JavaScript

MPRI 2.26.2: Web Data Management

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Motivation

- Dynamic changes on the client without refreshing the page
- Simple cases: form validation, menus, etc.
  - → going beyond what HTML and CSS allow
  - → being compatible with old browsers
- Complex cases: writing entire in-browser applications in JS (aka single page applications, SPA)
- The language of the Web is JavaScript (ECMAScript standard)
  - → Beware, it's unrelated to Java!

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The JavaScript language

- **ECMAScript**: name of the standard (ECMA-262, 2011, 258 pages)
- JavaScript is a **full-featured** programming language!
- It is **interpreted** (traditionally) and high-level
- **Dynamic** typing
  - → at runtime
  - → typing of values, not of variables (like Python)
  - → implicit **conversions** are very flexible (too flexible?)
- Dynamic code execution with **eval**

Evolution of JavaScript

- 1999: ECMAScript 3, addition of regexps, try/catch
- 2009: ECMAScript 5, addition of strict mode
- ES2015: addition of classes, iterators, generator expressions, promises, arrow functions
- ES2017: ECMAScript 8, adds atomics, async/await, etc.
- ES2018: asynchronous loops, promises extensions, regexp extensions (e.g., named capture groups)

→ Polyfills: implement new features in old language versions for legacy browsers

→ Style guides for JavaScript, e.g., Google[1], AirBNB[2]

[1] `https://google.github.io/styleguide/javascriptguide.xml`
[2] `https://github.com/airbnb/javascript`

JavaScript language (cont'd)

- Object-oriented language, with prototypes (cloning existing objects) rather than classes
- First-class functions (anonymous functions, closures; functions are also objects)
- Support for exceptions
- Object syntax:
  - `foo.a` for member `a` of object `foo`
  - `foo.b(arg)` to call method `b` of `foo` with argument `arg`

JavaScript example

```
function factorial(n) {
    if (n === 0) {
        return 1;
    }
    return n * factorial(n - 1);
}
```

JavaScript engines

IE Chakra, open-sourced in 2016, since IE9

Firefox SpiderMonkey, free and open-source, released in 1996

Chrome V8, released with Chrome in 2008

→ Also used by Opera and Node.js

Safari JavaScriptCore aka Nitro (2008)

→ Active research area to improve performance!

→ Just-in-time compilation ; not just interpreted

→ Some Javascript fragments are heavily optimized and used as compilation targets (`asm.js`, WebAssembly, ...)

Newer Javascript dialects

- **TypeScript:** Javascript with optional static typing
  → The main language of the **Angular** framework
- Also: **CoffeeScript**: adds syntactic sugar (matching, etc.)
- These languages can be **transpiled** to Javascript

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Integrating Javascript in HTML

- A bit like CSS:

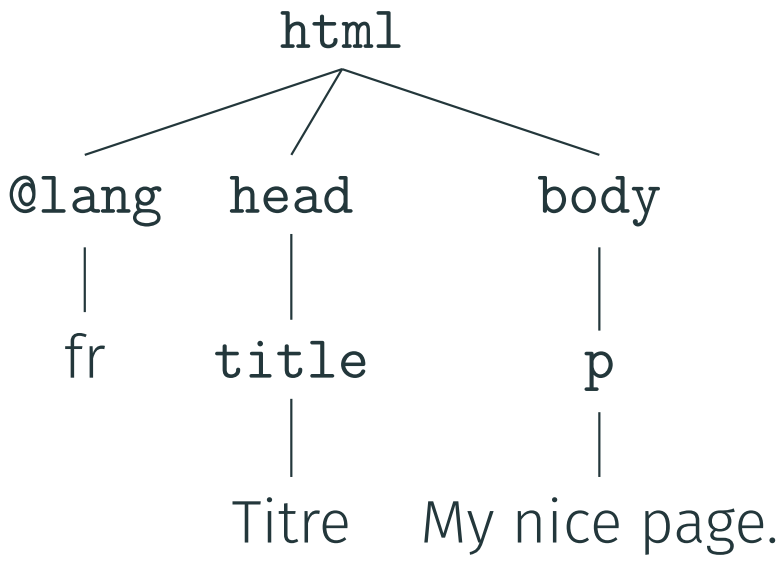
```
<head>
  <script src="script.js" type="text/javascript">
  </script>
</head>
```

- External dependency, and security risk with third-party codes!
- The code can also go directly in `<script>`
- Events like `onclick` (explained later)
- Also links starting with `javascript:`

→ Beware, some browsers do not support Javascript! (e.g., robots)
It's better not to require it if possible

Document Object Model

```
<html lang="fr">
  <head>
    <title>Titre</title>
  </head>
  <body>
    <p>
      My nice page.
    </p>
  </body>
</html>
```



The `document` object

The `document` object represents the current document:

`document.documentElement` Get the root node

`document.getElementById("foo")` Get the node with attribute `id="foo"` (or `null` if none exists)

`document.getElementByTagName("p")` Return a table of all `<p>` nodes

`Node` objects: basics

The `Node` objects represent **nodes** in the DOM tree:

`node.nodeName` Name of the element (`BODY`...) or attribute

`node.nodeType` Type, e.g., `Node.ELEMENT_NODE`, or `TEXT`, `ATTRIBUTE`, `COMMENT`...

`node.nodeValue` Value of text and attribute nodes (also: `node.setAttribute("name", "value")` and `node.getAttribute("name")`)

`node.className` Node class

`node.style` CSS style with the various properties (with dashes replaced by `camelCase`). For instance:

```
node.style.borderStyle = "solid"
```

`Node` objects: traversal

`node.parentNode` The parent node

`node.childNodes` Array of child nodes (or `null` if none)

`node.appendChild(child)` Add a child (at the end)

`node.removeChild(child)` Remove a child

`node.cloneNode(true)` Clone the node and its descendants

- The new clone is not yet added to the document
- Beware of duplicate `id`s!

`node.cloneNode(false)` Clone the node (but not its descendants)

`node.innerHTML` Get/set an HTML representation of the node contents

The `window` object

By default, the methods of `window` are in global scope:

`alert("x")` Message dialog showing `"x"`

`back()` Go to the previous page

`a = open("URL", "name")` Open a window (or tab) on `"URL"` with name `"name"`

`t = setTimeout("f()", 42000)` Call `f()` in 42 seconds, e.g.,

- for animations
- for polling

Events

- Attribute `onfoobar="return f(this)"` on `x`:
  - → When `foobar` happens on element `x`, call `f(x)`
- Many events. The most useful:

`onclick`	When a click happens; return False to cancel
`onchange`	When the contents of a field change
`onfocus`	When an element gets focus
`onsubmit`	When a `<form>` is submitted; cancellable
`onload`	On `<body>`: when the page is done loading
`onmouseover`	When the element is hovered
`onresize`	When the window is resized

Example: form validation

```
function vrf() {
  v1 = document.getElementById("pw1").value;
  v2 = document.getElementById("pw2").value;
  if (v1 != v2) {
    window.alert("The passwords don't match!");
    return false;
  }
}
```

```
<form action="test.php" method="post" onsubmit="return vrf()">
  <input type="text" name="name" placeholder="Name" required><br>
  <input type="password" name="pw1" id="pw1"
      placeholder="Password" required><br>
  <input type="password" name="pw2" id="pw2"
      placeholder="Retype password" required><br>
  <input type="submit">
</form>
```

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Asynchronous queries

- JavaScript can also do HTTP queries
- AJAX: Asynchronous JavaScript And XML
- Exchange data with the server without reloading
- Asynchronous means that queries are not blocking
- Introduced in Internet Explorer 5 in 1999, standardised by W3C (Working Draft, 2012)
- Security implications:
  - Same-origin policy: you cannot query a different domain (otherwise, danger!)
  - Special mechanisms for exceptions: `postMessage` between clients, Cross-Origin Resource Sharing

Example XMLHttpRequest

```
// Caution, not compatible with old IE versions
var req = new XMLHttpRequest();

req.onreadystatechange = function() {
  if (req.readyState === 4) { // is it ready?
    if (req.status === 200) { // did it go well?
      window.alert("Received: " + req.responseText);
    } else {
      window.alert("Problem with the query");
    }
  }
}

// true to be asynchronous, t to avoid caching
var t = new Date().getTime();
req.open("GET", "data.xml?t=" + t, true);
// can provide POST content (which you must encode)
req.send(null);
```

XML and JSON

- Generally, AJAX is not used to retrieve a Web page but to retrieve XML or JSON
- The Javascript code will parse it and update the page accordingly
- See next week for details about XML and JSON

Pushing data from the server

- AJAX allows us to query the server, but doesn't allow the server to **push** data
- Legacy solutions:
  - **Polling:** query periodically (latency, wasteful)
  - **Comet:** make a request and wait for an answer, the server waits until something new has arrived
- Current solution: **WebSocket** IETF, RFC 6455, 2011
  - **Upgrade** the HTTP connection to be bidirectional
  - Backwards-compatibility is **tricky** (proxies, caches...)

  → Javascript library: **socket.io**
- Alternative solution: **Server-Sent Events** (not in IE)

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jQuery

- Released in 2006
- About 87 kB
- Free and open-source (MIT)
- Used by 97% of the most visited websites.[3]
- Makes it simpler to write Javascript
- Abstract away some browser quirks

[3] `https://w3techs.com/technologies/overview/javascript_library/all`

Example jQuery

```
<script type="text/javascript" src="jquery-3.3.1.min.js">
</script>
<script type="text/javascript">
  $.ajax({
      url: "data.json",
      cache: false,
      success: function (data) {
          $( "#load" ).html( data.load );
          $( "#speed" ).html( data.speed );
        }
      });
</script>
```

General utility libraries

- Backbone.js, lightweight frontend JS framework
- Underscore.js, utility library for Backbone.js
- Lodash, successor of Underscore.js
- etc.

Angular

- AngularJS (version 1): a Javascript library
- Angular (version 2): a platform based on TypeScript
- Basic idea: update the view in a declarative way by specifying the link between the model and the view:
  - one direction: when the value changes, update the view
  - other direction: when the view is changed by the user, update the value

Templates

- **Idea:** instantiate HTML snippets with variable values provided by Javascript
- Several languages, e.g., **Mustache**, **Handlebars**,

```
<script id="entry-template" type="text/x-handlebars-template">
  <div class="entry">
    <h1>{{title}}</h1>
    <div class="body">
      {{body}}
    </div>
  </div>
</script>
```

React.js (Facebook)

- Allows you to create HTML directly in Javascript with JSX

```
function getGreeting(user) {
  if (user) {
    return <h1>Hello, {formatName(user)}!</h1>;
  }
  return <h1>Hello, Stranger.</h1>;
}
```

- Virtual DOM: don't manipulate the DOM (slow) but a copy of it, and do a tree diff to update the real DOM
- Data flow with Redux

→ More alternatives: Vue.js, Ember.js

Widget libraries

- Collections of widgets: jQuery UI, jQWidgets, Polymer, Angular Material, etc.
- Rich text editing: TinyMCE
- Data visualization and plotting: D3.js
  - → Bind data to visualizations
  - → Define rules to update the view when elements are updated/added/deleted
- Also: Web Components (in-browser)
  - Support for templates and includes
  - Shadow DOM to limit the scope of embedded components

Development tools

- Developer tools in Web browsers
- JSFiddle: share and test Javascript snippets
- Github gists

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Old technologies (not supported on Mobile)

- **Flash:** released in **1996** by Macromedia (bought by Adobe), used for videos, video games, etc.
  - Still used on **7%** of the most popular websites[4]
  - Supported by **95 à 99%** of **desktop** clients in 2012 [5]
  - No support on **mobile**, deprecated in **2017**
- **Java applets:** released in **1995**, rich applications but no interaction with the rest of the page: only on $<$ **0.1%** of the most popular websites[6]
- Old **Microsoft technologies**: ActiveX, Silverlight, etc.

[4] `https://w3techs.com/technologies/overview/client_side_language/all`
[5] Source: *The Tangled Web*, chapter 8, 2012
[6] `https://w3techs.com/technologies/details/cp-javaruntime/all/all`

New technologies

`<canvas>`	Page region with efficient bitmap drawing in Javascript, useful for video games
SVG+JS	Javascript manipulation of vector graphics
WebGL	Javascript API for accelerated 3D using a GPU
WebVR	Describe scenes for virtual reality headsets with `a-scene`
WebRTC	Voice and video communication across browsers
Offline	Web applications that can be used offline

Web development outside the Web

- Creating **Web applications** and porting them to other **platforms**
  - **Apache Cordova** for mobile: embed the app in a **Web View**
  - Also: **React Native**
  - **Firefox OS** (abandoned)
  - **Electron:** bundle the app with Node.js and Chromium

→ Advantage: portability (don't need to develop multiple apps)

→ Drawback: performance

Crédits

- Matériel de cours inspiré de notes par Pierre Senellart
- Merci à Pablo Rauzy et à Pierre Senellart pour leur relecture