many others, differences in **weight**, features

Model-View-Controller (MVC)



https://overiq.com/django-1-10/mvc-pattern-and-django/

MVC is ubiquitous

Separates:

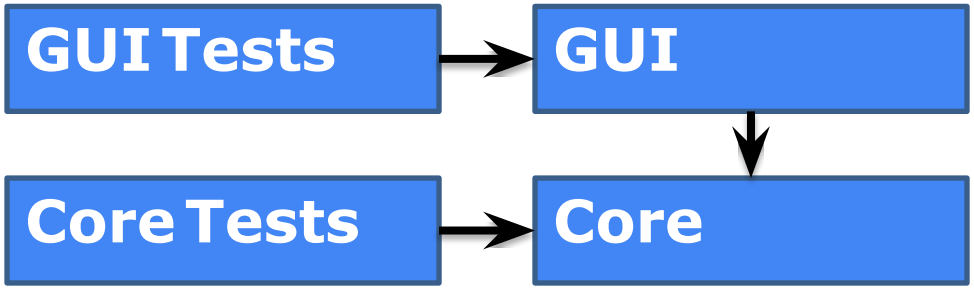
- Model: data organization
  - Interface to the database
- View: data representation (typically HTML)
  - Often called *templates* in web-dev; “view” is a bit overloaded
- Controller: intermediary between client and model/view
  - Typically asks model for data, view for HTML

Core implementation vs. GUI

- Core implementation: application logic
  - Computing some result, updating data
- GUI
  - Graphical representation of data
  - Source of user interactions
- Design guideline: *avoid coupling the GUI with core application*
  - Multiple UIs with single core implementation
  - Test core without UI

Separating application core and GUI

- Reduce coupling: do not allow core to depend on UI
- Create and test the core without a GUI
  - Use the Observer pattern to communicate information from the core (Model) to the GUI (View)



Summary

- GUIs are full of design patterns
  - Helpful for reuse, delegation in complex environments
- Covered the basics of HTML, CSS, JS, servers
  - Needed for dynamic web pages
  - Decouple the GUI; architect your backend
  - A lot more to learn (security, performance, privacy), but this will do
- You will build this
  - At a small scale