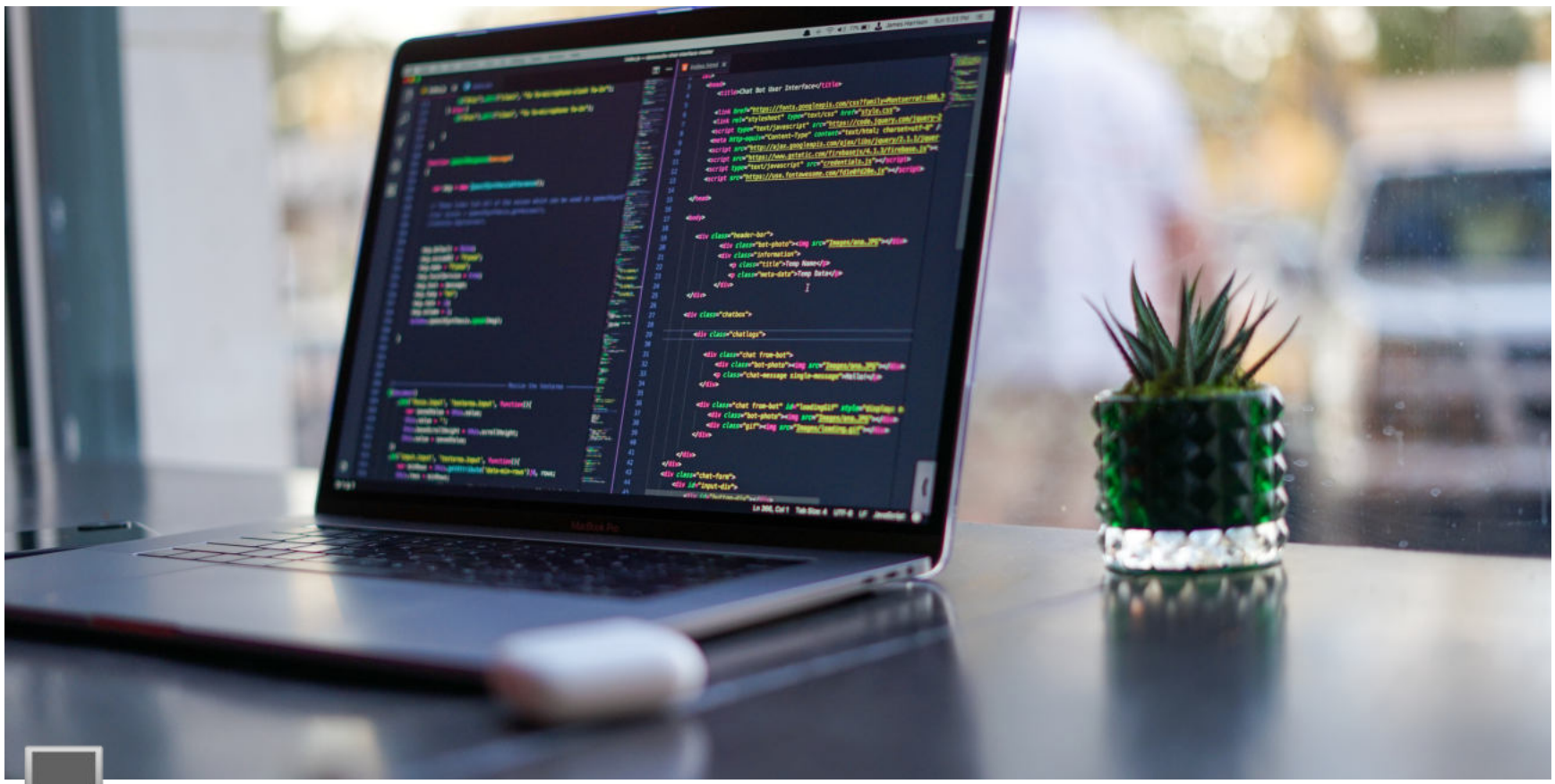


Week 8 Lecture 1

Class	BSCCS2003
Created	@October 24, 2021 12:43 AM
Materials	
Module #	44
Type	Lecture
Week #	8

Application Frontends

What is an application frontend?

- User-facing interface
  - General GUI application on the desktop
  - Browser based client
  - Custom embedded interface
- Device/OS specific controls and interfaces
- Web browser standardization
  - Common conventions among multiple browsers on how to render, what to render
- Browser vs Native
  - Look and feel
  - APIs, interfaces and interactions

Web Applications

- Browser based → HTML + CSS + JavaScript
  - HTML → What to show
  - CSS → How to show it
  - JavaScript → Bonus interaction (not core UI but essential for dynamic experience)
- Frontend mechanisms?

    - How to generate the HTML, CSS and JS?
    - Functional re-use, common frameworks
    - Server/Client load implications
    - Security implications

Fully static pages

- All (or most) pages on the site are statically generated
    - Compiled ahead of time
    - Not generated at run-time
- Excellent for high performance
    - Server just picks up the file and delivers
- How do you adapt to the runtime conditions?
    - User login, user specific information, time of the day
    - JavaScript can help a lot
- Increasingly popular → Static site generators
    - Jekyll, Hugo, Next.js, Gatsby
    - JavaScript allows very interesting variants

Run-time HTML generation

- Traditional CGI/WSGI based apps
    - Python (Flask, Django, ...), Ruby (Ruby on Rails)
    - PHPs core concept → Server-side run-time generation of HTML
    - WordPress, Drupal, Joomla → traditional CMS applications
- Great flexibility
    - Common layouts, adaptation and theming easy
    - Run-time changes, user login, time of the day, etc
- Server load
    - Every page has to be generated dynamically
    - May involve databases hits
    - Cost
    - SPeed
- Caching and other technologies can help, but complex

Client Load

- Typical Web browser
    - issue requests, wait for responses
    - render HTML
    - wait for the user input → most time spent waiting here
- Why not let client do more?
    - Allows more fancy interactions
- Client-side scripting
    - JavaScript de-factor standard
    - Component frameworks allows reuse, complex interactions
    - Server side JavaScript Node.js

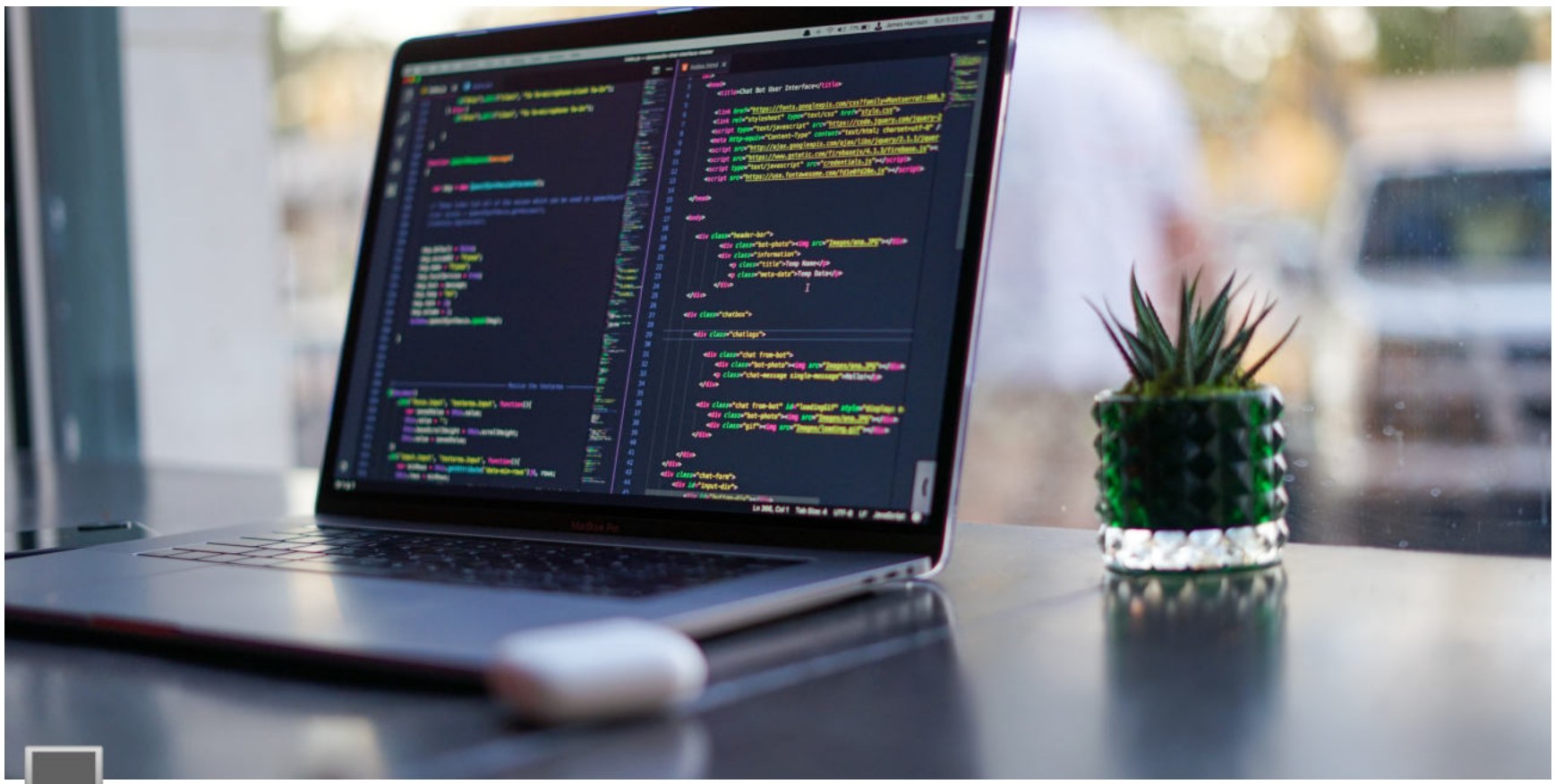
Tradeoffs

- Server-side rendering
  - Very flexible
  - May be easier to develop
  - Less security issues on client
  - Load on the server
  - More security issues on the server
- Static
  - Cache-friendly
  - Very fast
  - Interaction difficult/impossible?
  - Compilation phase → small changes require compilation
- Client-side
  - Can combine well with static pages
  - Less load on the server but still dynamic
  - More resources needed on client
  - Potential security issues, data leakage

Estimating performance

https://server.guy.com/comparison/apache-vs-nginx/

- Static pages:
  - Apache ~ 10,000 req/s - 512 parallel requests
  - Nginx ~ 20,000 req/s - 512 parallel requests
- Dynamic (call out to PHP - limited by page rendering in PHP)
  - Both ~ 100 req/s @ 16 parallel
- Dynamic occupies more resources for longer → harder to scale
- Severe impact on the server



Week 8 Lecture 2

Class	BSCCS2003
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Materials	
Module #	45
Type	Lecture
Week #	8

Asynchronous Updates

Original Web

- Client send request → Server responds → Client displays
- For any update of the page
  - A new request sent from the client to the server
  - Server has to respond with complete page, HTML, styling, etc
  - Client has to render the page again from scratch
- Potential issues
  - Server load → lots of redundant data to be sent each time
  - Server-rendering → More work
  - Slow updates → Load full page, re-render

Asynchronous Updates

- Update only part of the page
  - Load extra data in the background after the main page has been loaded and rendered
- Quick response on the main page → Better user experience
- Request for update can ask for just minimal data to refresh part of the page
  - Example → Show user a form to select animal
  - Request data about animal alone from the server → No need for HTML or other styling

    - Refresh only one `<div>` in the page with text about the animal
- Originally seen as AJAX, now many variants

Core idea → Refresh part of the document based on asynchronous (background) queries to the server

DOM

Document Object Model

- Programming interface for web documents
- What is a web-page?
    - HTML source? Rendered image?
- DOM is an abstract model (tree structure) of the document
- Object-oriented allows manipulation like known objects
- Tightly coupled with JavaScript in most cases
    - Can also be manipulated from other languages (Python has XML DOM interface for example)

Example Usage

https://developer.mozilla.org/en-US/docs/Web/API/Document_Object_Model/Introduction

```
const paragraphs = document.querySelectorAll("p");
// paragraphs[0] is the first <p> element
// paragraphs[1] is the second <p> element, etc.
alert(paragraphs[0].nodeName);
```

Manipulating the DOM

```
<html>
  <head>
    <script>
      // Run this function when the document is loaded
      window.onload = function() {
        // Create a couple of elements in an otherwise empty HTML page
        const heading = document.createElement("h1");
        const heading_text = document.createTextNode("Big Head!");
        heading.appendChild(heading_text);
        document.body.appendChild(heading);
      }
    </script>
  </head>
  <body>
  </body>
</html>
```

Component building

- DOM is manipulatable through programs
- Bring concepts of programming into DOM manipulation:
    - Objects
    - Composition of objects, inheritance
    - Loops, iterators, programmable placement
- Lot more flexibility in front-end
- Lot more complexity in the front-end

Summary

- Asynchronous updates opened up front-end development
- Many new frameworks, technologies

Week 8 Lecture 3

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Materials	
Module #	46
Type	Lecture
Week #	8

Browser/Client Operations

Minimal requirements

- Render HTML
- Cookie interaction → accept, return cookies from the server to allow sessions
- Text-mode browsers (lynx, elinks, etc) may not do anything more

Text-mode and Accessibility

- Browse from the command-line → only text displayed
- No images, limited styling

Accessibility:

- Page should not rely on colours or font size/styles to convey meaning
- W3C accessibility guidelines

Page styling

- Cascading Style Sheets (CSS) most popular now
- Difficult in text, accessible browsers
  - But has many features to help even with those!
- Proper separation of HTML and styling gives best freedom to browser, user

Interactivity

- Some form of client-side programming needed
- JavaScript most popular → de-facto standard
- Can interact with basic HTML elements (buttons, links, forms, etc)
- Can also be used independently to create more complex forms

Performance of JS depends on browser and choice of scripting engine

JavaScript engines

- Chrome/Chromium/Brave/Edge → V8
- Firefox → SpiderMonkey
- Safari, older versions of IE use their own

Impact

- Performance → V8 generally best at present
- JS standardization means differences in engines less important

Client load

- JS engines also use client CPU power
  - Complex page layouts require computation
- Can also use GPU → Extensive graphics support
  - Images
  - Video
- Potential to load CPU
  - Wasteful → Block useful computations
  - Energy drain! → https://www.websitecarbon.com

Machine clients

- Client may not always be a human
- Machine end-points → Typically access APIs
- Embedded devices → Post sensor information to data collection sites
  - Especially for monitoring, time series analysis, etc
- Typically cannot handle JS → only HTTP endpoints

Alternative scripting languages

Python inside a browser? Brython

https://brython.info

Problems with alternatives

- JS already included with browsers → why alternative?
- Usual approach → **transpilation**
  - Translation - Compilation
- Some older browsers tried directly including custom languages → Now mostly all convert

WASM

- WebAssembly
- Binary instruction format
- Targets a stack based virtual machine (similar to Java)
- Sandboxed with controlled access to APIs
- "Executable format for the Web"

- Handles high performance execution → can translate graphics to OpenGL, etc

Emscripten

- Compiler framework → compile C or C++ (or any other language that can target LLVM) to WebAssembly
- Potential for creating high performance code that runs inside the browser
- Limited usage so far

https://emscripten.org/index.html

Native mode

- File system
- Phone, SMS
- Camera object detection
- Web payments

Functionality can be exposed through suitable APIs → requires platform support

- Adds additional security concerns

Week 8 Lecture 4

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Materials	
Module #	47
Type	Lecture
Week #	8

Client side computations and Security Implications

Validation

- Server-side validation essential
  - No guarantees that request actually came from a given front-end
- But some client-side validation can reduce hits on the server
- Example → E-mail, date range, sanitization (no invalid characters) etc.
- Similar validation to backend, but now in front-end script
- Extra work, but better user experience

https://developer.mozilla.org/en-US/docs/Learn/Forms/Form_validation

Inbuilt HTML5 form controls

- Partial validation added by HTML5 standard
- `required` → mandatory field
- `minlength, maxlength` → for text fields
- `min, max` → for numeric values
- `type` → for some specific predefined types
- `pattern` → regular expression pattern match

Important → older browsers may not all these features

Is backward compatibility essential for your app?

JavaScript validation

Constraint Validation API

https://developer.mozilla.org/en-US/docs/Web/API/Constraint_validation

- Supported by most browsers
- Much more complex validation possible

Remember → not a substitute for server-side validation

```
<form>
  <label for="mail">I would like you to provide me with an e-mail address:</label>
  <input type="email" id="mail" name="mail">
  <button>Submit</button>
</form>
```

```
const email = document.getElementById("mail");

email.addEventListener("input", function (event) {
  if (email.validity.typeMismatch) {
    email.setCustomValidity("I am expecting an e-mail address");
  } else {
    email.setCustomValidity("");
  }
});
```

Captcha

- **Problem** → scripts that try to automate web-pages
- Can generate large number of reports in short time - server load
- Railway Tatkal, CoWin appointments, etc

Solution

- Prove that you are a human

- Limited number of clicks per possible unit time
- Script on the page will generate some token - server will reject requests without that token

Crypto-mining?

- JavaScript is a "complete" language
- Can implement any computation with JavaScript
- Modern JS engines are very powerful and fast
  - Can even access system graphics processor (GPU) for rendering, etc.
- Run a simple page that loads and runs a JS script

- Script will send results back to the server through async calls
- Client may not even be aware

Security Implications

Sandboxing

- Should JS be run automatically on every page
  - Yes → provides significant capabilites
  - No → what if the page tries to load local files and send them to the server?
- Sandbox → secure area that JS engine has access to
- Cannot access files, network resources, local storage
- Similar to Virtual Machines, but at a higher level (JS interpreter)

Overload and DoS

- DoS → Denial of Service
- Run a script that takes over the browser engine and runs at high load
- Difficult to even navigate away from the page, or close the page
- Potential exploit bugs in the browser
- Server attack:
  - Replace some popular JS file with a bad version
  - Will be loaded by a large number of sites, users → can write script to access some other site
  - Target site will be hit by a large number of requests from several sources, very difficult to control

Access to native resources

- Can JS be used to write fully native applications?
- Access to resources like local storage, sensors (tilt, magneto, camera)
- Can be permitted explicitly through the browser

Can also be compiled directly to native resources

- Reduce browser overheads
- Smoother interaction with the system

Summary

- Frontend experience determined by browser capabilities
  - Basic HTML + CSS rendering → styling
  - JavaScript/client-side scripting for user interaction, smoother intergration
- Native clients possible
- Potentially serious security implications
- Always validate data again at the server, do not assume client validation (Never trust the client)
  - HTTP is stateless → server cannot assume client was in a particular state