

WEBASSEMBLY

RUNNING C++ AND RUST IN THE BROWSER

Hendrik Niemeyer ([@hniemeye](#))

LINK TO SLIDES AND CODE

<https://git.io/JvRan>

MOTIVATION



Solomon Hykes

@solomonstre

Folgen



If WASM+WASI existed in 2008, we wouldn't have needed to create Docker. That's how important it is. Webassembly on the server is the future of computing. A standardized system interface was the missing link. Let's hope WASI is up to the task!



Lin Clark @linclark

WebAssembly running outside the web has a huge future. And that future gets one giant leap closer today with...

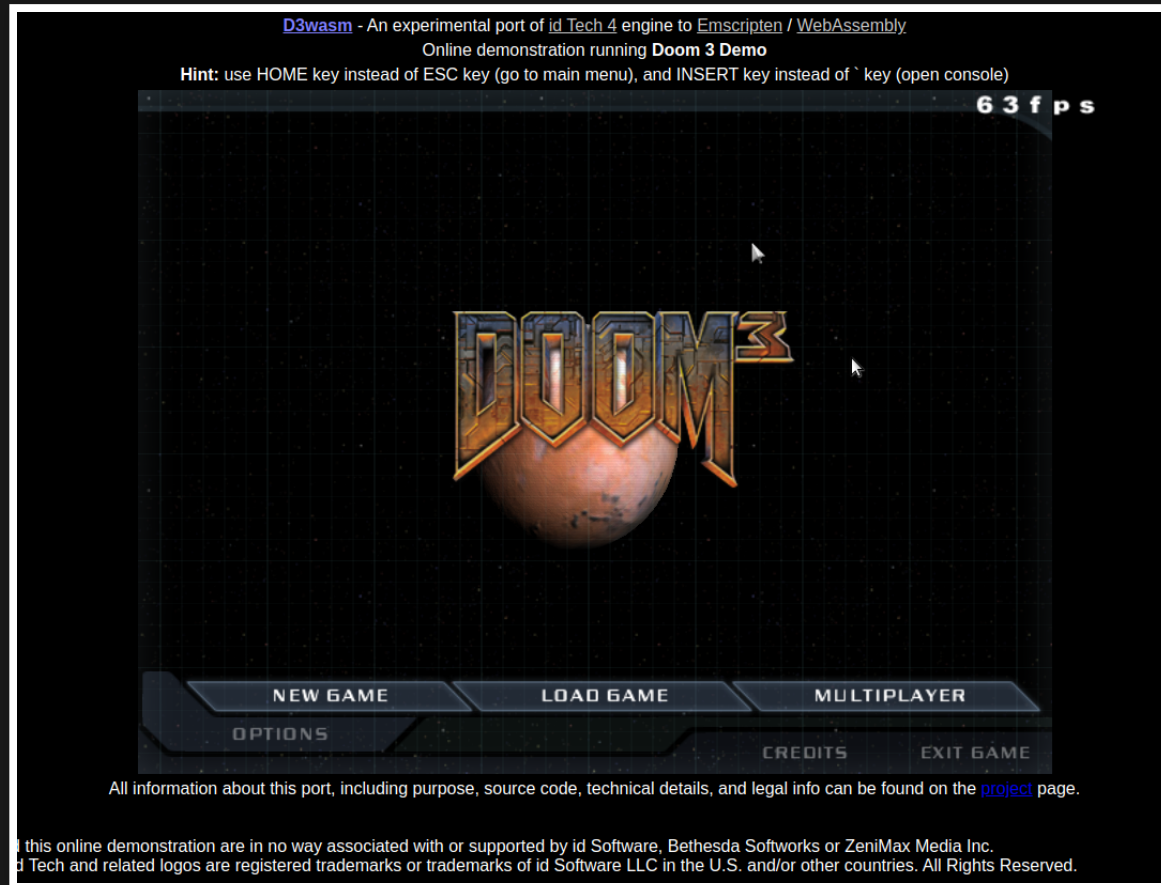


Announcing WASI: A system interface for running WebAssembly...

[Diesen Thread anzeigen](#)

13:39 - 27. März 2019

WHAT CAN WEBASSEMBLY DO?



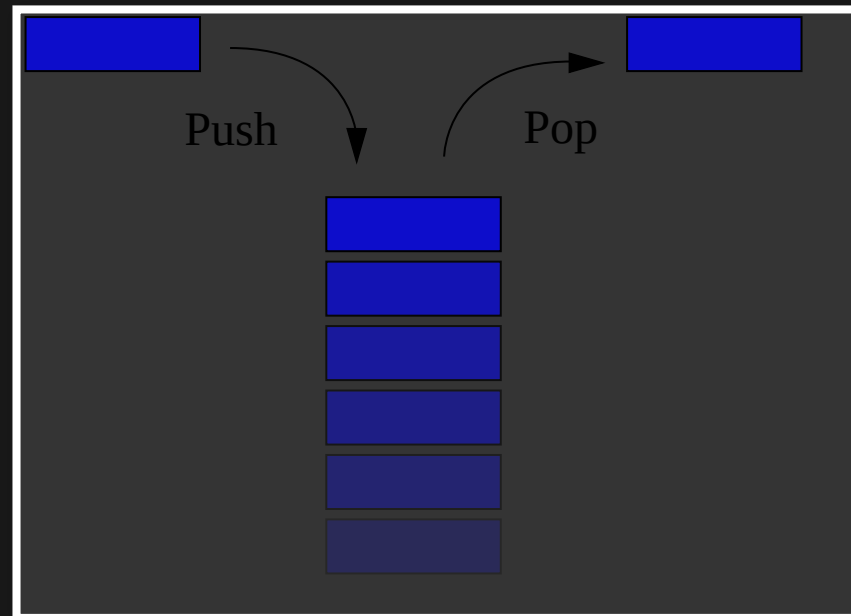
Doom

WHAT IS WEBASSEMBLY?

WebAssembly (abbreviated Wasm) is a binary instruction format for a stack-based virtual machine. Wasm is designed as a portable target for compilation of high-level languages like C/C++/Rust, enabling deployment on the web for client and server applications. (Source: webassembly.org)

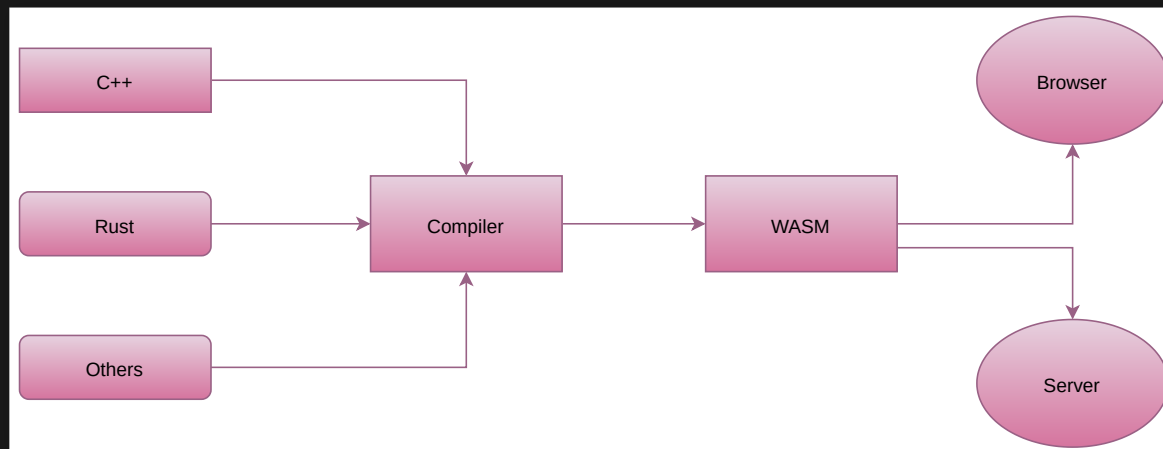
WHAT IS WEBASSEMBLY?

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WHAT IS WEBASSEMBLY?

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OPEN STANDARD

WebAssembly Core Specification

W3C Recommendation, 5 December 2019



WebAssembly Core Specification

USE CASES

- Porting an existing codebase to the browser
- Writing performant code for the browser
- A portable and secure compilation target outside of the browser

WHAT IS WEBASSEMBLY NOT?




- Not a programming language
- Not intended to replace JavaScript

WHERE IS IT EXECUTED?













LANGUAGE SUPPORT

Legend

-  - Work in progress.
-  - Unstable but usable.
-  - Stable for production usage.

Contents

 .Net
 AssemblyScript
 Astro
 Brainfuck
 C
 C#
 C++
 Clean
 D
 Elixir
 F#
 Faust
 Forest
 Forth
 Go
 Grain
 Haskell
 Java
 JavaScript
 Julia
 Idris
 Kotlin/Native
 Kou
 Lobster
 Lua
 Lys
 Nim
 Ocaml
 Perl
 PHP
 Plorth

LANGUAGE SUPPORT

- Curated list of languages
- No builtin garbage collector
- Languages need to compile their own gc to wasm

STACK-BASED VIRTUAL MACHINE

```
int add(int a, int b) {  
    return a+b*3;  
}
```

becomes

```
1 (func $func0(param $var0 i32)(param $var1 i32)(result i32)  
2 get_local $var1  
3 i32.const 3  
4 i32.mul  
5 get_local $var0  
6 i32.add  
7 )
```

STACK-BASED VIRTUAL MACHINE

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3

var1

STACK-BASED VIRTUAL MACHINE

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3*var1

STACK-BASED VIRTUAL MACHINE

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```

var0

3*var1

STACK-BASED VIRTUAL MACHINE

```
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```

var0+3*var1



TYPES

- i32, i64 are 32/64-bit integer
- f32, f64 are 32/64-bit floating point

OTHER TYPES?

- What becomes of structs, arrays, vectors, ... ?

MEMORY

```
struct Point {  
    double x;  
    double y;  
};  
  
double scalar_product(const Point& p1, const Point& p2) {  
    return p1.x*p2.x + p1.y*p2.y;  
}
```

MEMORY

becomes

```
1 (func $func0(param $var0 i32)(param $var1 i32)(result f64)
2 get_local $var0
3 f64.load
4 get_local $var1
5 f64.load
6 f64.mul
7 get_local $var0
8 f64.load offset=8
9 get_local $var1
10 f64.load offset=8
11 f64.mul
12 f64.add
13 )
```


MEMORY

```
1 (func $func0(param $var0 i32)(param $var1 i32)(result f64)
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LINEAR MEMORY

- contiguous, byte-addressable range of memory
- untyped array of bytes
- load and store instructions for floats and integers

ARRAYS

```
void change_fifth(std::array<int,10>& arr, int n)
{
    arr[5] = n - 5;
}
```

becomes

```
1 (func $func0 (param $var0 i32) (param $var1 i32)
2 get_local $var0
3 get_local $var1
4 i32.const -5
5 i32.add
6 i32.store offset=20
7 )
```


ARRAYS

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CONTROL FLOW

- `block ... end`: Sequence of instructions with label at the end
- `loop ... end`: Sequence of instructions with label at the beginning
- Comparison instructions like `f32.lt`
- `br, br_if`: jump (conditionally) to a given label in an enclosing construct

WEBASSEMBLY EXPLORER

COMPILING C++ TO WASM DIRECTLY

```
clang++ \  
  --target=wasm32 \  
  -nostdlib \ # Don't link against a standard library  
  -Wl,--no-entry \ # We don't have an entry function  
  -Wl,--export-all \ # Export everything  
  -o add.wasm \  
  add.cpp
```

LOADING WASM INTO THE BROWSER

```
<script type="module">
async function init() {
const { instance } = await WebAssembly.instantiateStreaming(
  fetch("./add.wasm")
);
console.log(instance.exports._Z3addii(4, 1));
const pre = document.getElementById("my-canvas");
pre.textContent = instance.exports._Z3addii(4, 1)

}
init();
</script>
```


COMPILING C++ TO WASM WITH COMPILER EXPLORER

<https://godbolt.org/z/6pF8pm>

C++ TO WEBASSEMBLY



emscripten

EMSCRIPTEN

```
em++ -o hello.html hello.cpp
```

RUST TO WEBASSEMBLY



WASMPACK

```
wasm-pack build  
cd www/ || exit  
npm install  
npm run start
```

RUN DIRECTLY ON THE OS



CONCLUSION



QUESTIONS AND FEEDBACK

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