JFOKUS2020

Hands on WebAssembly

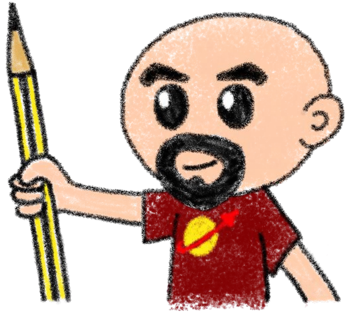
Horacio Gonzalez

@LostInBrittany

OVHcloud

Who are we?

Introducing myself and introducing ~~OVH~~ OVHcloud



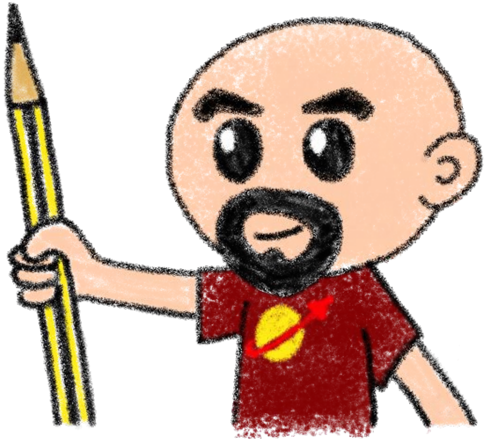
Horacio Gonzalez

@LostInBrittany

Spaniard lost in Brittany, developer, dreamer and all-around geek

OVHcloud

DevRel Leader



DevFest du Bout du Monde

Finist Devs

Google Developers Experts 2019

Web Technologies GDE

Flutter

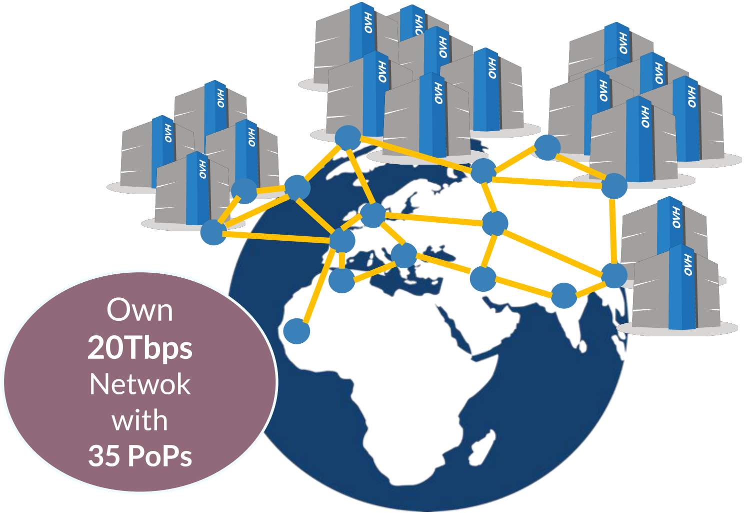
OVHcloud: A Global Leader

200k Private cloud VMs running

1 **Dedicated IaaS Europe**

Hosting capacity : **1.3M** Physical Servers

360k Servers already deployed



Own **20Tbps** Netwok with **35 PoPs**

30 Datacenters

> 1.3M Customers in 138 Countries

OVHcloud: Our solutions

Cloud

- VPS
- Public Cloud
- Private Cloud
- Serveur dédié
- Cloud Desktop
- Hybrid Cloud

Mobile Hosting

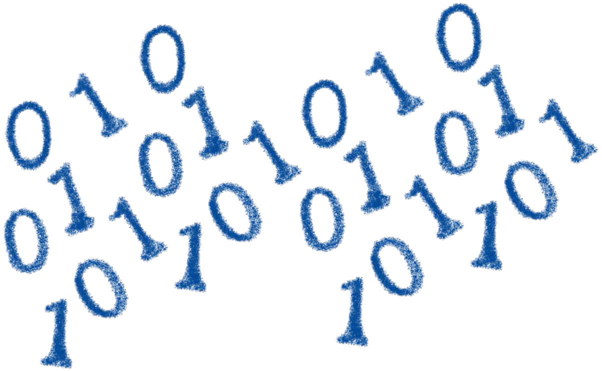
- Containers
- Compute
- Database
- Object Storage
- Securities
- Messaging

Web Hosting

- Domain names
- Email
- CDN
- Web hosting
- MS Office
- MS solutions

Telecom

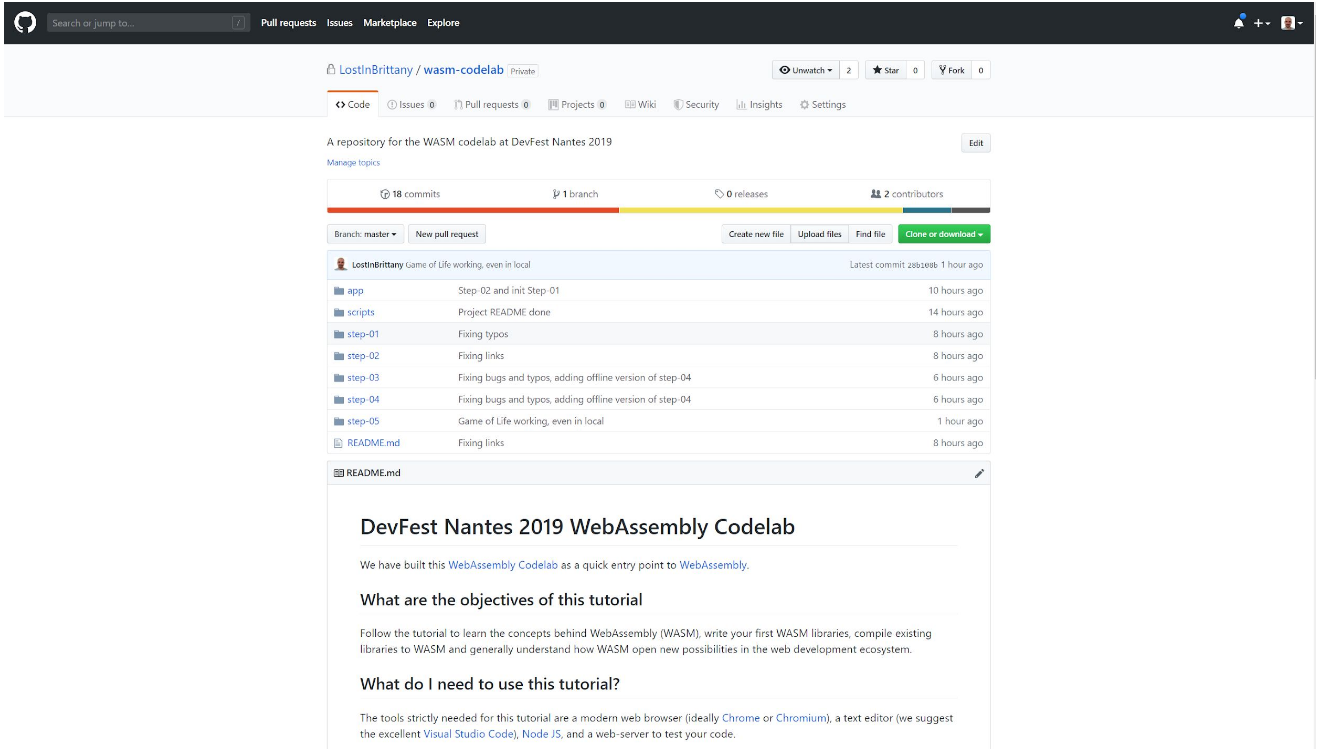
- VoIP
- SMS/Fax
- Virtual desktop
- Cloud Storage
- Over the Box



How is the codelab structured?

What are we coding today?

A GitHub repository



LostInBrittany / wasm-codelab Private

A repository for the WASM codelab at DevFest Nantes 2019

LostInBrittany Game of Life working, even in local — Latest commit 28b108b 1 hour ago

app	Step-02 and init Step-01	10 hours ago
scripts	Project README done	14 hours ago
step-01	Fixing typos	8 hours ago
step-02	Fixing links	8 hours ago
step-03	Fixing bugs and typos, adding offline version of step-04	6 hours ago
step-04	Fixing bugs and typos, adding offline version of step-04	6 hours ago
step-05	Game of Life working, even in local	1 hour ago
README.md	Fixing links	8 hours ago

README.md

DevFest Nantes 2019 WebAssembly Codelab

We have built this WebAssembly Codelab as a quick entry point to WebAssembly.

What are the objectives of this tutorial

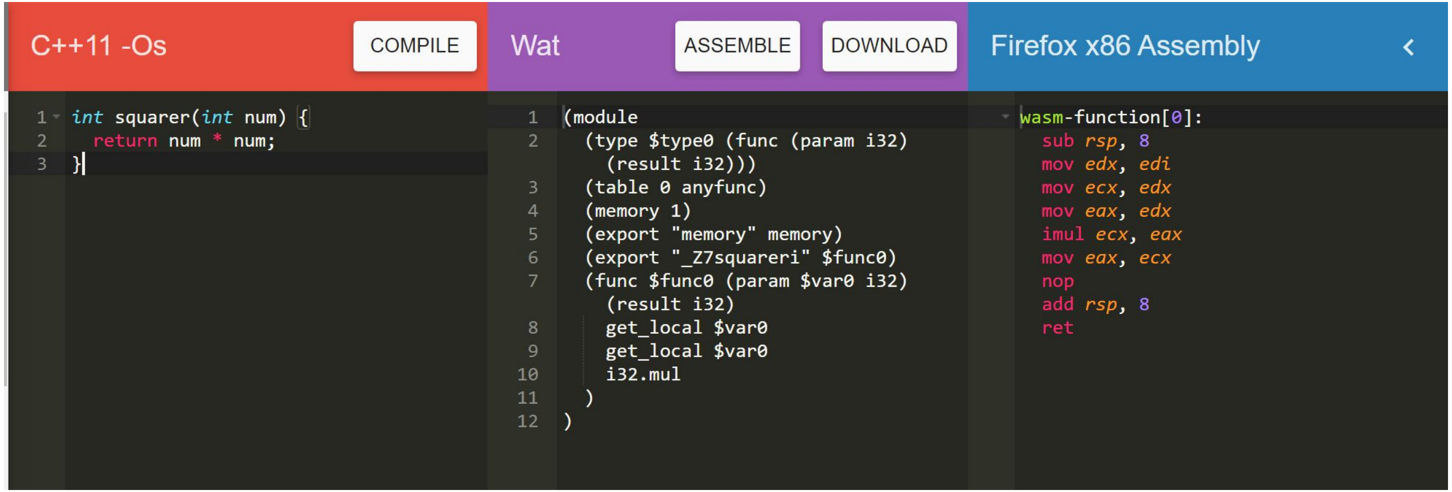
Follow the tutorial to learn the concepts behind WebAssembly (WASM), write your first WASM libraries, compile existing libraries to WASM and generally understand how WASM open new possibilities in the web development ecosystem.

What do I need to use this tutorial?

The tools strictly needed for this tutorial are a modern web browser (ideally Chrome or Chromium), a text editor (we suggest the excellent Visual Studio Code), Node JS, and a web-server to test your code.

https://github.com/LostInBrittany/wasm-codelab

Nothing to install



```
int squarer(int num) {
  return num * num;
}
```

```
(module
  (type $type0 (func (param i32)
    (result i32)))
  (table 0 anyfunc)
  (memory 1)
  (export "memory" memory)
  (export "_Z7squareri" $func0)
  (func $func0 (param $var0 i32)
    (result i32)
    get_local $var0
    get_local $var0
    i32.mul
  )
)
```

```
wasm-function[0]:
  sub rsp, 8
  mov edx, edi
  mov ecx, edx
  mov eax, edx
  imul ecx, eax
  mov eax, ecx
  nop
  add rsp, 8
  ret
```

Using WebAssembly Explorer
and WebAssembly Studio

Only additional tool: a web server

Because of the browser security model

Procedure: follow the steps

Step by step

But before coding, let's speak

What's this WebAssembly thing?

Did we say WebAssembly?

WASM for the friends...

WebAssembly, what's that?

Can I code webapps in Rust?

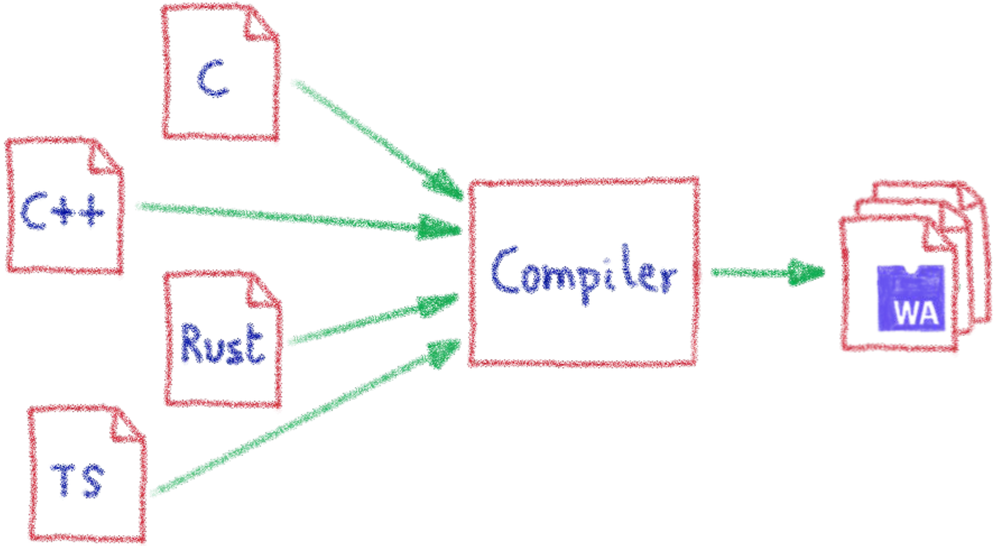
What's WASM?

Does it replace JS?

Is HTML/CSS/JS stack obsolete?

Let's try to answer those (and other) questions...

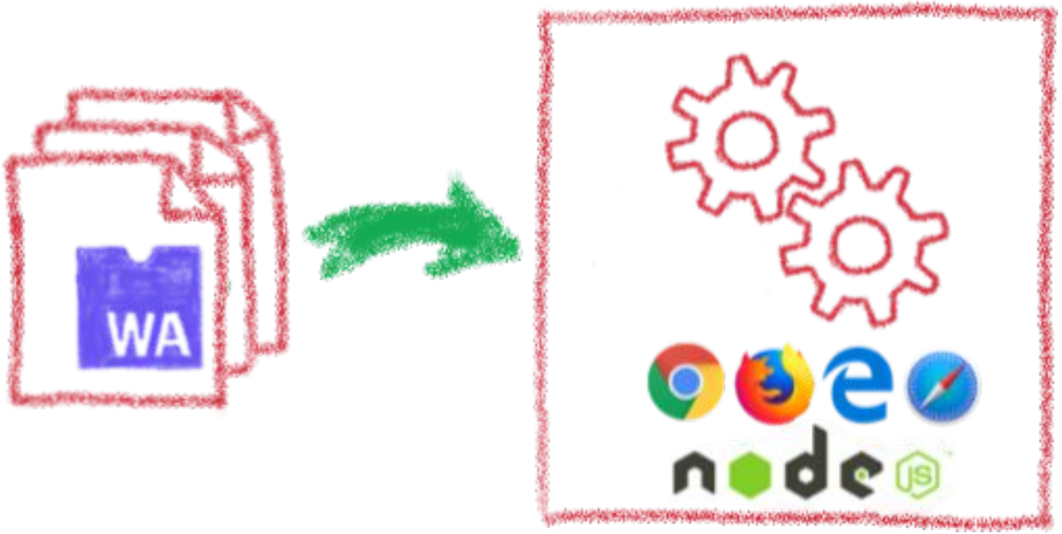
A low-level binary format for the web



Not a programming language

A compilation target

That runs on a stack-based virtual machine



A portable binary format that runs on all modern browsers... but also on NodeJS!

With several key advantages

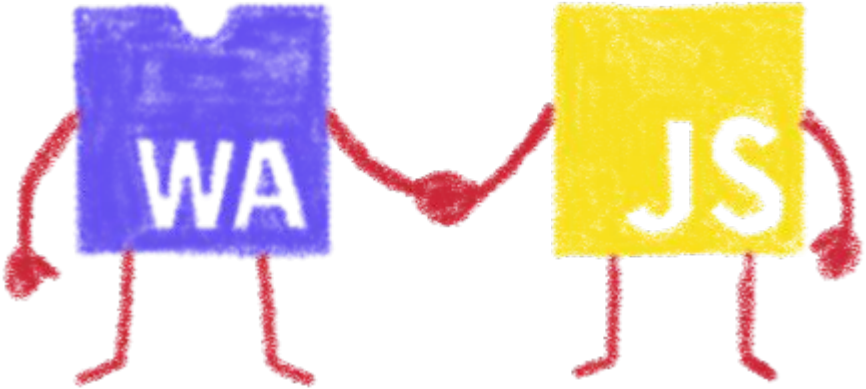
Fast & Efficient ⚡

🔒 Memory-safe & Sandboxed

Open & Deboggable 📄

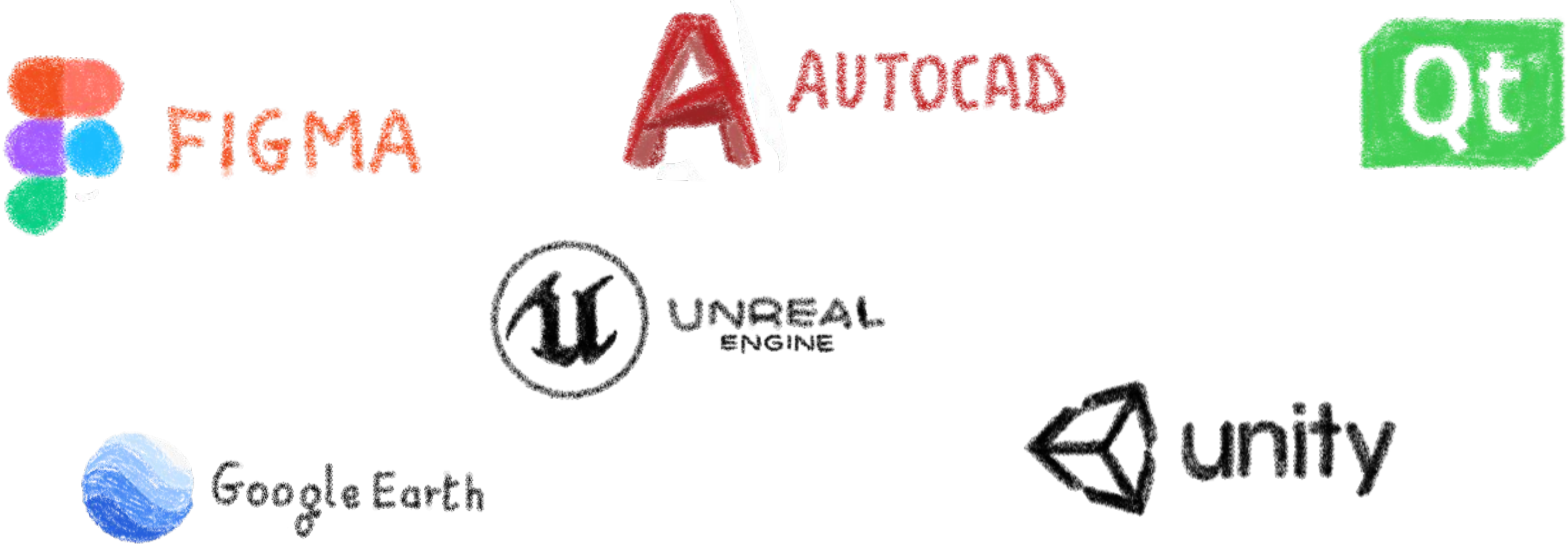
www Part of the Web Platform

But above all...



WebAssembly is not meant to replace JavaScript

Who is using WebAssembly today?



And many more others...

Java Applets

W3C

Macromedia FLASH

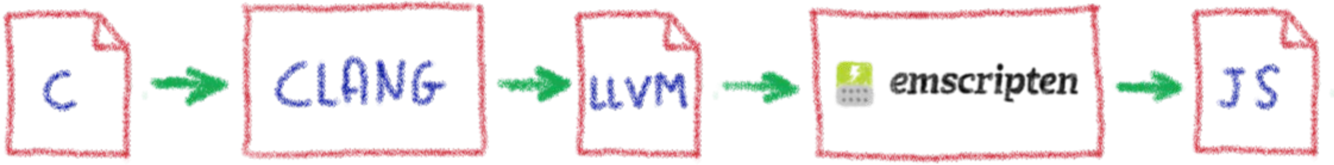
A bit of history

Remembering the past
to better understand the present

Executing other languages in the browser

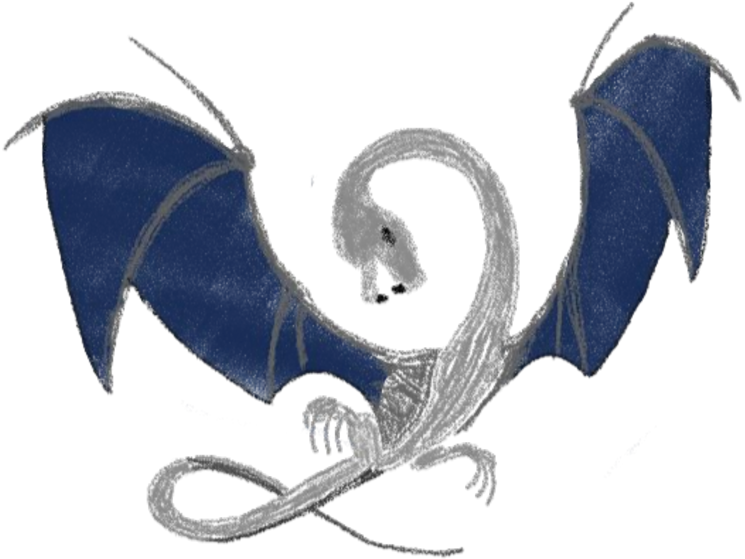
A long story, with many failures...

2012 - From C to JS: enter emscripten



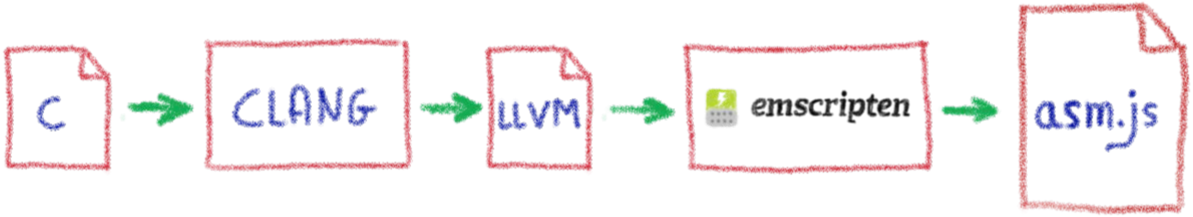
Passing by LLVM pivot

Wait, dude! What's LLVM?



A set of compiler and toolchain technologies

2013 - Generated JS is slow...



Let's use only a strict subset of JS: asm.js

Only features adapted to AOT optimization

WebAssembly project

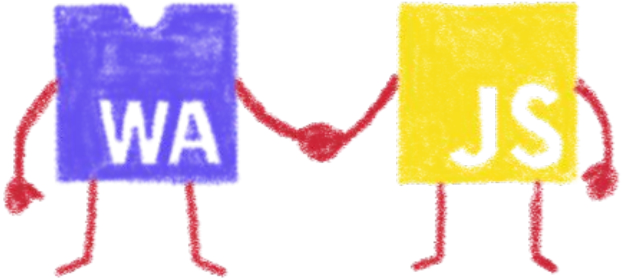
moz://a

Google

Joint effort

Microsoft

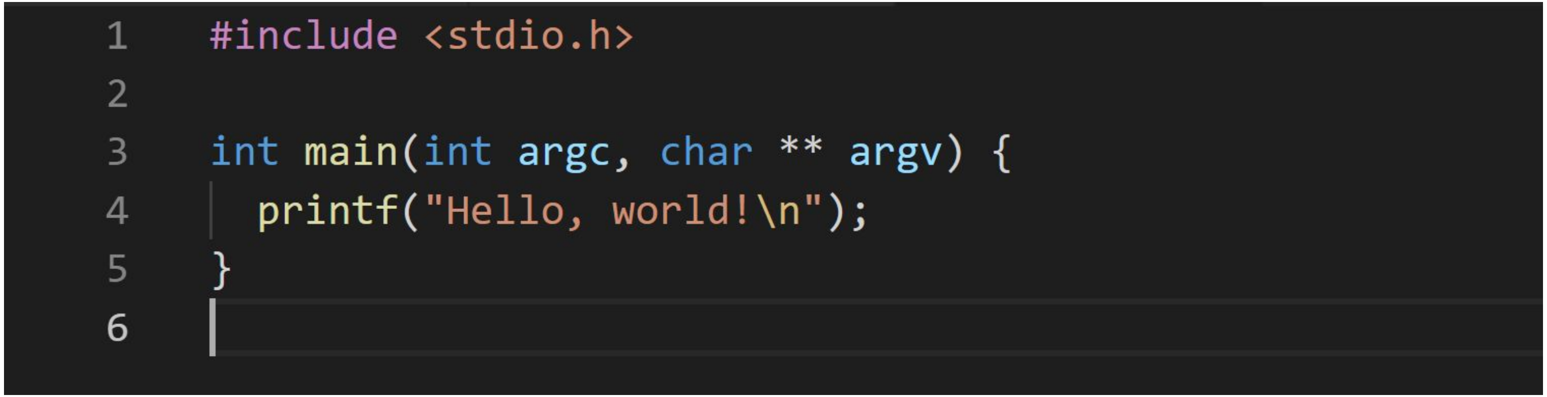
W3C



Hello W(ASM)orld

My first WebAssembly program

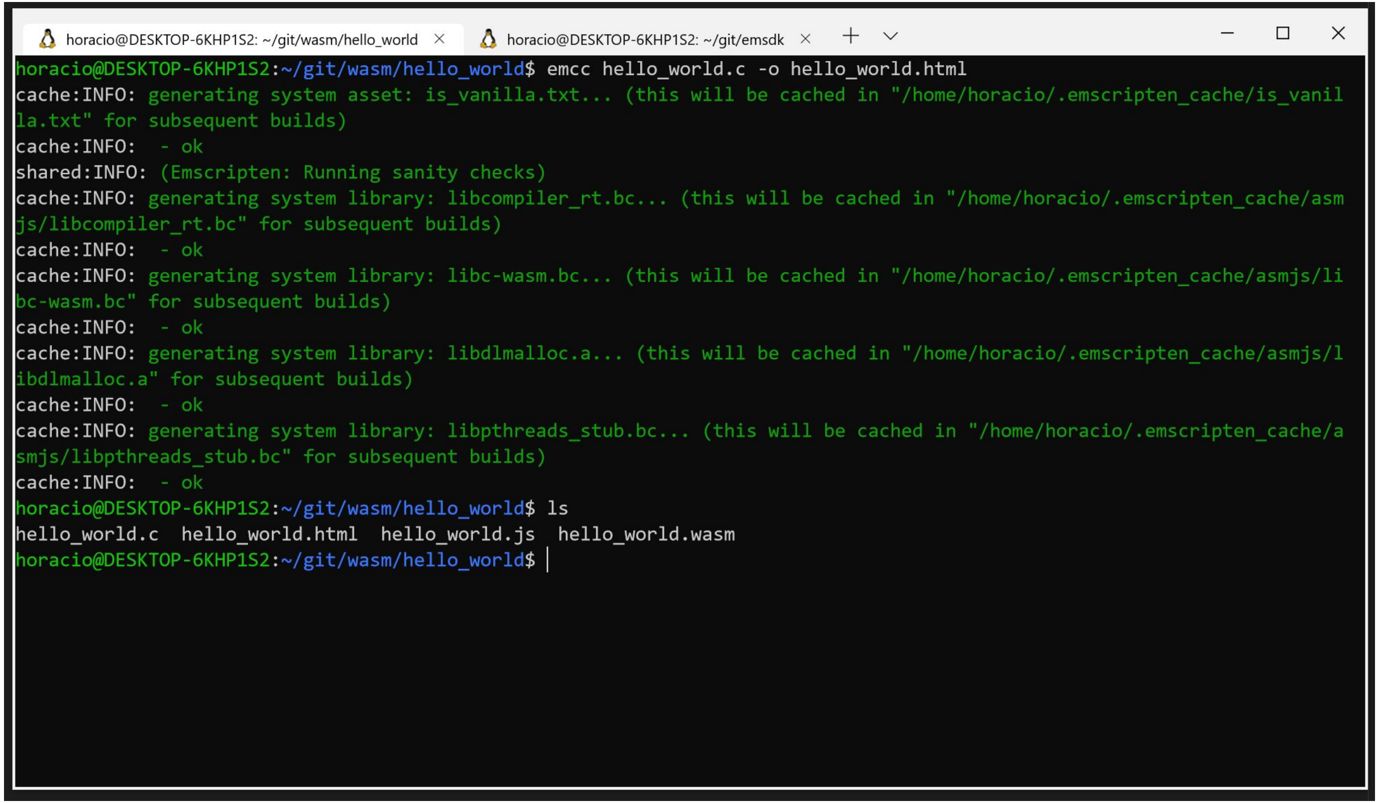
Do you remember your 101 C course?



```c
#include <stdio.h>

int main(int argc, char ** argv) {
  printf("Hello, world!\n");
}

```

A simple *HelloWorld* in C

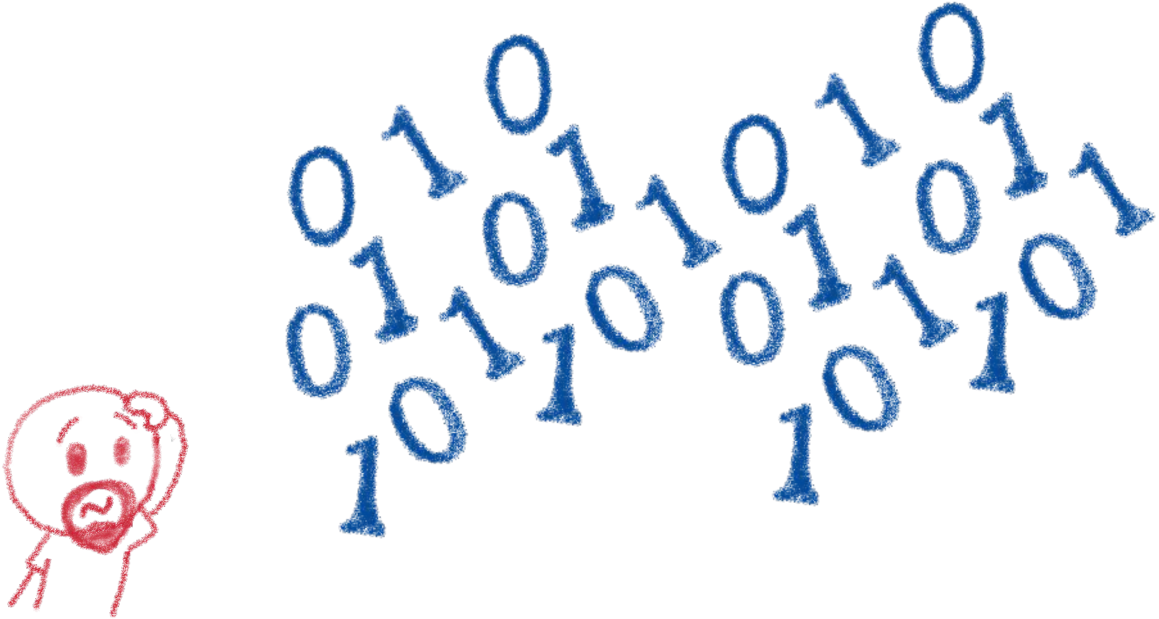
We compile it with emscripten



horacio@DESKTOP-6KHP1S2: ~/git/wasm/hello_world
horacio@DESKTOP-6KHP1S2: ~/git/emsdk

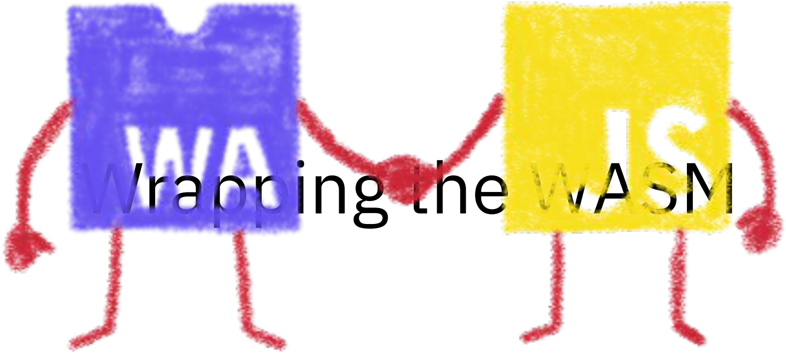
```
horacio@DESKTOP-6KHP1S2:~/git/wasm/hello_world$ emcc hello_world.c -o hello_world.html
cache:INFO: generating system asset: is_vanilla.txt... (this will be cached in "/home/horacio/.emscripten_cache/is_vanil
la.txt" for subsequent builds)
cache:INFO:  - ok
shared:INFO: (Emscripten: Running sanity checks)
cache:INFO: generating system library: libcompiler_rt.bc... (this will be cached in "/home/horacio/.emscripten_cache/asm
js/libcompiler_rt.bc" for subsequent builds)
cache:INFO:  - ok
cache:INFO: generating system library: libc-wasm.bc... (this will be cached in "/home/horacio/.emscripten_cache/asmjs/li
bc-wasm.bc" for subsequent builds)
cache:INFO:  - ok
cache:INFO: generating system library: libdlmalloc.a... (this will be cached in "/home/horacio/.emscripten_cache/asmjs/l
ibdlmalloc.a" for subsequent builds)
cache:INFO:  - ok
cache:INFO: generating system library: libpthreads_stub.bc... (this will be cached in "/home/horacio/.emscripten_cache/a
smjs/libpthreads_stub.bc" for subsequent builds)
cache:INFO:  - ok
horacio@DESKTOP-6KHP1S2:~/git/wasm/hello_world$ ls
hello_world.c  hello_world.html  hello_world.js  hello_world.wasm
horacio@DESKTOP-6KHP1S2:~/git/wasm/hello_world$
```

We get a .wasm file...



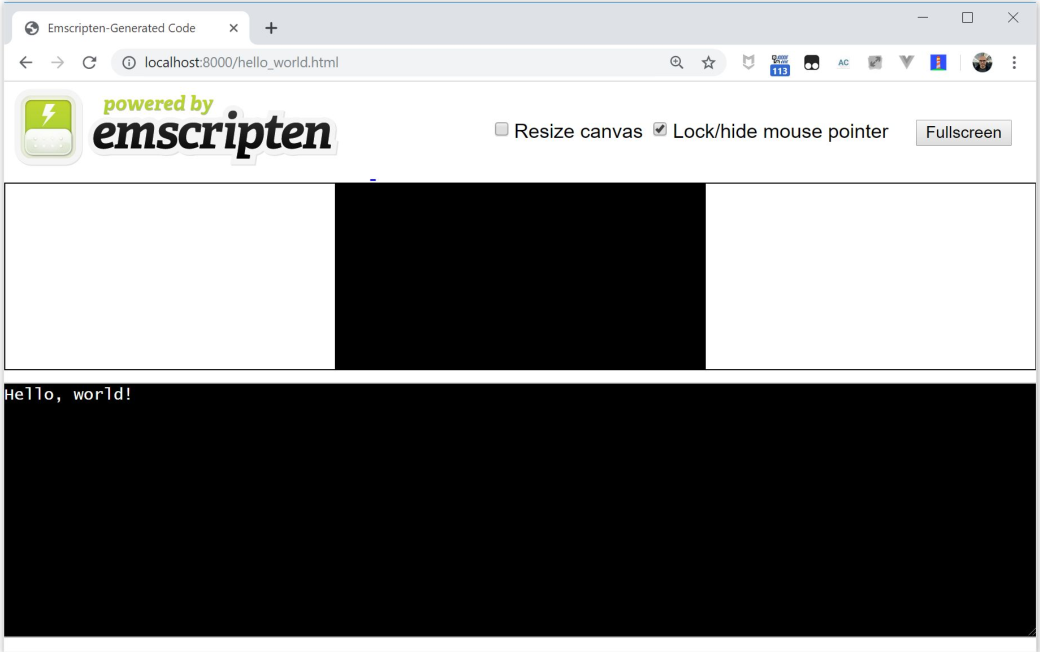
Binary file, in the binary WASM format

We also get a `.js` file…



Wrapping the WASM

And a `.html` file


Emscripten-Generated Code
localhost:8000/hello_world.html
powered by emscripten
□ Resize canvas ☑ Lock/hide mouse pointer
Fullscreen

```
Hello, world!
```

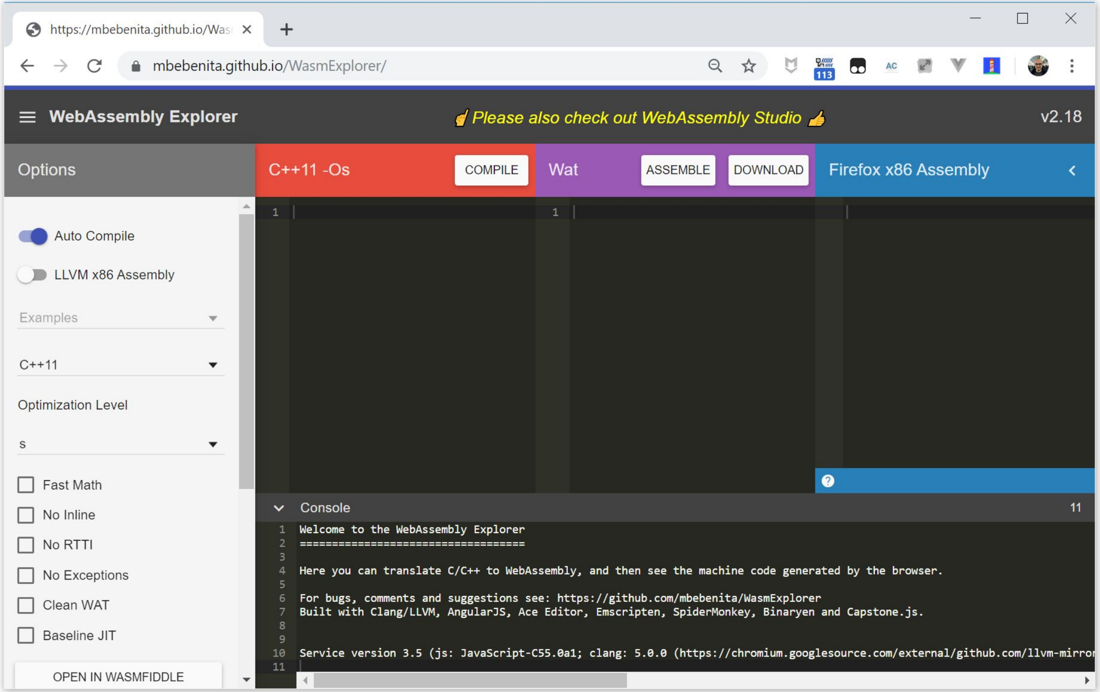
To quickly execute in the browser our WASM

And in a more Real World^{TM} case?

A simple process:

- Write or use existing code
  - In C, C++, Rust, Go, AssemblyScript...
- Compile
  - Get a binary `.wasm` file
- Include
  - The `.wasm` file into a project
- Instantiate
  - Async JavaScript compiling and instantiating the `.wasm` binary

I don't want to install a compiler now...



● Auto Compile

○ LLVM x86 Assembly

C++11

Optimization Level

s

□ Fast Math

□ No Inline

□ No RTTI

□ No Exceptions

□ Clean WAT

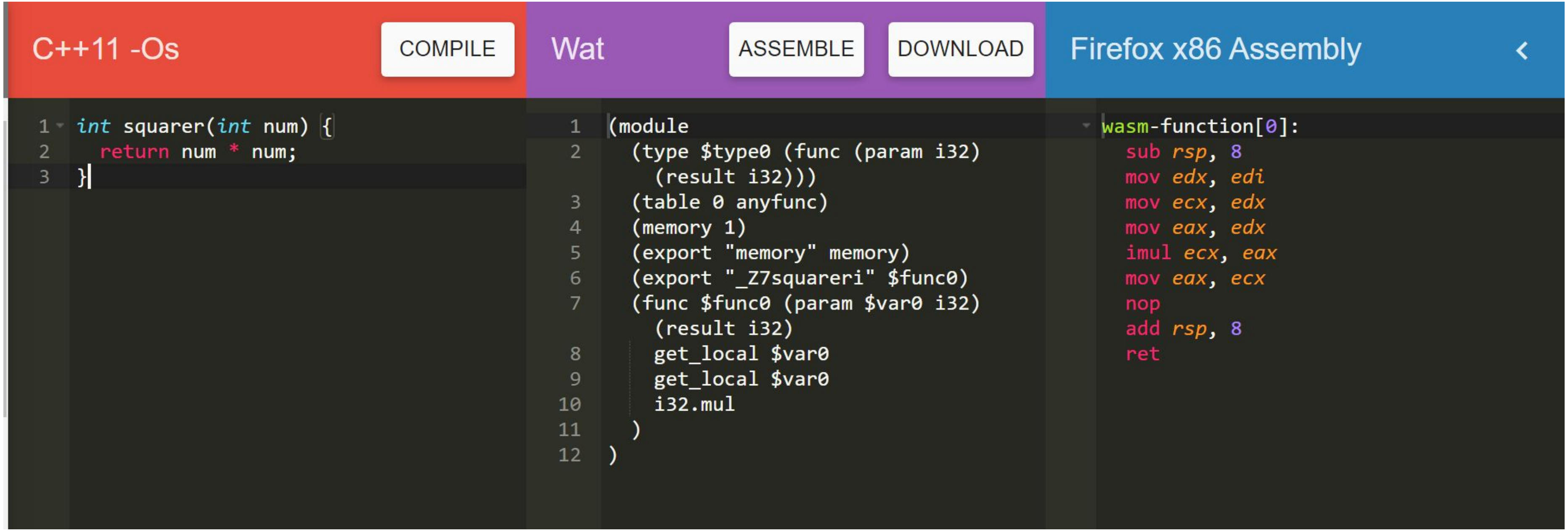
□ Baseline JIT

```
Welcome to the WebAssembly Explorer
==================================

Here you can translate C/C++ to WebAssembly, and then see the machine code generated by the browser.

For bugs, comments and suggestions see: https://github.com/mbebenita/WasmExplorer
Built with Clang/LLVM, AngularJS, Ace Editor, Emscripten, SpiderMonkey, Binaryen and Capstone.js.


Service version 3.5 (js: JavaScript-C55.0a1; clang: 5.0.0 (https://chromium.googlesource.com/external/github.com/llvm-mirror
```

Let's use WASM Explorer

https://mbebenita.github.io/WasmExplorer/

Let's begin with the a simple function



```cpp
int squarer(int num) {
  return num * num;
}
```

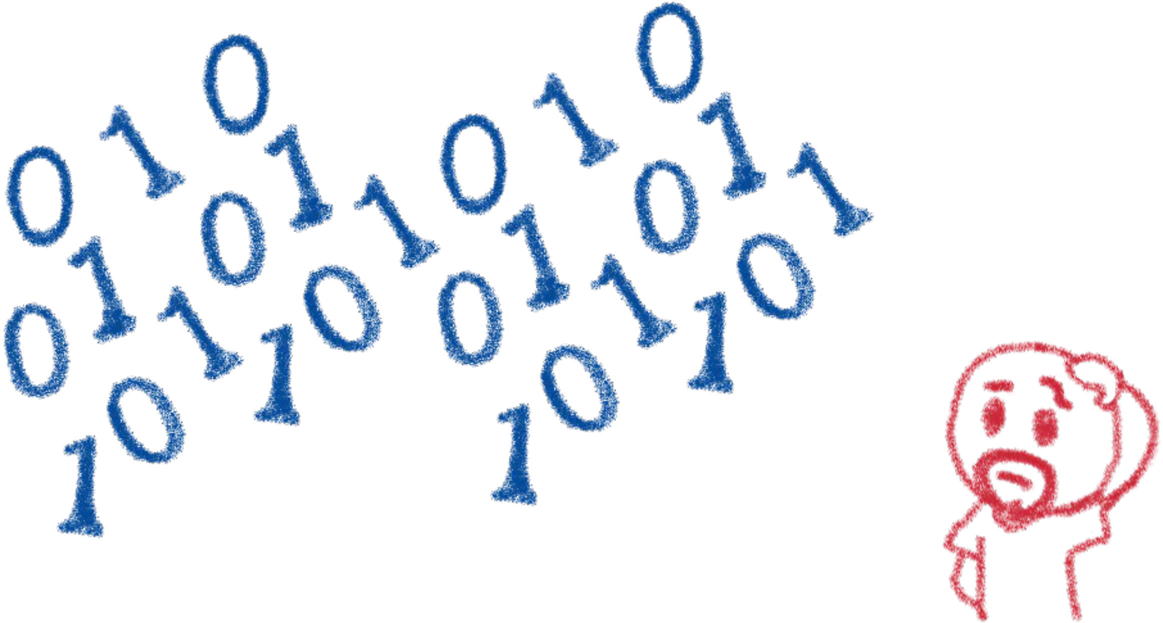
```
(module
  (type $type0 (func (param i32)
    (result i32)))
  (table 0 anyfunc)
  (memory 1)
  (export "memory" memory)
  (export "_Z7squareri" $func0)
  (func $func0 (param $var0 i32)
    (result i32)
    get_local $var0
    get_local $var0
    i32.mul
  )
)
```

```
wasm-function[0]:
  sub rsp, 8
  mov edx, edi
  mov ecx, edx
  mov eax, edx
  imul ecx, eax
  mov eax, ecx
  nop
  add rsp, 8
  ret
```

WAT: WebAssembly Text Format

Human readable version of the `.wasm` binary

Download the binary .wasm file

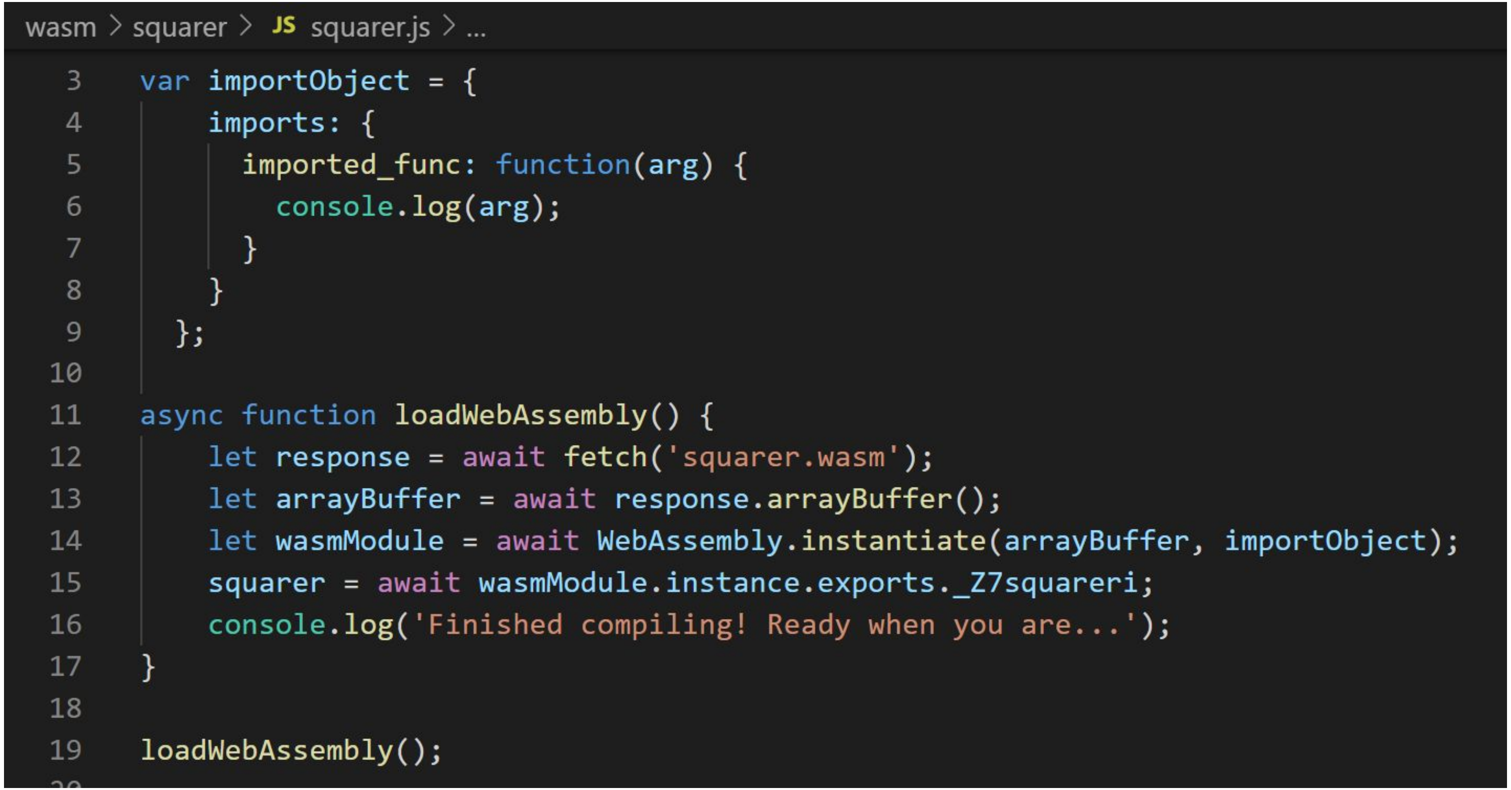


Now we need to call it from JS...

Instantiating the WASM

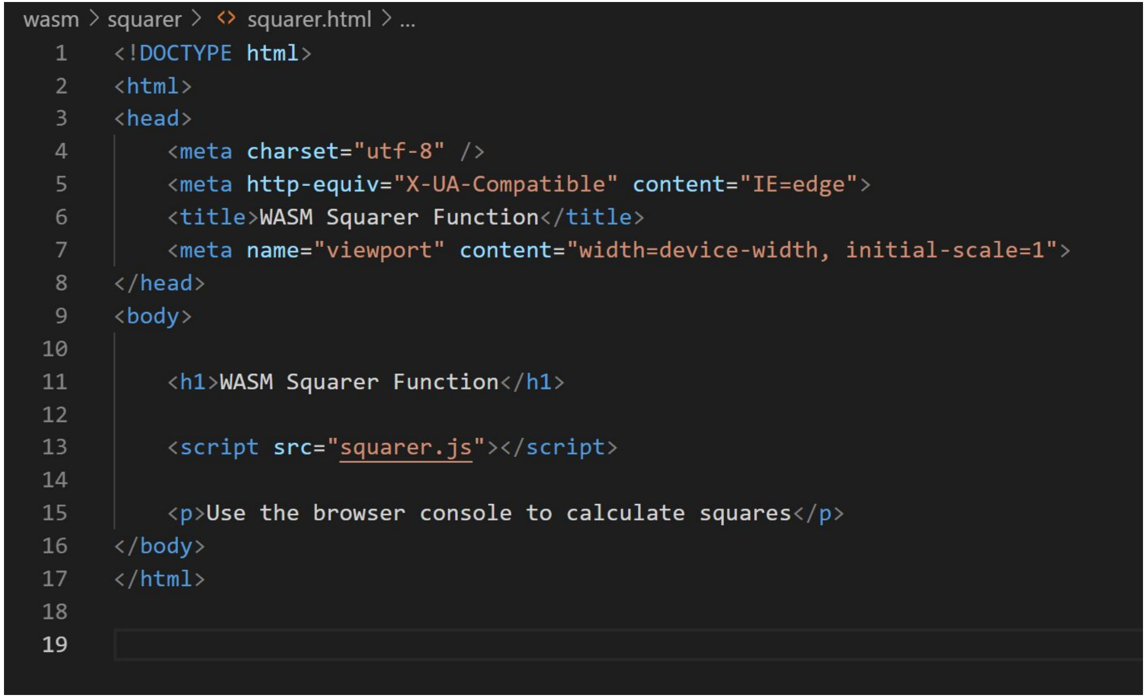
1. Get the `.wasm` binary file into an array buffer
2. Compile the bytes into a WebAssembly module
3. Instantiate the WebAssembly module

Instantiating the WASM



```
var importObject = {
    imports: {
      imported_func: function(arg) {
        console.log(arg);
      }
    }
  };

async function loadWebAssembly() {
    let response = await fetch('squarer.wasm');
    let arrayBuffer = await response.arrayBuffer();
    let wasmModule = await WebAssembly.instantiate(arrayBuffer, importObject);
    squarer = await wasmModule.instance.exports._Z7squareri;
    console.log('Finished compiling! Ready when you are...');
}

loadWebAssembly();
```

Loading the `squarer` function

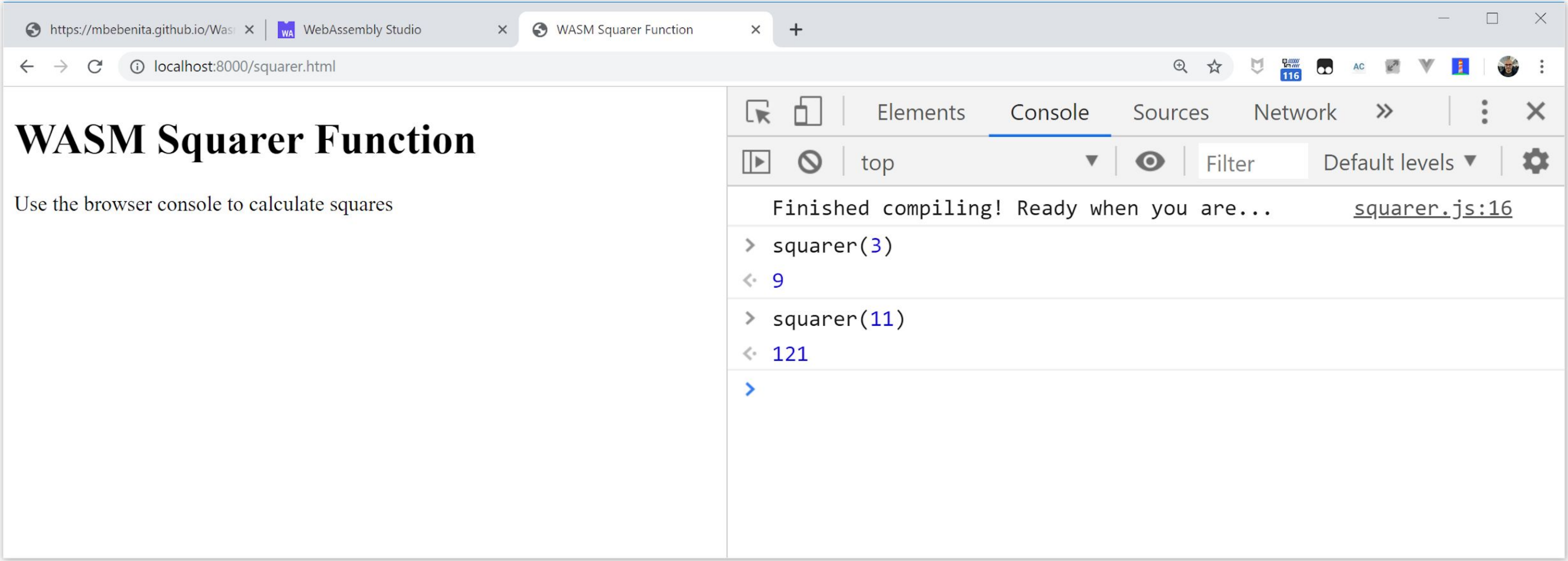


wasm > squarer > squarer.html > ...

```html
<!DOCTYPE html>
<html>
<head>
    <meta charset="utf-8" />
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <title>WASM Squarer Function</title>
    <meta name="viewport" content="width=device-width, initial-scale=1">
</head>
<body>

    <h1>WASM Squarer Function</h1>

    <script src="squarer.js"></script>

    <p>Use the browser console to calculate squares</p>
</body>
</html>

```

We instantiate the WASM by loading the wrapping JS

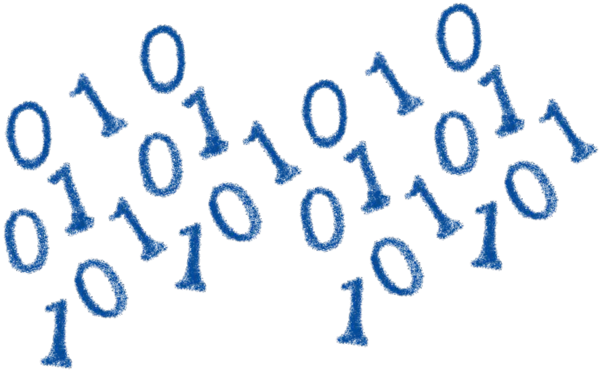
Using it!



WASM Squarer Function

Use the browser console to calculate squares

```
Finished compiling! Ready when you are...          squarer.js:16
> squarer(3)
<· 9
> squarer(11)
<· 121
>
```



You sold us a codelab!

Stop speaking and let us code

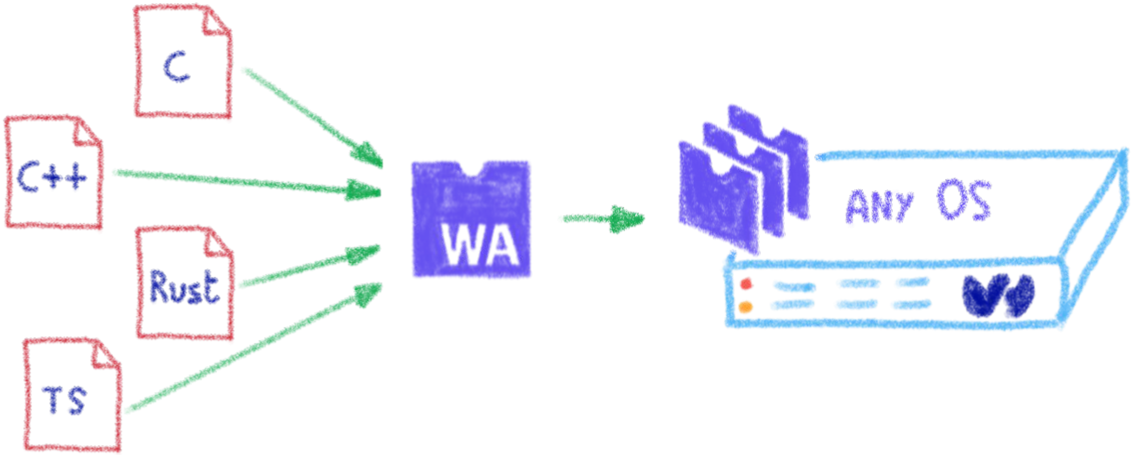
You can do steps 01 and 02 now

Let's code, mates!

WASM outside the browser

Not only for web developers

Run any code on any client... almost



Languages compiling to WASM

Includes WAPM

```
wapm install optipng
```

Oh, like npm for WASM!

The WebAssembly Package Manager

Some use cases

What can I do with it?

Tapping into other languages ecosystems

OptiPNG (c)

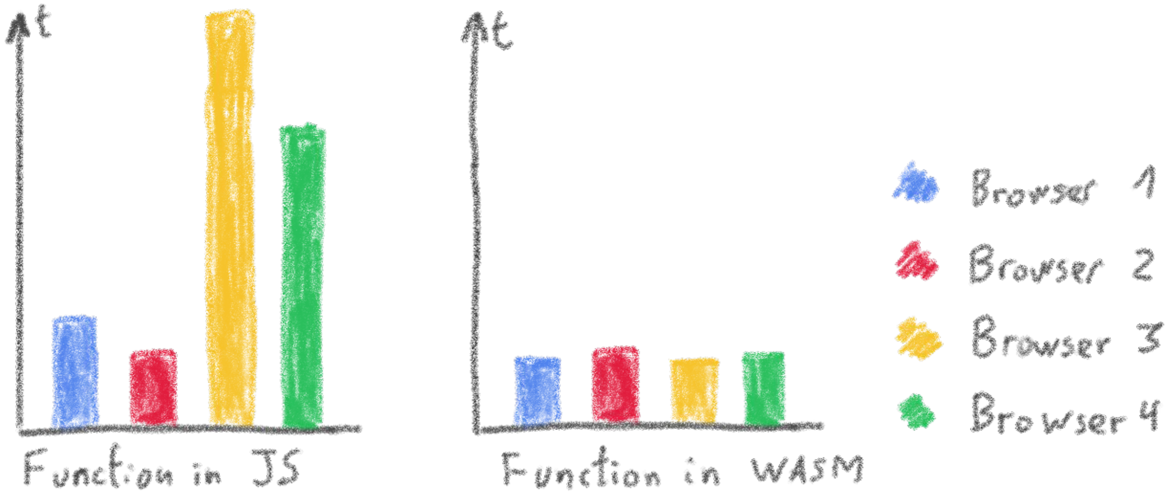
Resize (Rust)

MozJPEG (C++)

webp (c)

Don't rewrite libs anymore

Replacing problematic JS bits



Predictable performance

Same peak performance, but less variation

Communicating between JS and WASM

Shared memory, functions...

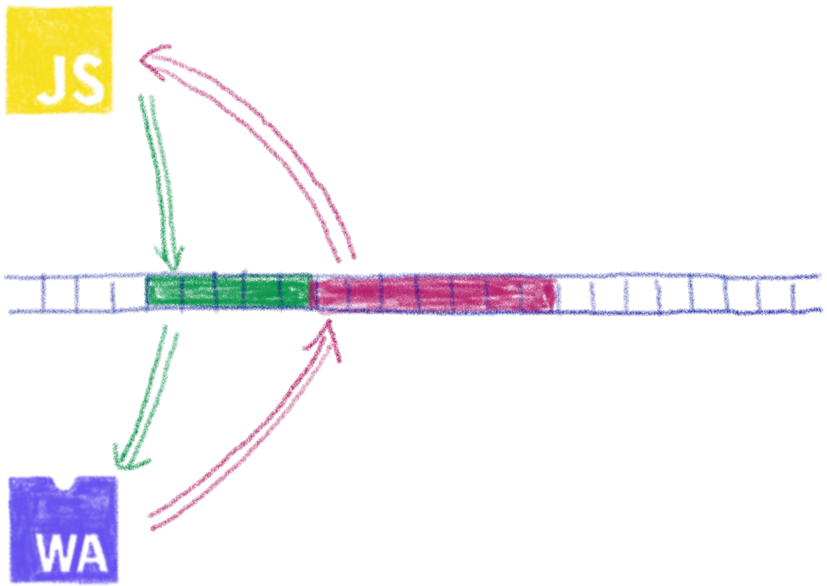
Native WASM types are limited

WASM currently has four available types:

- `i32`: 32-bit integer
- `i64`: 64-bit integer
- `f32`: 32-bit float
- `f64`: 64-bit float

Types from languages compiled to WASM are mapped to these types

How can we share data?



Using the same data in WASM and JS?
Shared linear memory between them!

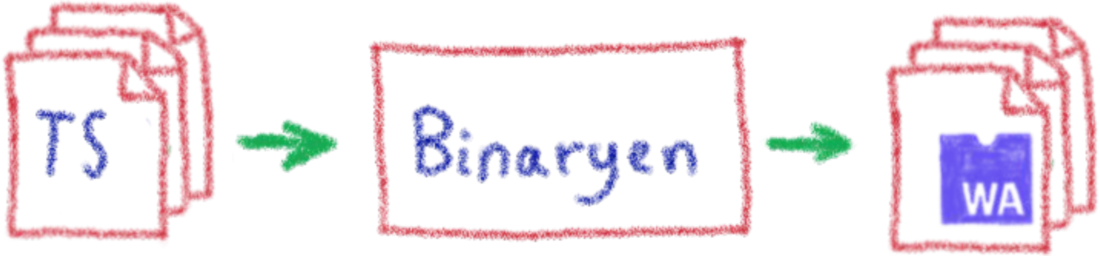
You can do steps 03 and 04 now

Let's code, mates!

AssemblyScript

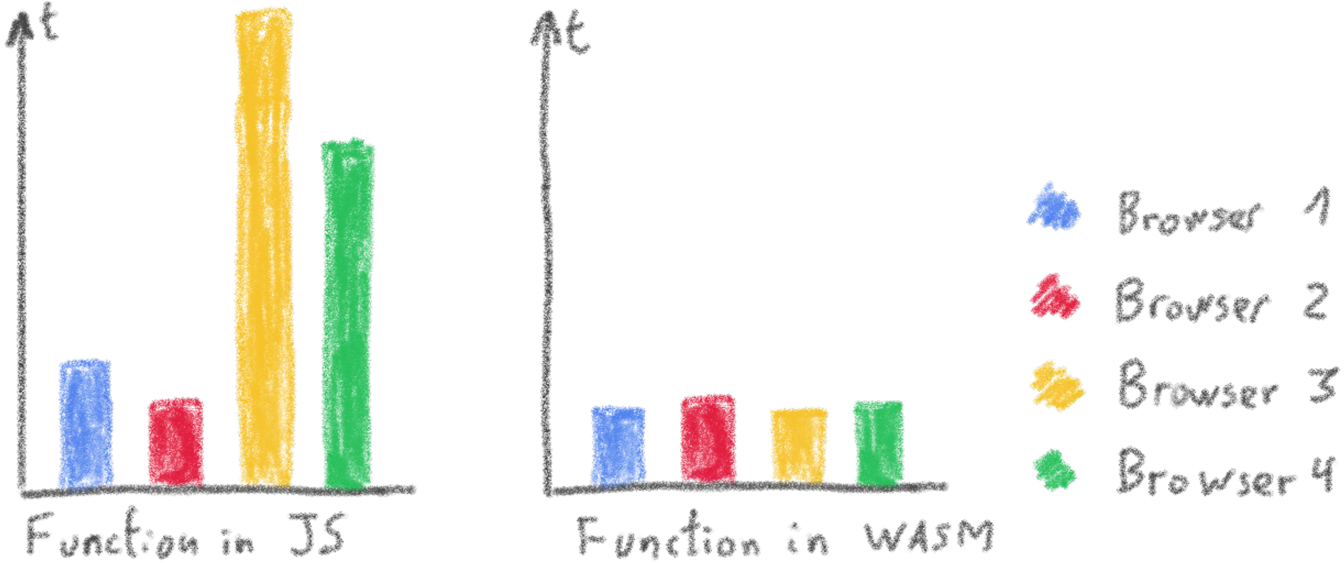
Writing WASM without learning a new language

TypeScript subset compiled to WASM



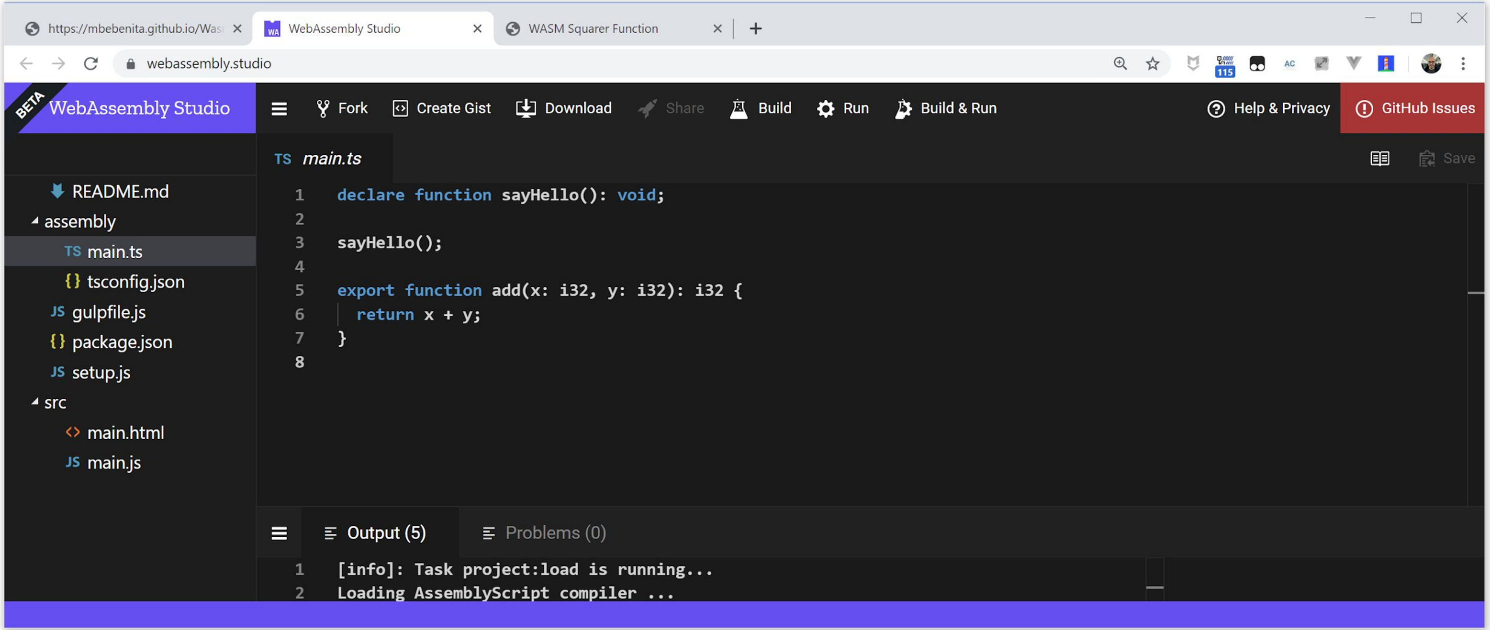
Why would I want to compile TypeScript to WASM?

Ahead of Time compiled TypeScript



More predictable performance

Avoiding the dynamicness of JavaScript

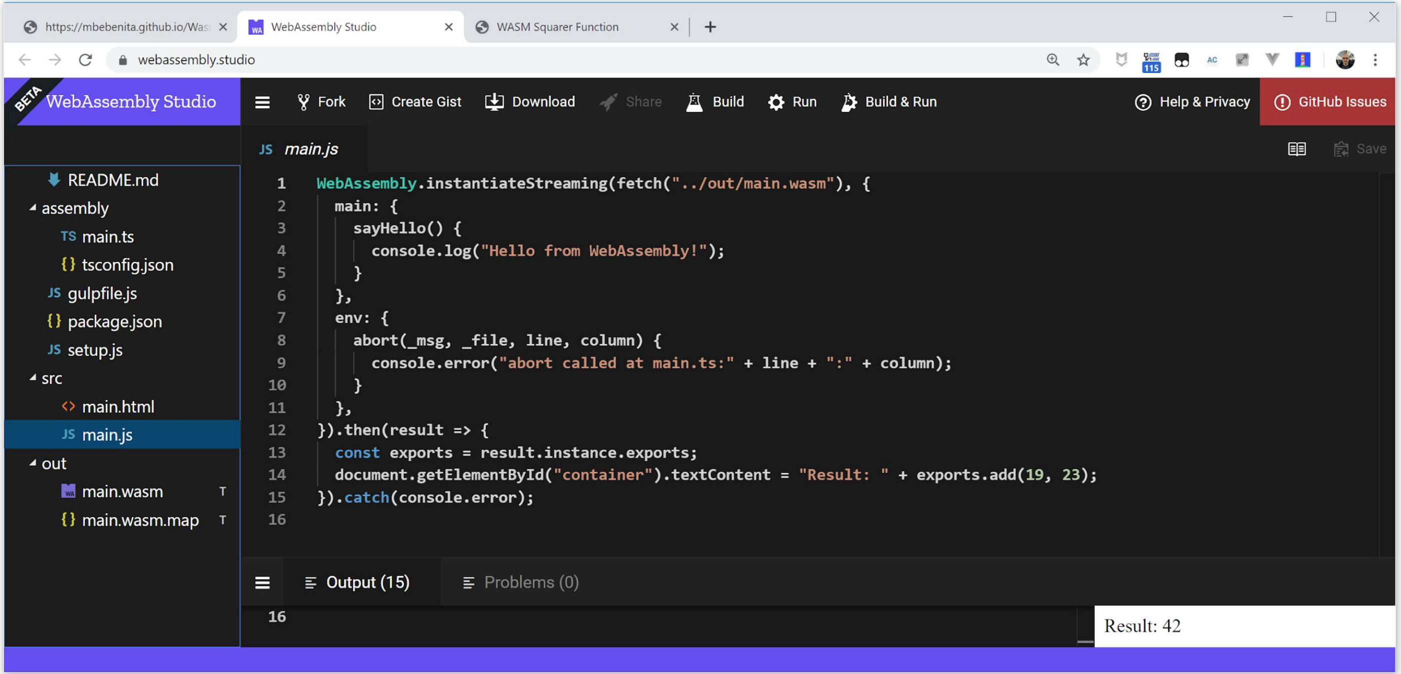


```
declare function sayHello(): void;

sayHello();

export function add(x: i32, y: i32): i32 {
  return x + y;
}
```

```
[info]: Task project:load is running...
Loading AssemblyScript compiler ...
```

More specific integer and floating point types

Objects cannot flow in and out of WASM yet



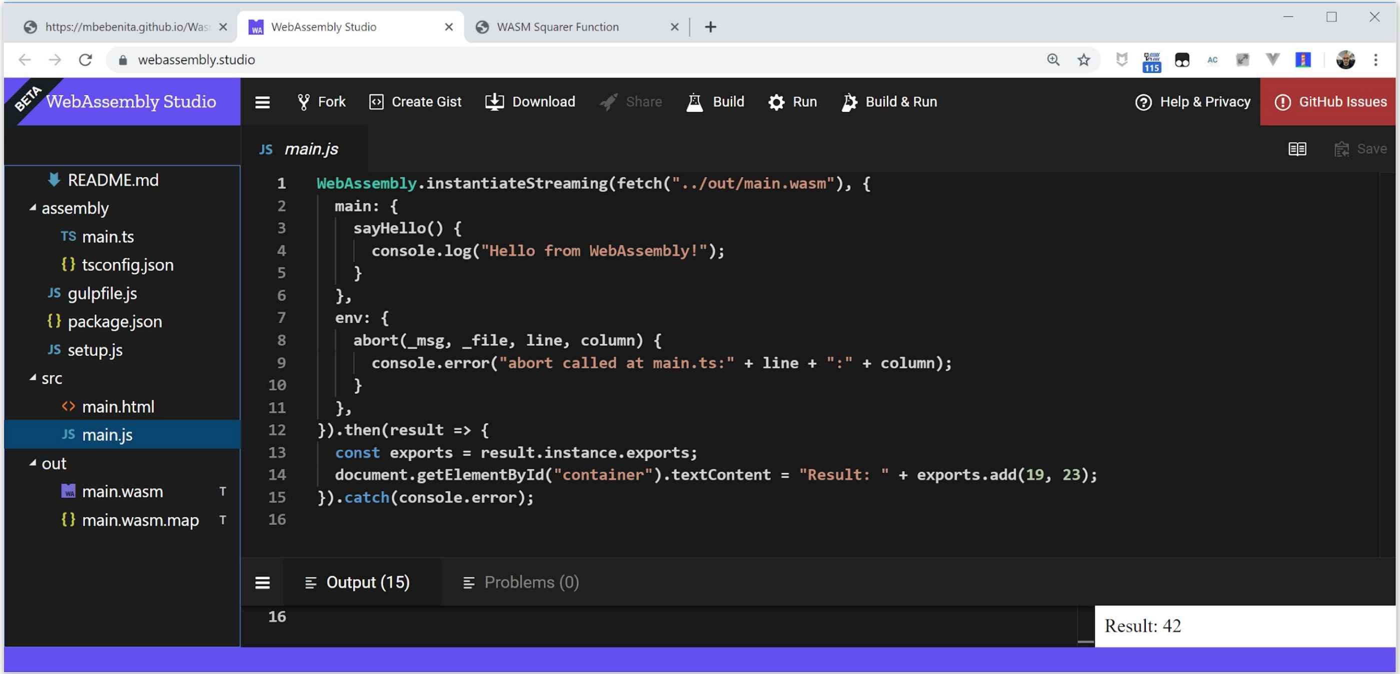
```
WebAssembly.instantiateStreaming(fetch("../out/main.wasm"), {
  main: {
    sayHello() {
      console.log("Hello from WebAssembly!");
    }
  },
  env: {
    abort(_msg, _file, line, column) {
      console.error("abort called at main.ts:" + line + ":" + column);
    }
  },
}).then(result => {
  const exports = result.instance.exports;
  document.getElementById("container").textContent = "Result: " + exports.add(19, 23);
}).catch(console.error);
```

```
16
```

Result: 42

Using a loader to write/read them to/from memory

No direct access to DOM



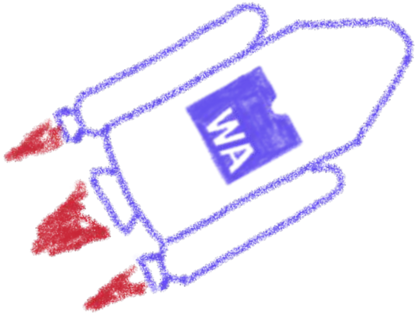
```
WebAssembly.instantiateStreaming(fetch("../out/main.wasm"), {
  main: {
    sayHello() {
      console.log("Hello from WebAssembly!");
    }
  },
  env: {
    abort(_msg, _file, line, column) {
      console.error("abort called at main.ts:" + line + ":" + column);
    }
  },
}).then(result => {
  const exports = result.instance.exports;
  document.getElementById("container").textContent = "Result: " + exports.add(19, 23);
}).catch(console.error);
```

```
Result: 42
```

Glue code using exports/imports to/from JavaScript

You can do step 05 now

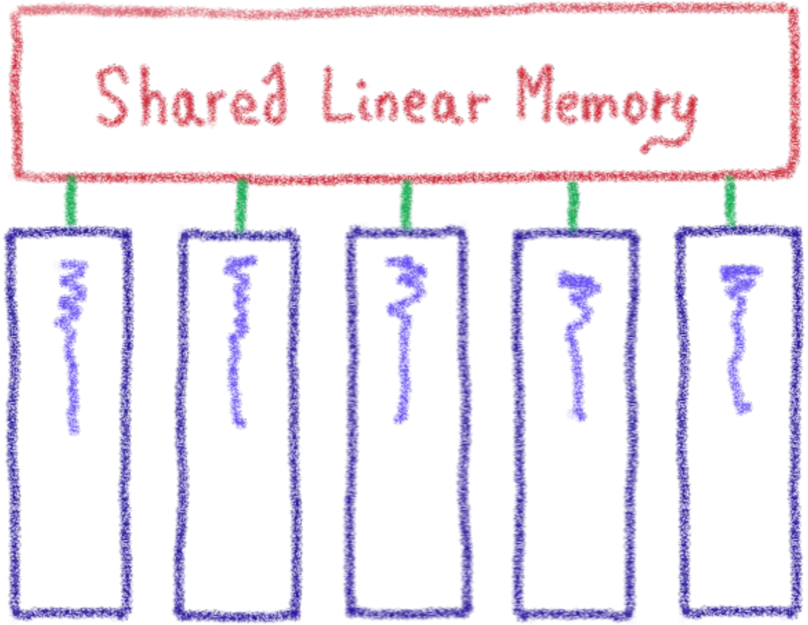
Let's code, mates!



Future

To the infinity and beyond!

WebAssembly Threads

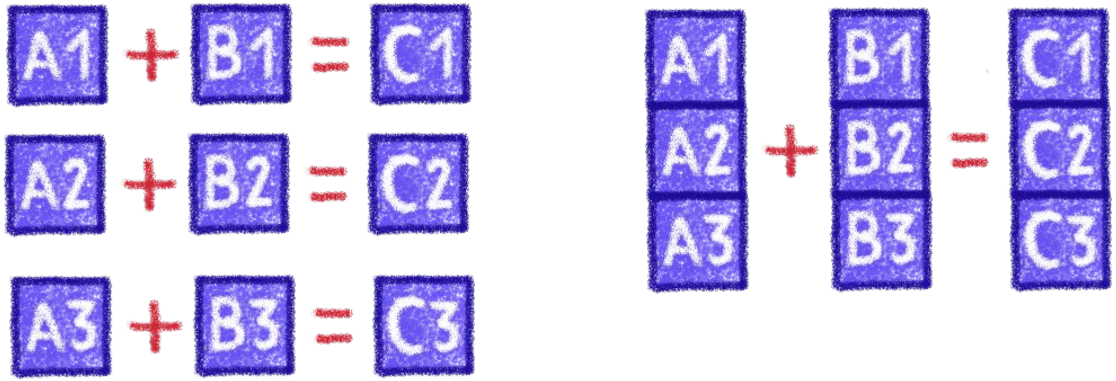


Threads on Web Workers with shared linear memory

SIMD

Multiple scalar operations

Single vectorial operation



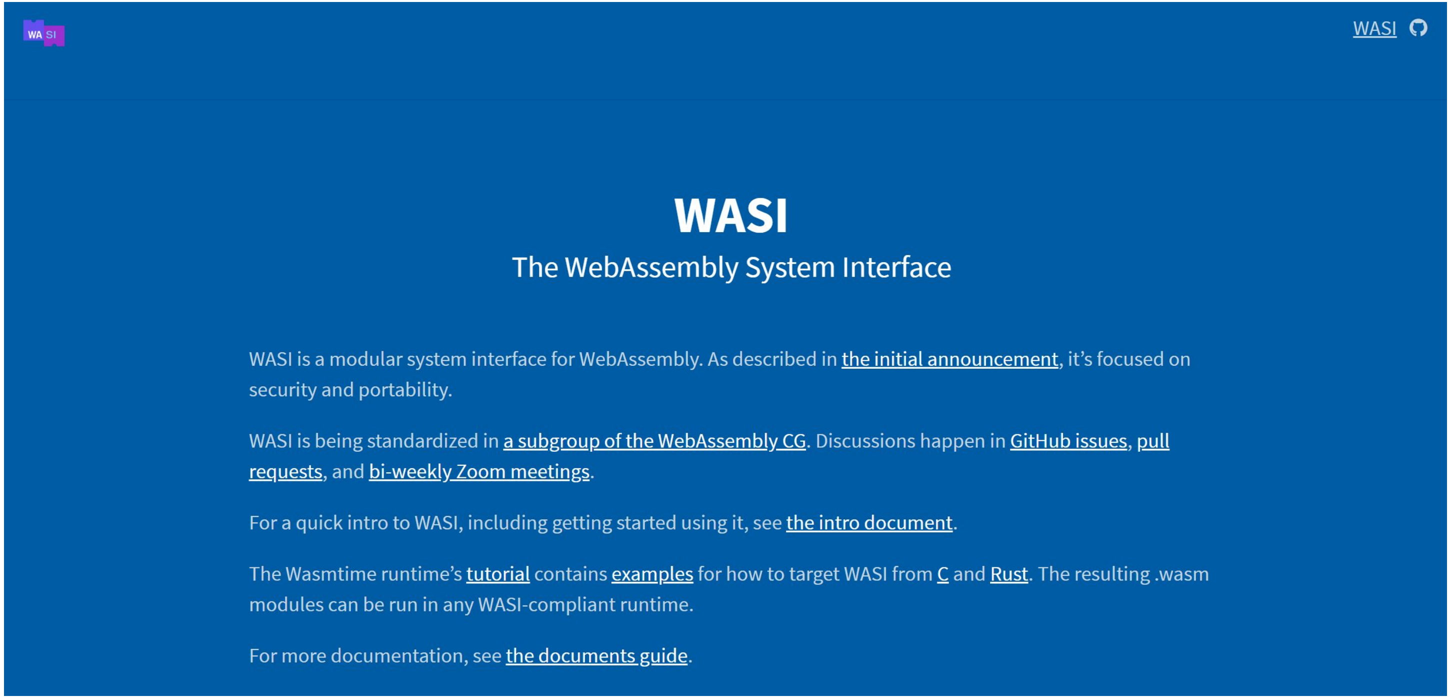
Already available in Wasmer

Single Instruction, Multiple Data

Garbage collector

And exception handling

WASI



WASI

The WebAssembly System Interface

WASI is a modular system interface for WebAssembly. As described in the initial announcement, it's focused on security and portability.

WASI is being standardized in a subgroup of the WebAssembly CG. Discussions happen in GitHub issues, pull requests, and bi-weekly Zoom meetings.

For a quick intro to WASI, including getting started using it, see the intro document.

The Wasmtime runtime's tutorial contains examples for how to target WASI from C and Rust. The resulting .wasm modules can be run in any WASI-compliant runtime.

For more documentation, see the documents guide.

WebAssembly System Interface

WebAssembly ~~❤️~~ Web Components

How to hide the complexity and remove friction

The 3 minutes context

What the heck are web component?

Web Components

Web standard W3C

Web Components

Available in all modern browsers:

Firefox, Safari, Chrome

Web Components

Create your own HTML tags

Encapsulating look and behavior

Web Components

Fully interoperable

With other web components, with any framework

Web Components

CUSTOM ELEMENTS

SHADOW DOM

TEMPLATES

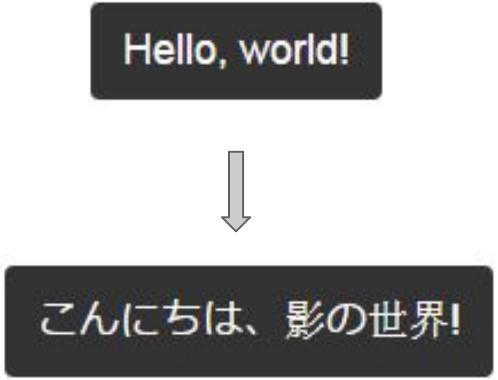
Custom Element

</> To define your own HTML tag

```
<body>
  ...
  <script>
    window.customElements.define('my-element',
        class extends HTMLElement {...});
  </script>
  <my-element></my-element>
</body>
```

Shadow DOM

To encapsulate subtree and style in an element



```
<button>Hello, world!</button>
<script>
var host = document.querySelector('button');
const shadowRoot = host.attachShadow({mode:'open'});
shadowRoot.textContent = 'こんにちは、影の世界!';
</script>
```

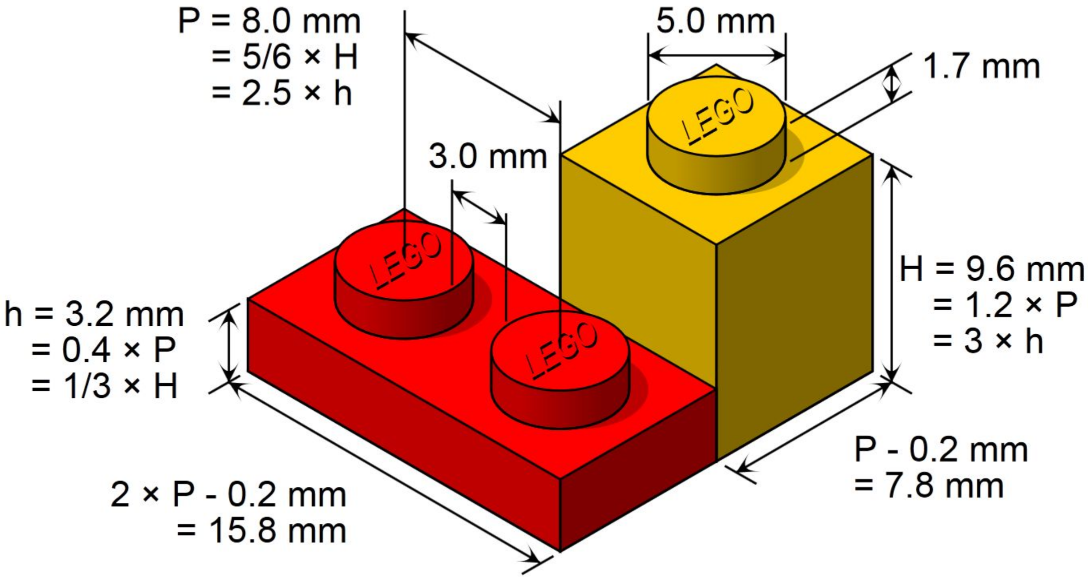
Template

To have clonable document template

```
<template id="mytemplate">
  <img src="" alt="great image">
  <div class="comment"></div>
</template>

var t = document.querySelector('#mytemplate');
// Populate the src at runtime.
t.content.querySelector('img').src = 'logo.png';
var clone = document.importNode(t.content, true);
document.body.appendChild(clone);
```

But in fact, it’s just an element...

- Attributes
- Properties
- Methods
- Events



You can do step 06 and 07 now

Let's code, mates!