WebAssembly

and the death of JavaScript?

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@ColinEberhardt, Scott Logic

A brief history of the web

JavaScript

(created in 10 days in May 1995, by Brendan Eich)

Java Applets

ActiveX

Flash

Silverlight

Dart

2018 - JavaScript (still!)

2018 - JavaScript (still!)

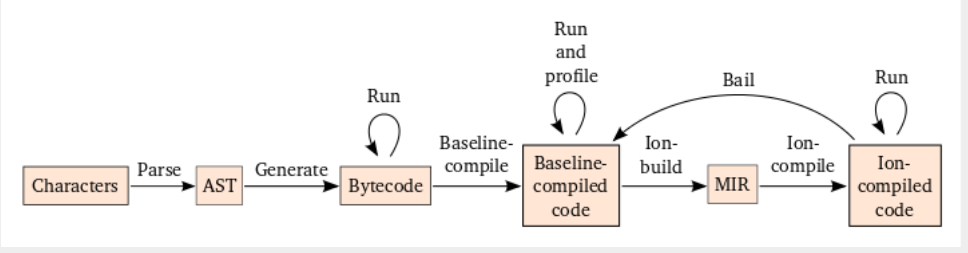
... but the way we are using it has changed

We are writing a *lot* of JavaScript

```
$ npx create-react-app my-app
$ cd my-app
$ find . -name '*.js' | xargs wc -l | tail -1
   79905 total
```

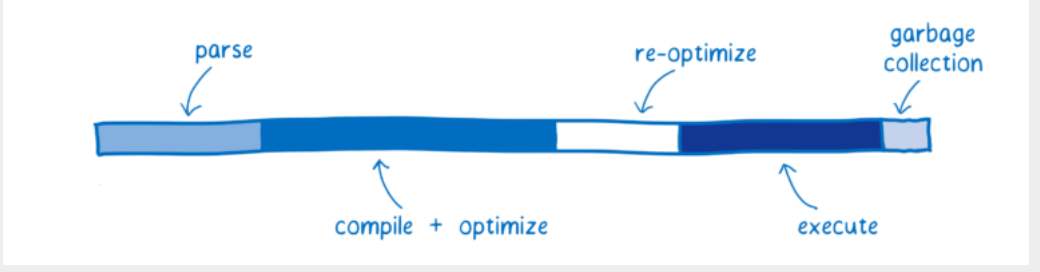
JavaScript is the Assembly Language of the Web

JavaScript isn't a very good Assembly Language!



https://blog.mozilla.org/luke/2014/01/14/asm-js-aot-compilation-and-startup-performance/

What does JavaScript execution look like today?



https://hacks.mozilla.org/2017/02/a-cartoon-intro-to-webassembly/

> *the Web has become the most ubiquitous application platform ever, and yet by historical accident the only natively supported programming language for that platform is JavaScript!*

WebAssembly

> *WebAssembly or wasm is a new portable, size- and load-time-efficient format suitable for compilation to the web.*

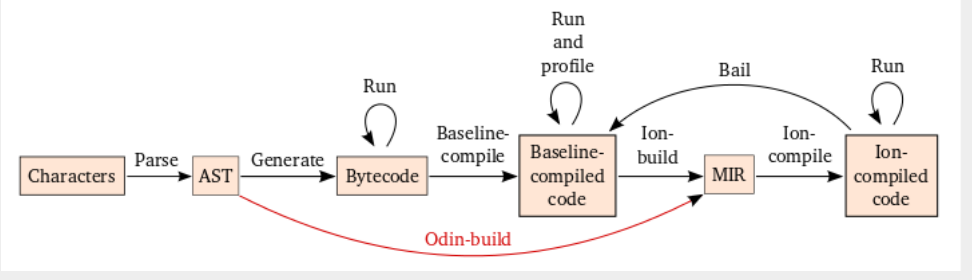
asm.js

```
float power(float number, int pow) {
  float res = number;
  for (int i = 0;i < pow - 1; i++) {
    res = res * number;
  }
  return res;
}
```

```
emcc power.c -O3  -s ONLY_MY_CODE=1 -s EXPORTED_FUNCTIONS="['_power']"
```

```
"use asm";
function X(a, b) {
 a = +a;
 b = b | 0;
 var c = 0.0, d = 0;
 d = b + -1 | 0;
 if ((b | 0) > 1) {
  b = 0;
  c = a;
 } else return +a;
 do {
  c = c * a;
  b = b + 1 | 0;
 } while ((b | 0) != (d | 0));
 return +c;
}
```

asm.js optimised execution



WebAssembly Roadmap

- 2015 - WebAssembly Community Group formed
- 2017 - WebAssembly MVP released
- 2018 - W3C public draft published

WebAssembly - OTHER

Usage % of all users
Global 72.75%

WebAssembly or "wasm" is a new portable, size- and load-time-efficient format suitable for compilation to the web.

Current aligned | Usage relative | Date relative | Show all

IE	Edge *	Firefox	Chrome	Safari	iOS Safari *	Opera Mini *	Chrome for Android	UC Browser for Android	Samsung Internet
			49		10.2				
			63		10.3				4
11	16	58	64	11	11.2	all	64	11.8	6.2
	17	59	65	11.1	11.3				
		60	66	TP					
		61	67						

WebAssembly In Practice

WebAssembly In Practice

```
float power(float number, int pow) {
  float res = number;
  for (int i = 0;i < pow - 1; i++) {
    res = res * number;
  }
  return res;
}
```

```
$ xxd add.wasm
00000000: 0061 736d 0100 0000 0107 0160 027d 7f01  .asm.......`.}..
00000010: 7d03 0201 0004 0401 7000 0005 0301 0001  }.......p.......
00000020: 0712 0206 6d65 6d6f 7279 0200 0570 6f77  ....memory...pow
00000030: 6572 0000 0a33 0131 0101 7d02 4020 0141  er...3.1..}.@ .A
00000040: 0248 0d00 2001 417f 6a21 0120 0021 0203  .H.. .A.j!. .!..
00000050: 4020 0220 0094 2102 2001 417f 6a22 010d  @ . ..!. .A.j"..
00000060: 000b 2002 0f0b 2000 0b                   .. ... ..
```

```
(module
 (table 0 anyfunc)
 (memory $0 1)
 (export "memory" (memory $0))
 (export "power" (func $power))
 (func $power (param $0 f32) (param $1 i32) (result f32)
  (local $2 f32)
  (block $label$0
   (br_if $label$0
    (i32.lt_s
     (get_local $1)
     (i32.const 2)
    )
   )
   (set_local $1
    (i32.add
     (get_local $1)
     (i32.const -1)
    )
   )
   (set_local $2
    (get_local $0)
   )
   (loop $label$1
    (set_local $2
     (f32.mul
      (get_local $2)
      (get_local $0)
     )
    )
    (br_if $label$1
     (tee_local $1
      (i32.add
       (get_local $1)
       (i32.const -1)
      )
     )
    )
   )
   (return
    (get_local $2)
   )
  )
  (get_local $0)
 )
)
```

```
// read the binary into a buffer
const fs = require("fs");
const buf = fs.readFileSync("./add.wasm");

// create a wasm module
const wasmModule = new WebAssembly.Module(new Uint8Array(buf));

// construct an instance of the module
const wasmInstance = new WebAssembly.Instance(wasmModule);

// invoke the exported function
const result = wasmInstance.exports.power(2, 3)
console.log(result);
```

```
char *message = "hello wasm!";

char *getMessageRef()
{
  return message;
}
```

```
const { TextDecoder } = require("util");

// read the binary into a buffer
const fs = require("fs");
const buf = fs.readFileSync("./string.wasm");

// create a module and an instance
const wasmModule = new WebAssembly.Module(new Uint8Array(buf));
const wasmInstance = new WebAssembly.Instance(wasmModule);

// obtain a reference to linear and read the string
const linearMemory = wasmInstance.exports.memory;
const offset = wasmInstance.exports.getMessageRef();
const buffer = new Uint8Array(linearMemory.buffer, offset, 12);

// decode and log
const str = new TextDecoder("utf-8").decode(buffer);
console.log(str);
```

WebAssembly Architecture

- A stack machine, 4 types, 67 instructions
- Designed to support streaming compilation
- Simple validation rules
- Exports / imports functions
- Linear memory is shared with JavaScript

WebAssembly Future

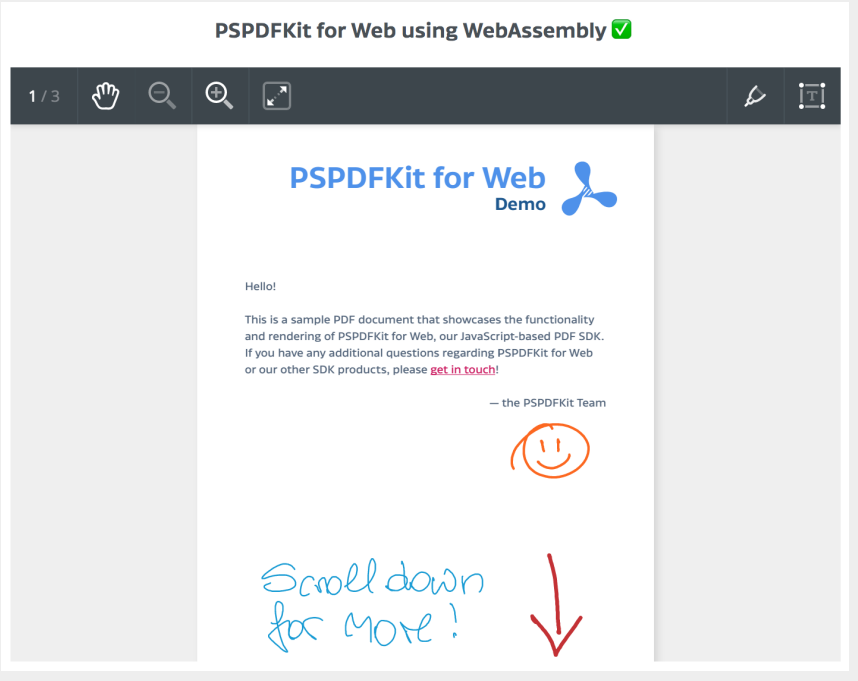
- Garbage collector
- Threads
- Host bindings
- SIMD
- Exception handling

WebAssembly Language Support

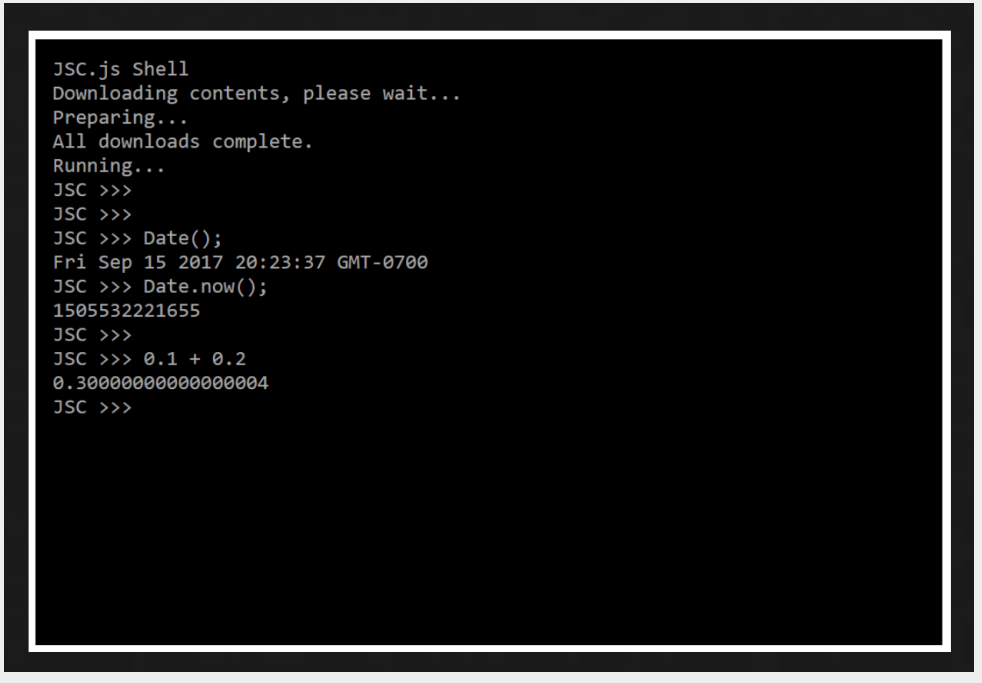
(and what people are doing with it)

C / C++

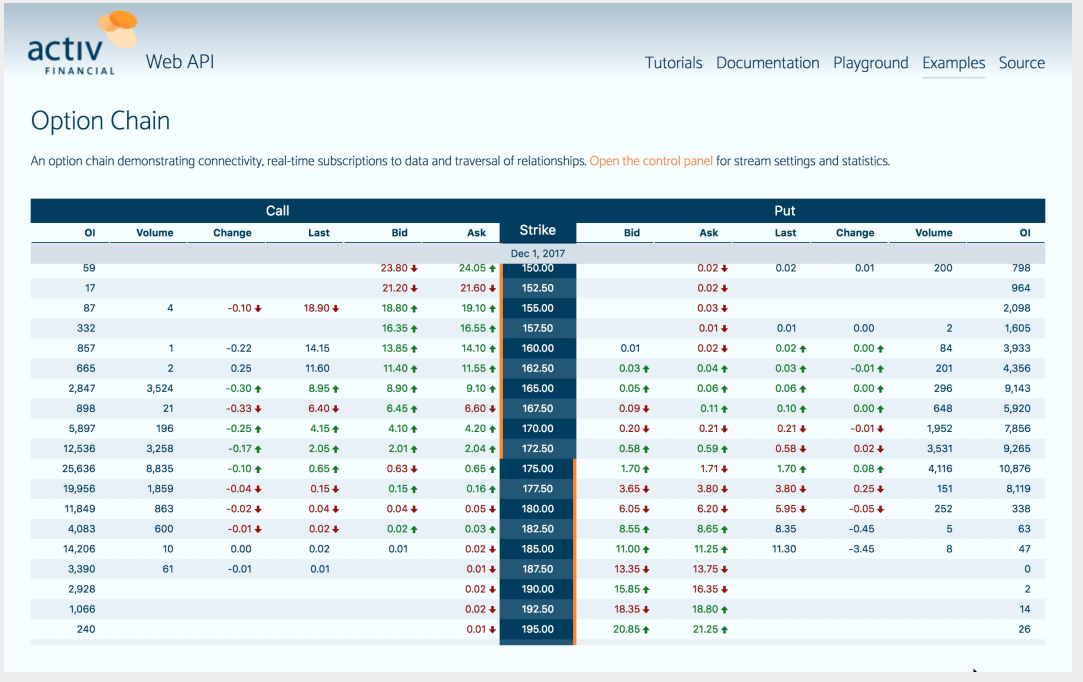
- Emscripten
- Based on LLVM
- Originally used to create asm.js



https://pspdfkit.com/blog/2017/webassembly-a-new-hope/



https://mbbill.github.io/JSC.js/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Web API
Tutorials Documentation Playground Examples Source
Option Chain
An option chain demonstrating connectivity, real-time subscriptions to data and traversal of relationships. Open the control panel for stream settings and statistics.
Call
Put
OI Volume Change Last Bid Ask Strike Bid Ask Last Change Volume OI
Dec 1, 2017
59 23.80 24.05 150.00 0.02 0.02 0.01 200 798
17 21.20 21.60 152.50 0.02 964
87 4 -0.10 18.90 18.80 19.10 155.00 0.03 2,098
332 16.35 16.55 157.50 0.01 0.01 0.00 2 1,605
857 1 -0.22 14.15 13.85 14.10 160.00 0.01 0.02 0.02 0.00 84 3,933
665 2 0.25 11.60 11.40 11.55 162.50 0.03 0.04 0.03 -0.01 201 4,356
2,847 3,524 -0.30 8.95 8.90 9.10 165.00 0.05 0.06 0.06 0.00 296 9,143
898 21 -0.33 6.40 6.45 6.60 167.50 0.09 0.11 0.10 0.00 648 5,920
5,897 196 -0.25 4.15 4.10 4.20 170.00 0.20 0.21 0.21 -0.01 1,952 7,856
12,536 3,258 -0.17 2.05 2.01 2.04 172.50 0.58 0.59 0.58 0.02 3,531 9,265
25,636 8,835 -0.10 0.65 0.63 0.65 175.00 1.70 1.71 1.70 0.08 4,116 10,876
19,956 1,859 -0.04 0.15 0.15 0.16 177.50 3.65 3.80 3.80 0.25 151 8,119
11,849 863 -0.02 0.04 0.04 0.05 180.00 6.05 6.20 5.95 -0.05 252 338
4,083 600 -0.01 0.02 0.02 0.03 182.50 8.55 8.65 8.35 -0.45 5 63
14,206 10 0.00 0.02 0.01 0.02 185.00 11.00 11.25 11.30 -3.45 8 47
3,390 61 -0.01 0.01 0.01 187.50 13.35 13.75 0
2,928 0.02 190.00 15.85 16.35 2
1,066 0.02 192.50 18.35 18.80 14
240 0.01 195.00 20.85 21.25 26

Java / C#

- More challenging, these languages require a GC

Java / C#

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- Blazor, experimental project, using Mono
  - Testing interpreted mode, vs. AOT (with runtime for GC etc …)
  - Blazor is an SPA framework

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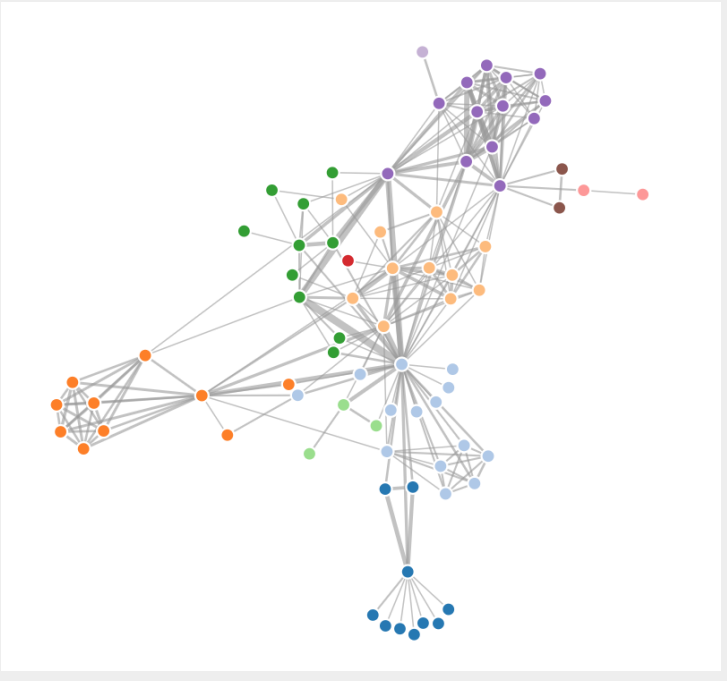
- “Walt is a JavaScript-like syntax for WebAssembly text format”
- AssemblyScript - a TypeScript to WebAssembly compiler
  - Awaiting GC before it can really become powerful



https://bl.ocks.org/ColinEberhardt/6ceb7ca74aabac9c8534d7120d31b382

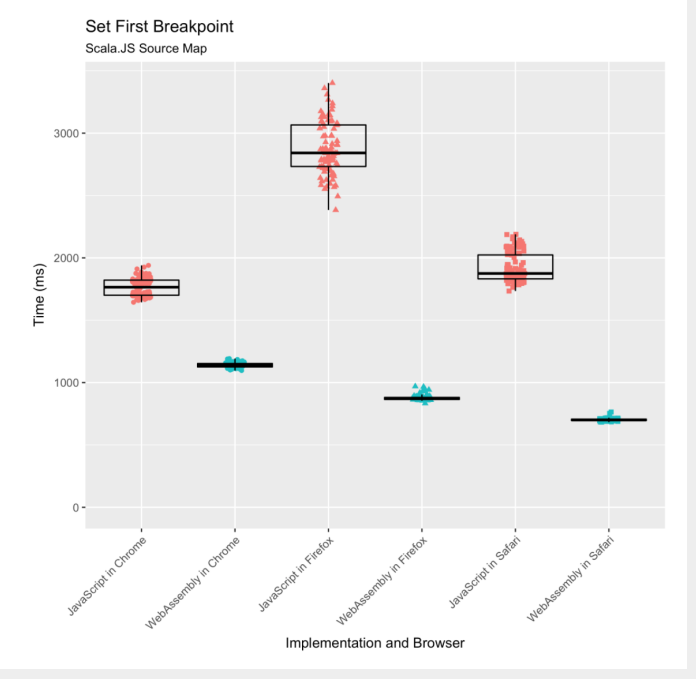
```
simulation = d3.forceSimulation()
    .force("link", d3.forceLink().id(function(d) { return d.id; }))
    .force("charge", d3.forceManyBody())
    .force("center", d3.forceCenter(width / 2, height / 2));

function ticked() {
  simulation.tick();
  link
      .attr('x1', d => d.source.x)
      .attr('y1', d => d.source.y)
      .attr('x2', d => d.target.x)
      .attr('y2', d => d.target.y);

  node
      .attr('cx', d => d.x)
      .attr('cy', d => d.y);
}

setInterval(ticked, 25);
```

Rust

- Doesn’t require a GC
- Originally used Emscripten, but moved to a simpler toolchain

> *We're poised to be THE language of choice for wasm.*

http://blog.scottlogic.com/2017/12/13/chip8-emulator-webassembly-rust.html



https://hacks.mozilla.org/2018/01/oxidizing-source-maps-with-rust-and-webassembly/

Crystal Ball Gazing

2018

- Rust, C, C++ used in production for performance critical, algorithmic tasks

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- Java, C#, Typescript lots of creative experiments / POCs
- Native node modules
- GC support

2019

- Host bindings, SIMD, threading, …

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2019

- Host bindings, SIMD, threading, …
- Java, C# become production ready
- Another wave of mobile, desktop and server-side UI frameworks will re-target the web
  - write once, run everywhere
- Performance gains fail to materialise, with backlash from early adopters
- Heavyweight productivity tools start moving to the web (e.g. Photoshop, AutoCAD)

2020 - and beyond

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- A new DOM alternative will emerge?
- JavaScript's monopoly will be lost, and it's popularity will fade
- The ubiquity of the web extends further still

WebAssembly

and the death of JavaScript?

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