WebAssembly - 技术变革，未来已来

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自我介绍

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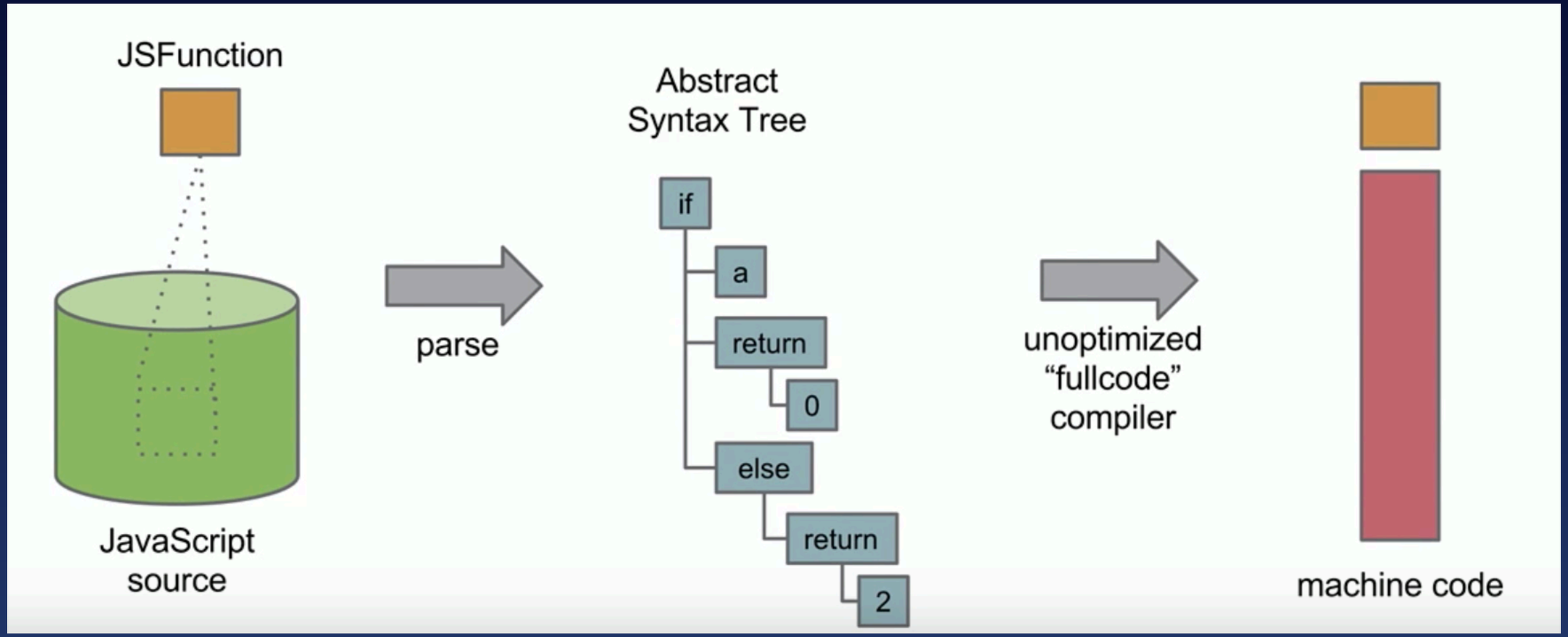
《深入浅出 WEBASSEMBLY》作者

FCC 上海社区负责人

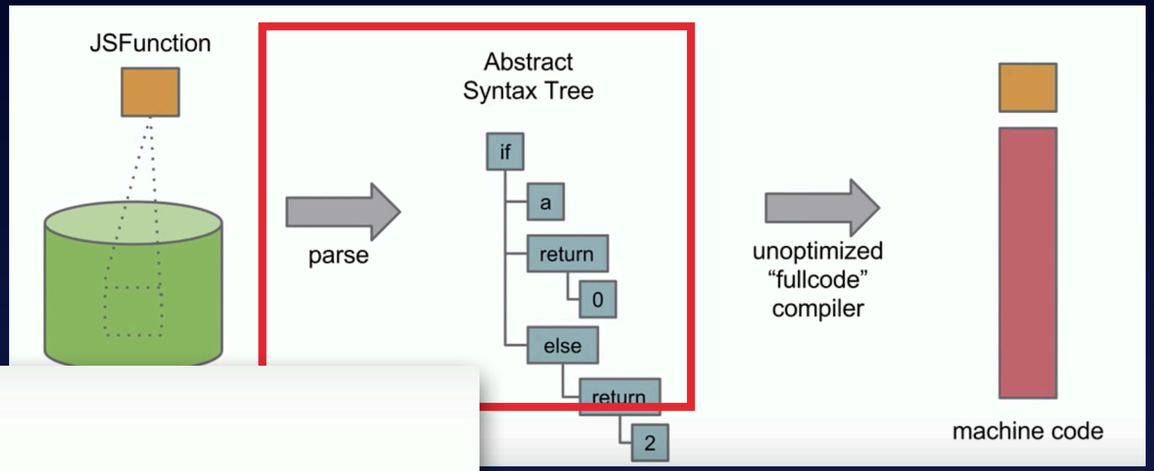
目录

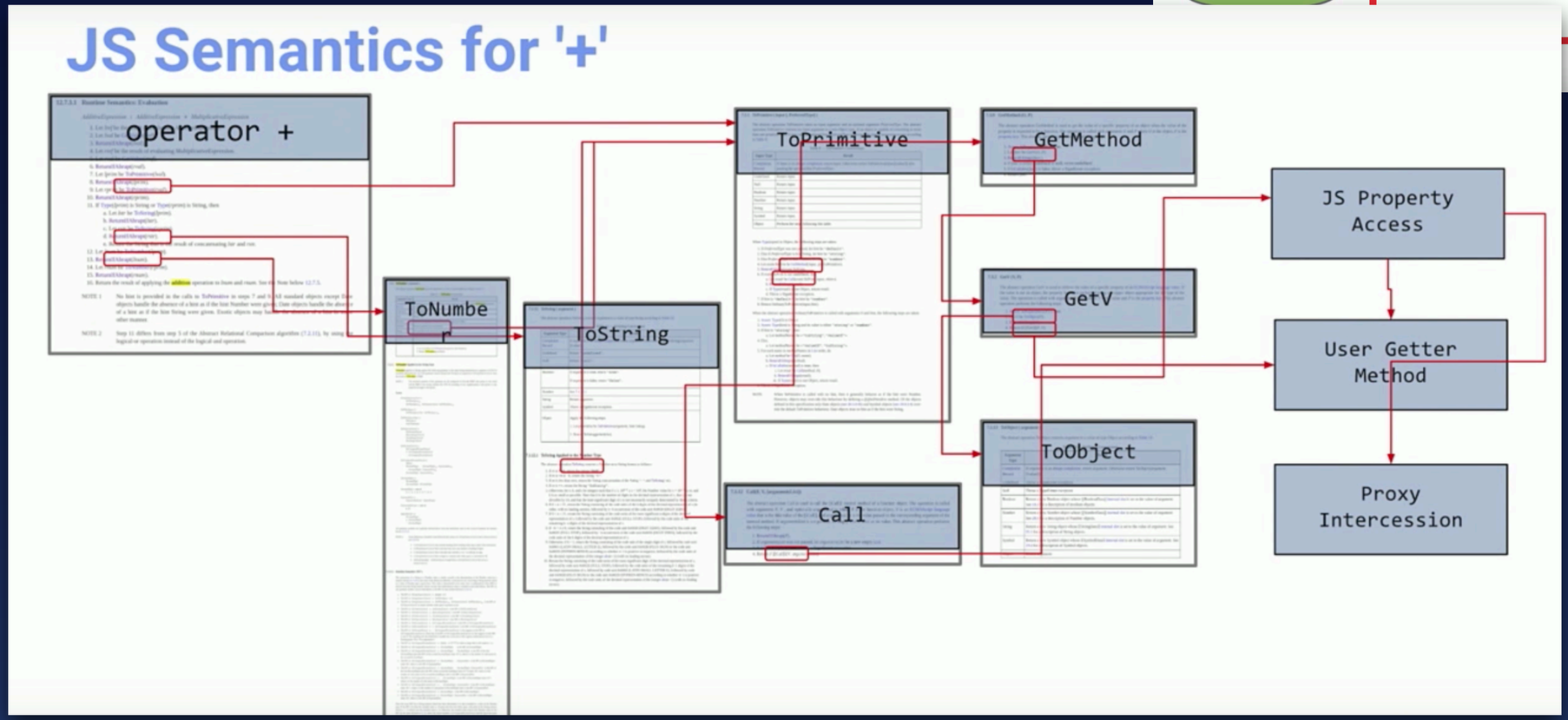
- WebAssembly 简短回顾（背景、原理）；
- 各大公司的 WebAssembly 线上实践；
- Roadmap & Milestone 发展规划；
- 未来可期的 - WASI；

Javascript 部分执行链路（V8）



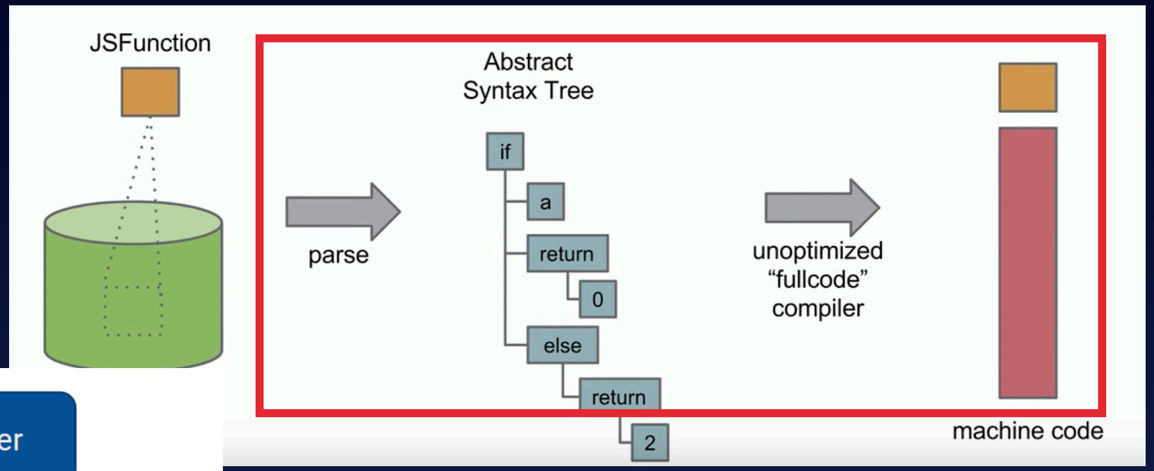
ECMA 规定的“+”执行流程





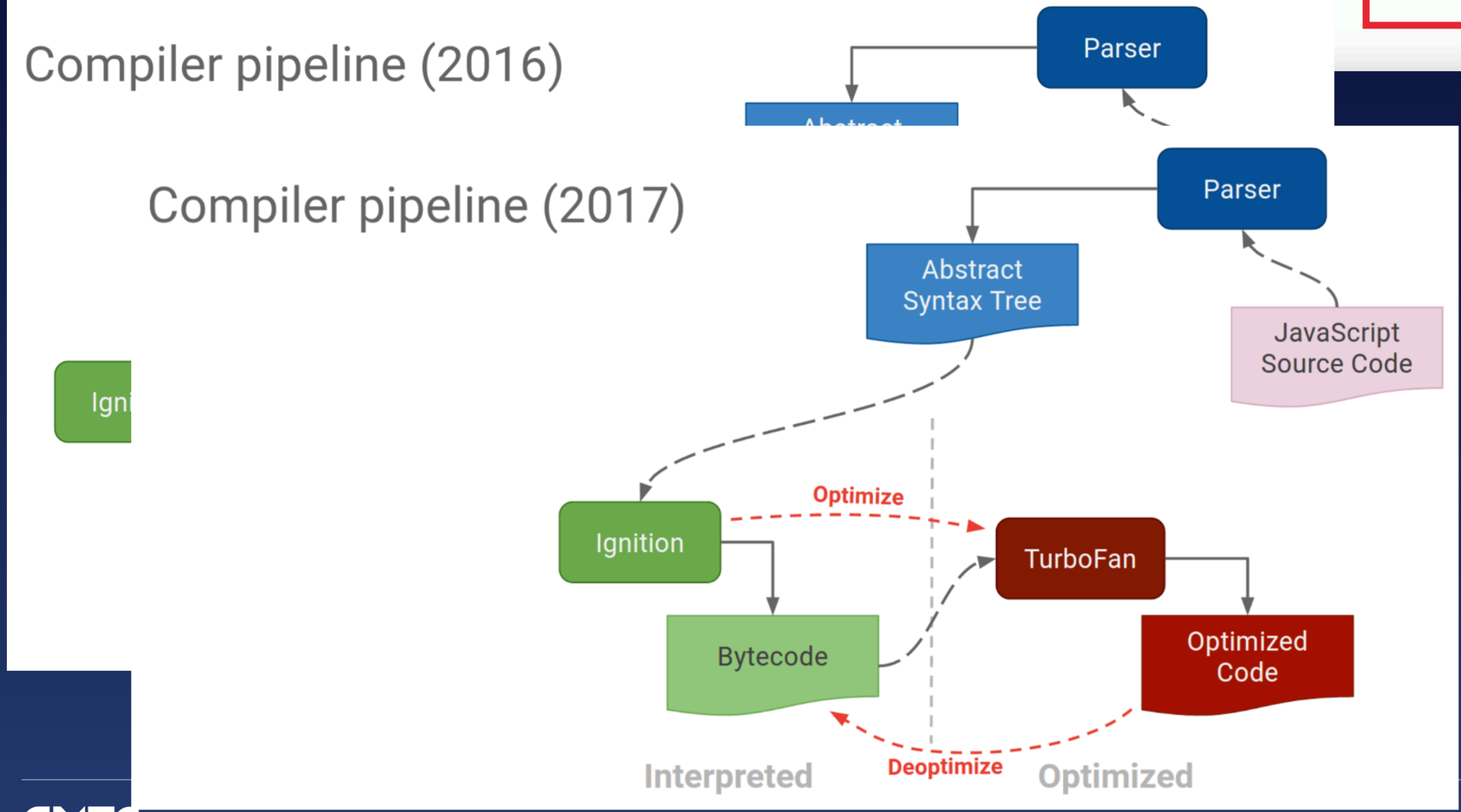
x + y

编译链路优化与问题（V8）



Compiler pipeline (2016)

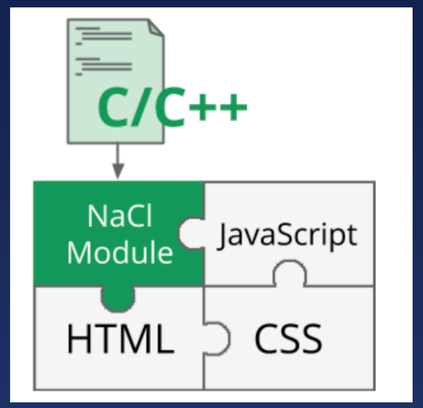
Compiler pipeline (2017)



曾经的尝试 - ASM.js & PNACL

```
function plusOne (x) {
    x = x|0; // x : int
    return (x + 1)|0;
}
```

- 是一种 JavaScript 严格子集；
- 通过 Annotation 的方式标注了变量的类型；
- 利于编译器的优化；



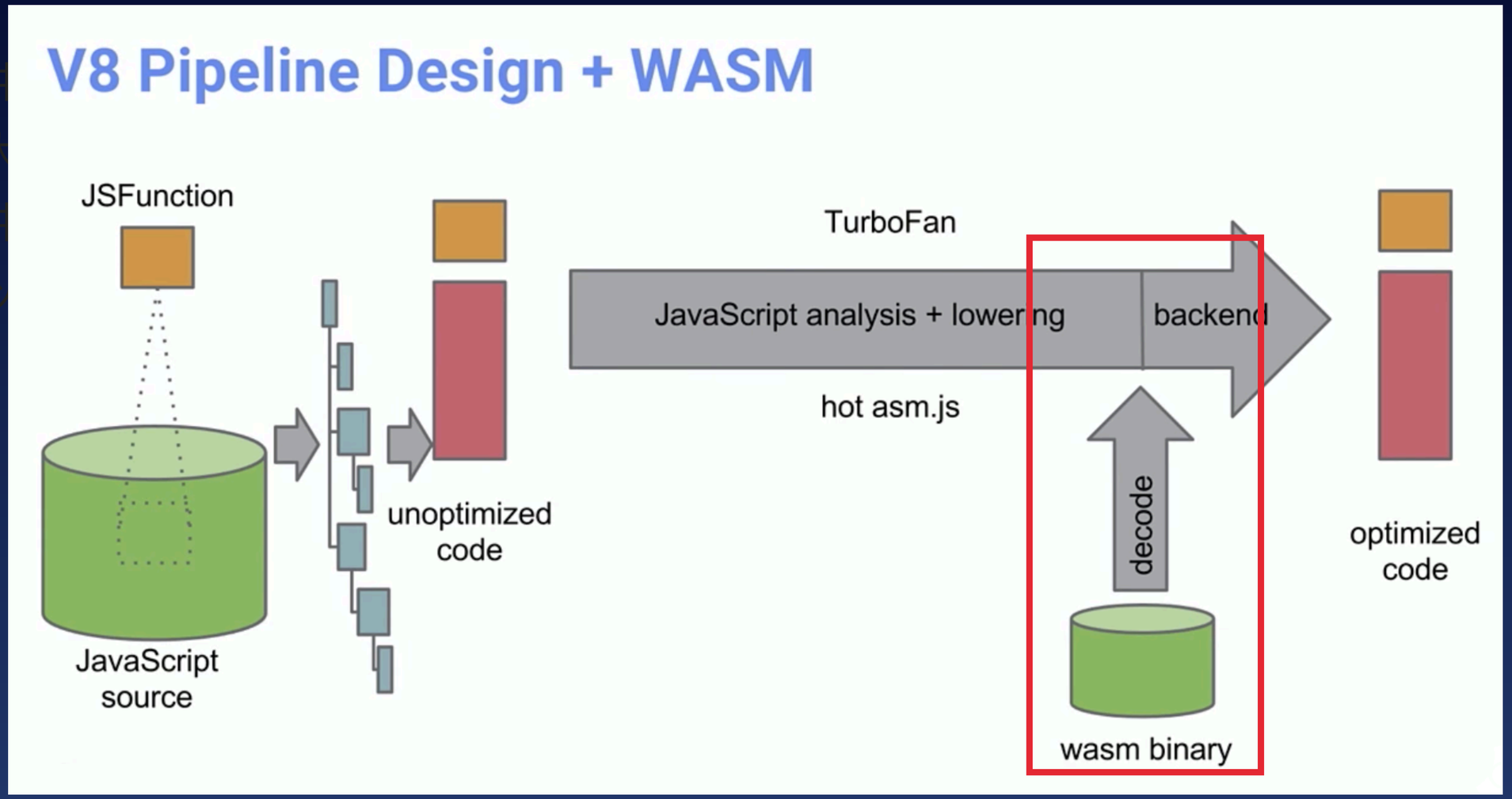
- 提供沙盒环境在浏览器中执行的 C/C++ 代码；
- 充分利用 CPU 的特性，如 SIMD、多核心处理等；
- 平台独立，一次编译到处运行；

新的方案 - WebAssembly

- 一种新的抽象虚拟机（W3C）标准；
- 四大浏览器已支持该标准 MVP 版本的所有特性；
- 一种以 .wasm 为后缀的二进制格式（0x6d736100）；
- 可以通过标准 Web API 接口在浏览器中加载、解析和运行；

```
➜  WasmPlay git:(master) ✗ hexdump -C program.wasm | head -n 5
00000000  00 61 73 6d 01 00 00 00  01 d3 80 80 80 00 0d 60  |.asm...........`|
00000010  03 7f 7f 7f 01 7f 60 00  00 60 04 7f 7f 7f 7f 00  |......`..`......|
00000020  60 06 7f 7f 7f 7f 7f 7f  00 60 05 7f 7f 7f 7f 7f  |`........`......|
00000030  00 60 01 7f 00 60 01 7f  01 7f 60 00 01 7f 60 02  |.`...`....`...`.|
00000040  7f 7f 01 7f 60 03 7f 7f  7f 00 60 02 7f 7f 00 60  |....`.....`....`|
```

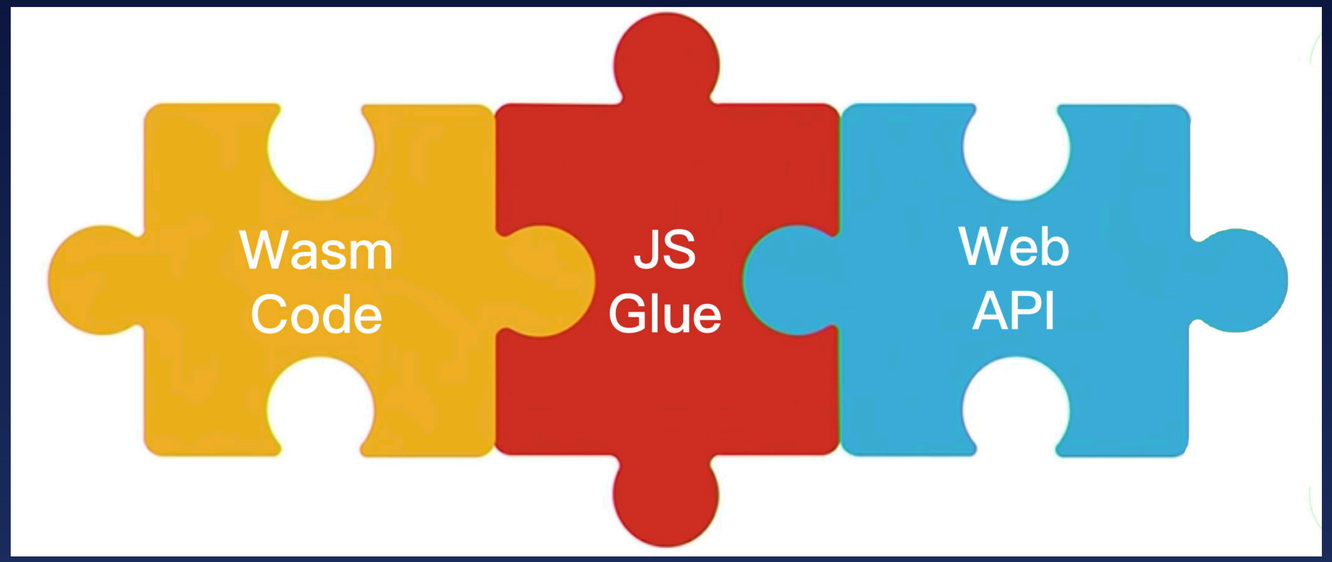
WebAssembly 编译完整链路



使用 Emscripten 构建 Wasm 应用

- *Virtual File System;*
- *Pthread;*
- *Linear Memory;*
- *…*

C/C++ Source Code



一个简单的例子-C++

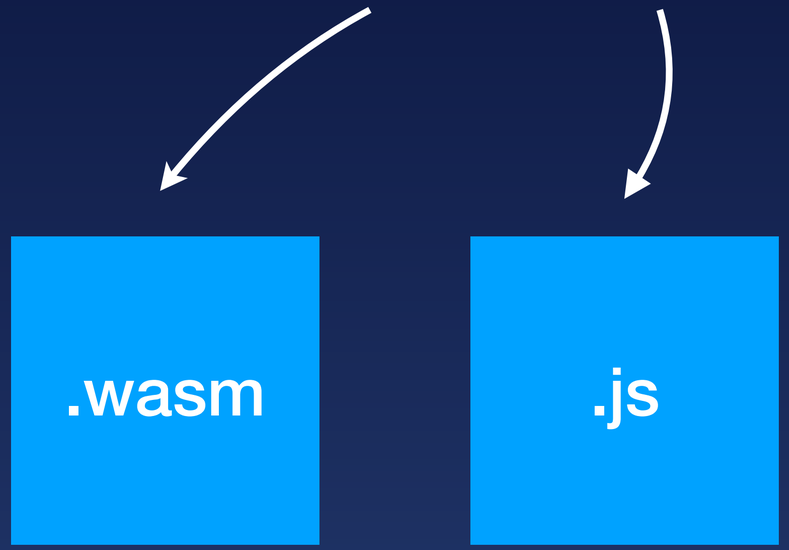
C++

toy.cc

```
#include "emscripten.h"
extern "C" {
    EMSCRIPTEN_KEEPALIVE int add(int x, int y) {
        return x + y;
    }
}
```

一个简单的例子-CLI

CLI `emcc toy.cc -s WASM=1 -O3 -o toy.js`



一个简单的例子-HTML

HTML

toy.html

```
<script>
 fetch('toy.wasm').then(response =>
   response.arrayBuffer()
 ).then(bytes =>
   WebAssembly.instantiate(bytes, {})
 ).then(result => {
   console.log(result.instance.exports['_add'](10, 20));
 });
</script>
```

实例化模块对象

一个简单的例子-WAT

WAT

toy.wasm

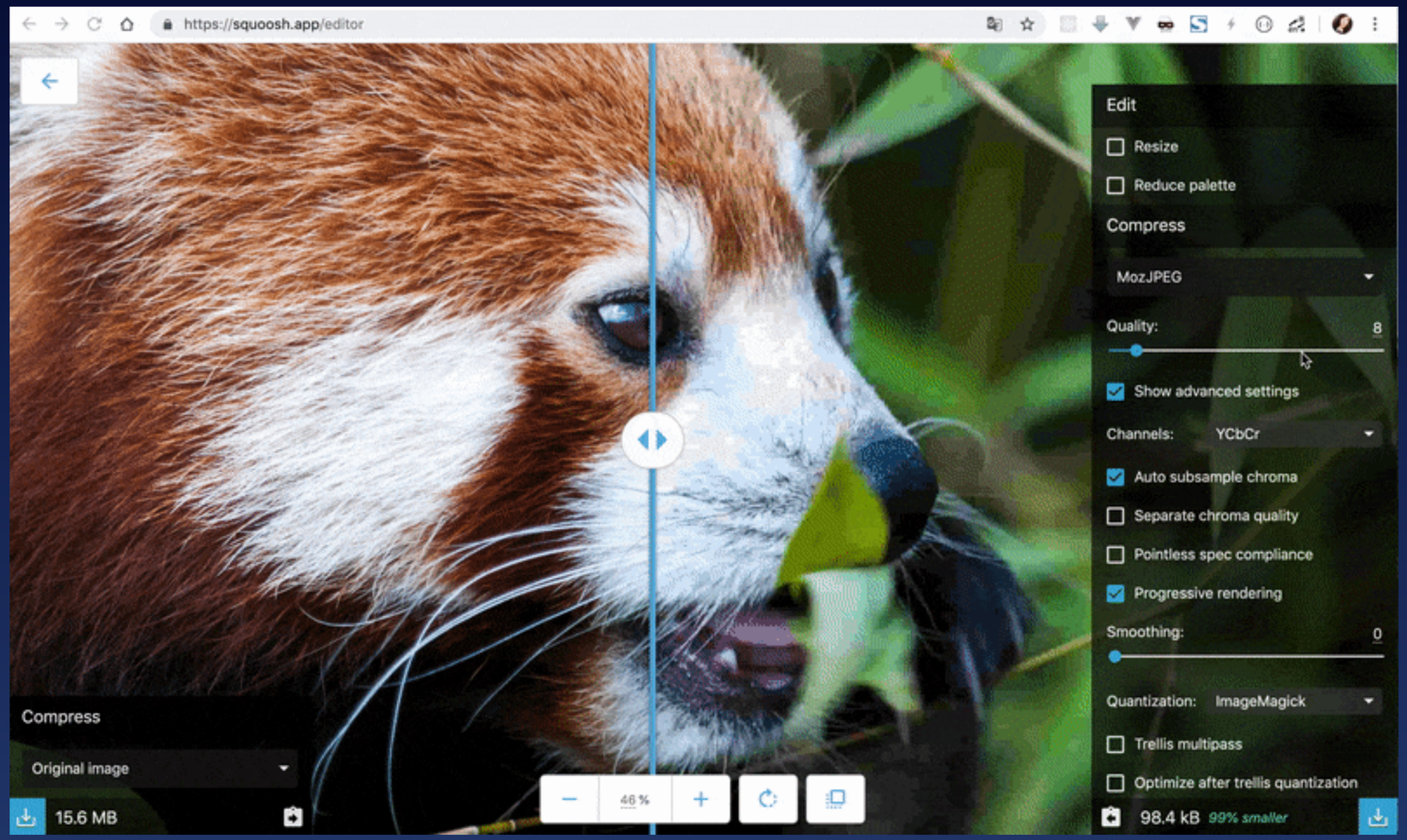
```
(module
  (type (;0;) (func (param i32 i32) (result i32)))
  (func (;0;) (type 0) (param i32 i32) (result i32)
    get_local 1
    get_local 0
    i32.add)
  (export "_add" (func 0)))
```

类型声明段

函数声明段

导出段

WASM 实际应用（一） - 在线图像处理 Squoosh

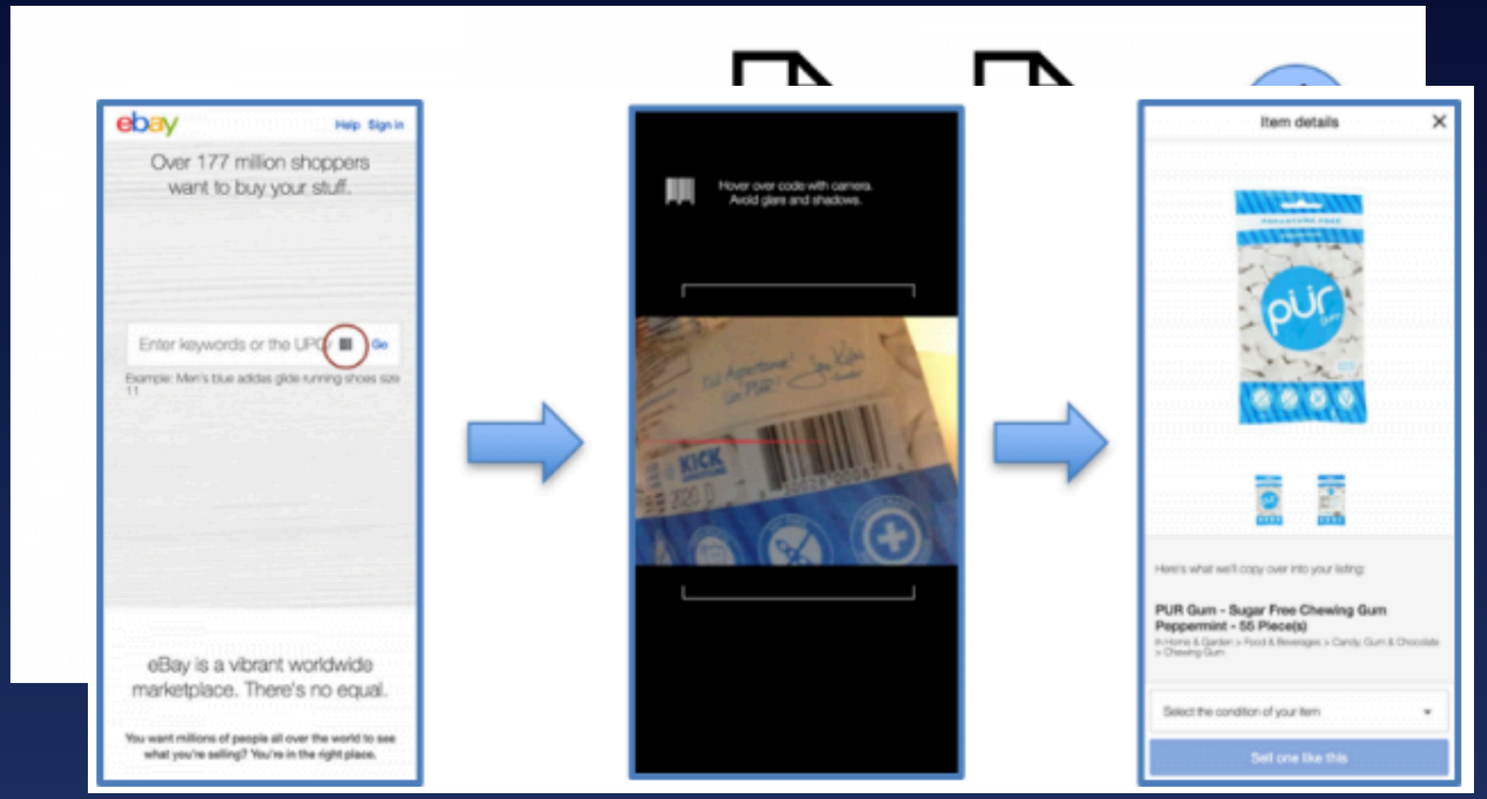


libimagequant (C)

MozJPEG (C++)

webp (C)

WASM 实际应用（二） - Ebay Barcode scanner



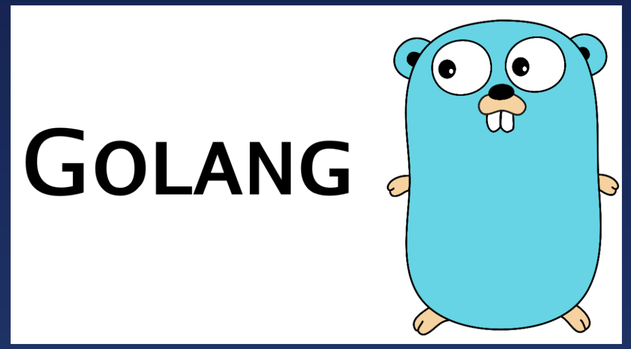
ZBar (C)

Custome Lib (C/C++)

BarcodeReader (JavaScript)

***三个 Worker 对应三种方案，依次竞争；**

Wasm 语言编译器 / 解释器



其他应用领域

- 视频/直播编解码；
- 在线图像/视频处理应用；
- 基于边缘计算的机器/深度学习：MXNet.js；
- 高性能 Web 游戏：Unity、Unreal、Ammo.js 等游戏库和引擎；
- 区块链 Ethereum 核心；
- 前端框架：sharpen、asm-dom、yew；
- IOT：wasmachine；

Wasm MVP 两个重点：

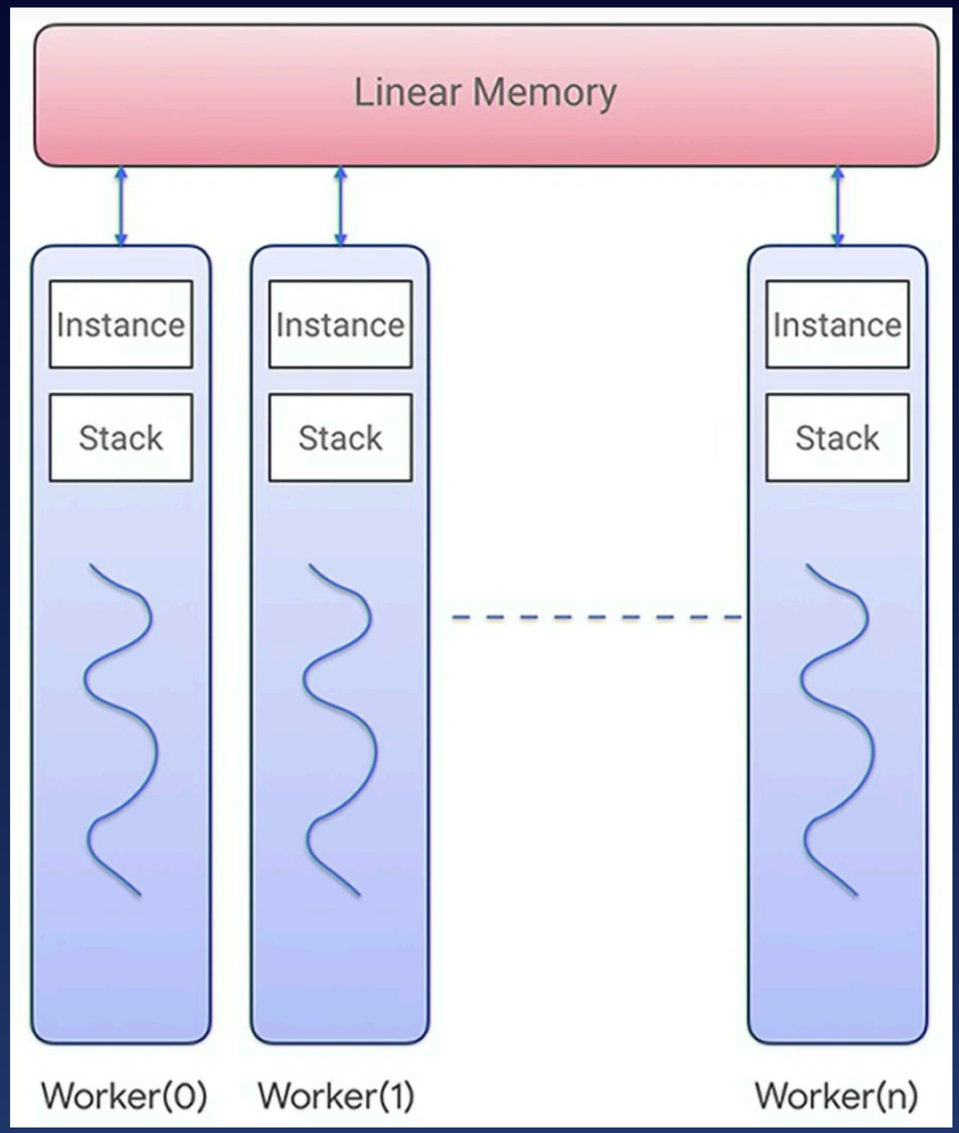
高性能计算

代码库复用

WebAssembly Post-MVP

WebAssembly Thread (Chrome74)

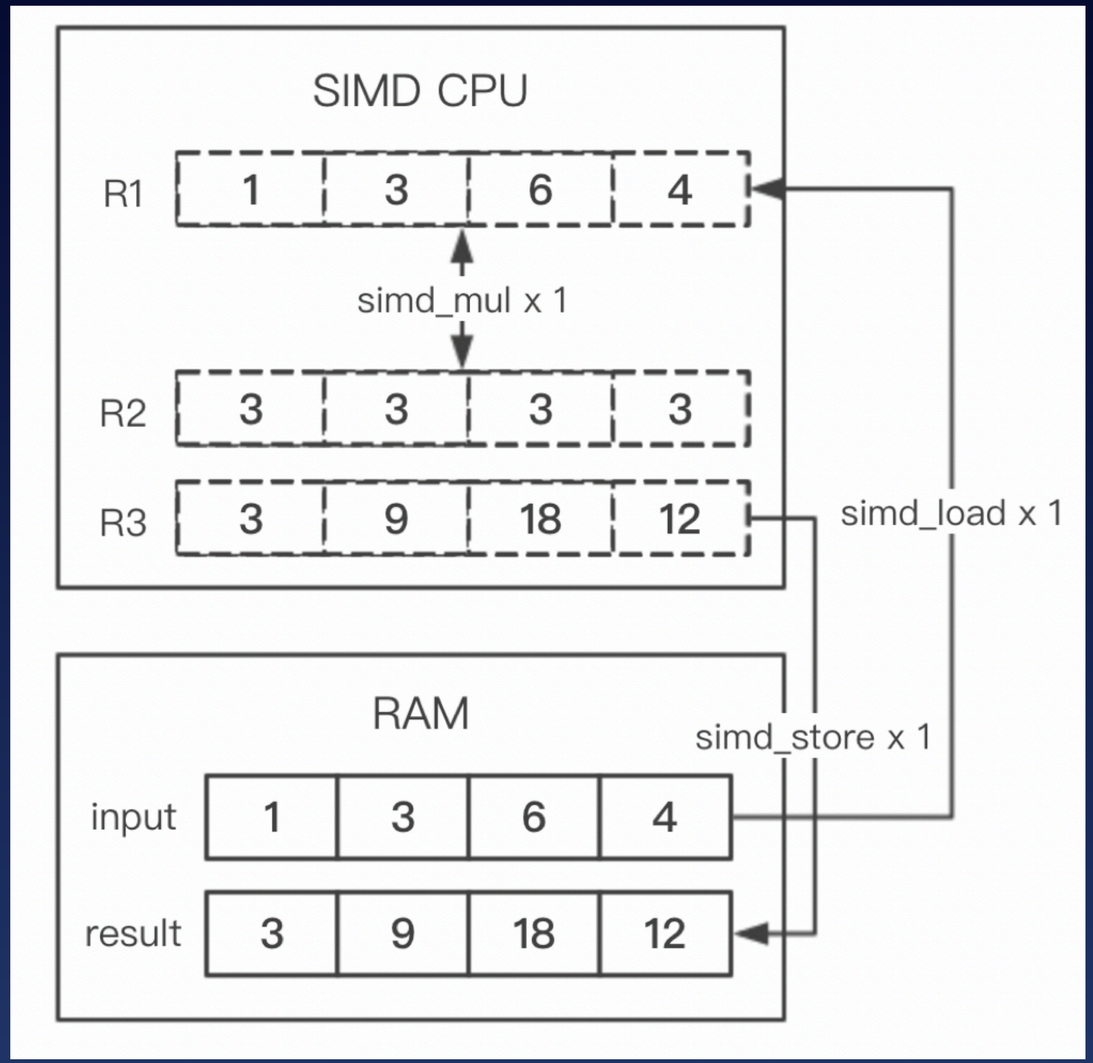
- i32.atomic.load8_u 等原子操作；
- i32.atomic.wait 可用于实现互斥锁；
- 可用于移植 Pthreads 多线程；
- SharedArrayBuffer 共享内存；



WebAssembly Post-MVP

WebAssembly 128-bit SIMD

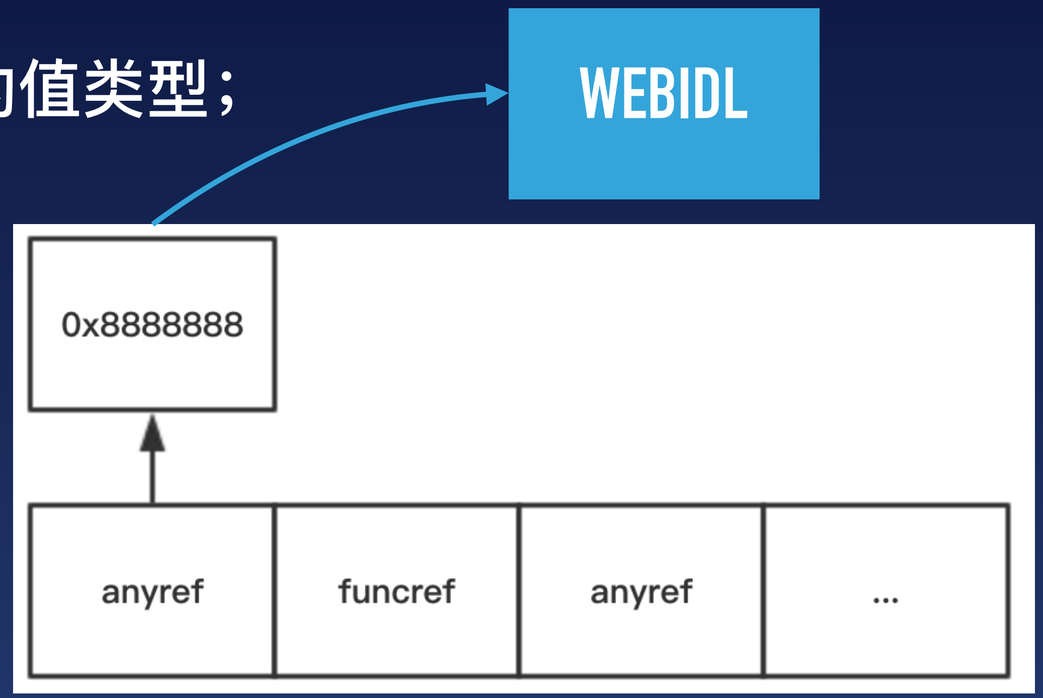
- 固定 128 位（bit）；
- i8x16.add(a: v128, b: v128) -> v128；



WebAssembly Post-MVP

Reference Types

- 新的 “anyref / funcref” 类型，用于引用宿主的值类型；
- 更好地与宿主（比如浏览器）进行交互；
- 所引用的值是不透明且抽象的；



WebAssembly Post-MVP

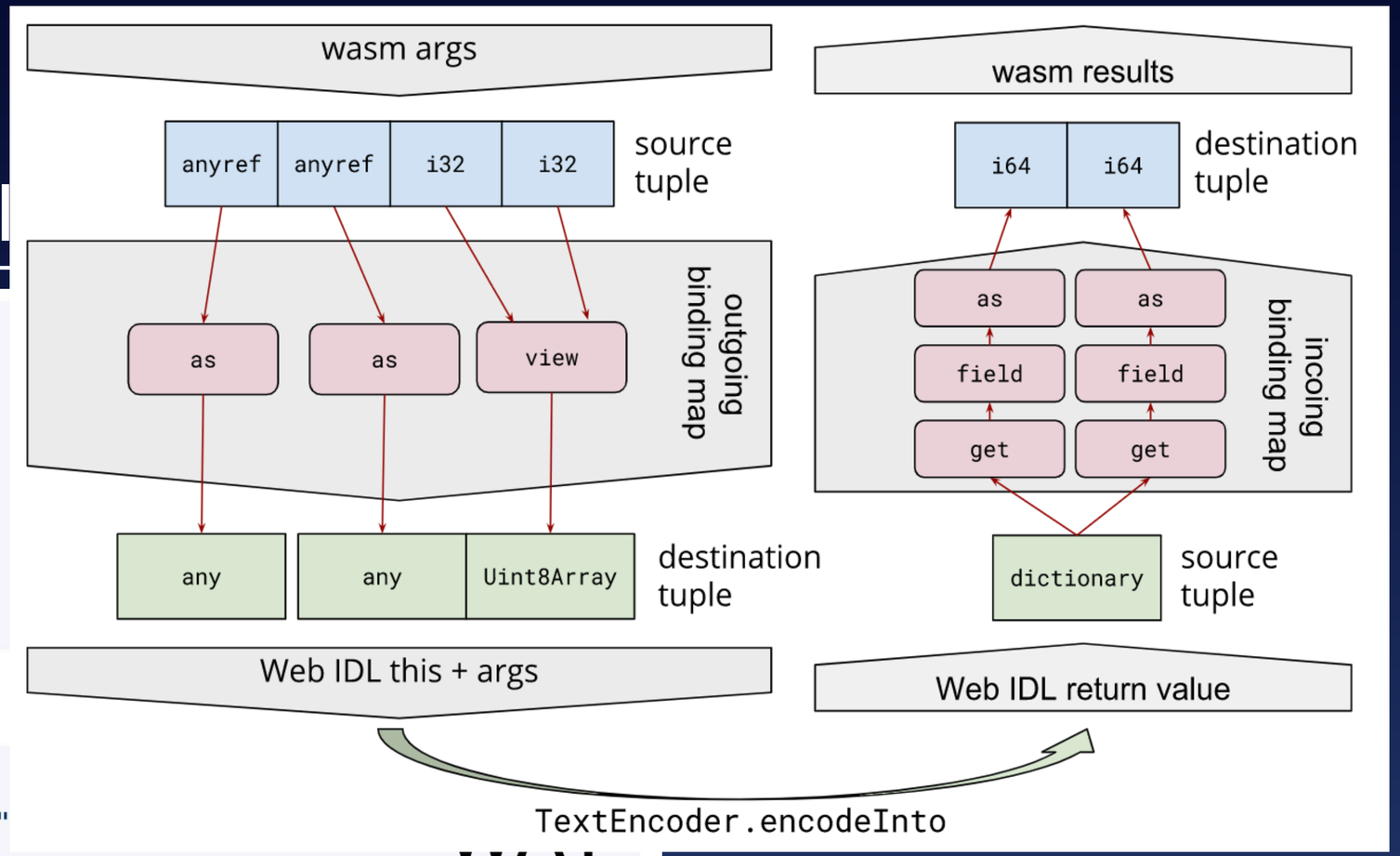
WebIDL Binding Proposal

```
dictionary TextEncoderEncodeIntoResult {
  unsigned long long read;
  unsigned long long written;
};

[Constructor]
interface TextEncoder {
  TextEncoderEncodeIntoResult encodeInto(USVString source,
};
```

TextEncoder.encodeInto

```
(@webidl type $TextEncoderEncodeIntoResult
   (dict (field "read" unsigned long long) (field "written"
(@webidl type $EncodeIntoFuncWebIDL
   (func (method any)
      (param USVString Uint8Array)
      (result (dict $TextEncoderEncodeIntoResult))))
```



WebAssembly Post-MVP

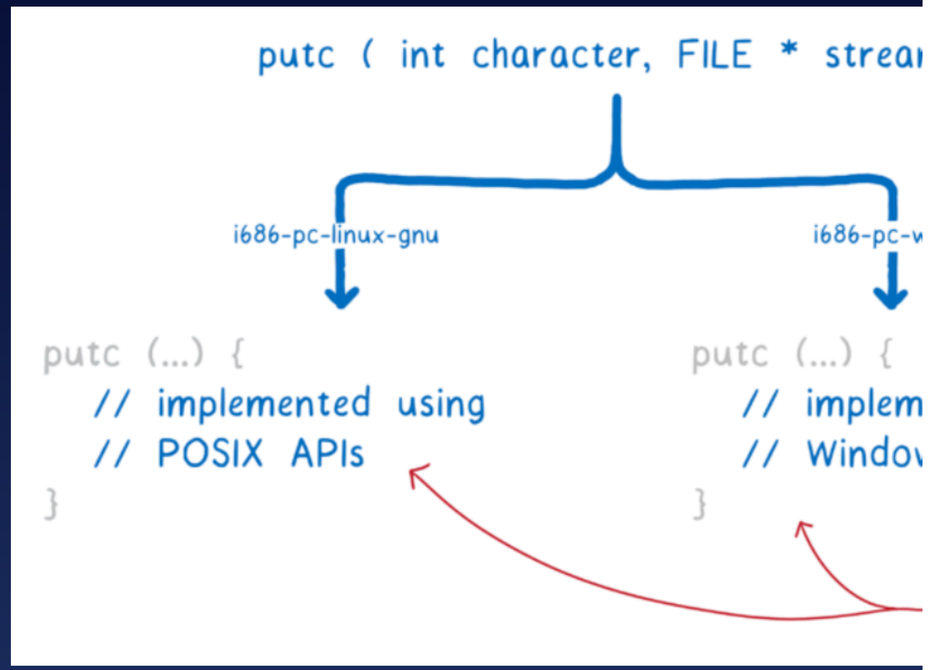
- Tail Call Optimization；
- Custom Annotation Syntax in the Text Format；
- Garbage collection；
- Exception handling；
- JavaScript BigInt to WebAssembly i64 integration；
- …

Wasm 虚拟机 - WASI

WASI

WebAssembly System Interface

传统接口抽象（musl）




```
6   FILE *fopen(const char *restrict filename, const char *restrict mode)
7   {
8           FILE *f;
9           int fd;
10          int flags;
11
12          /* Check for valid initial mode character */
13          if (!strchr("rwa", *mode)) {
14                  errno = EINVAL;
15                  return 0;
16          }
17
18          /* Compute the flags to pass to open() */
19          flags = __fmodeflags(mode);
20
21          fd = sys_open(filename, flags, 0666);
22          if (fd < 0) return 0;
23          if (flags & O_CLOEXEC)
24                  __syscall(SYS_fcntl, fd, F_SETFD, FD_CLOEXEC);
25
26          f = __fdopen(fd, mode);
27          if (f) return f;
28
29          __syscall(SYS_close, fd);
30          return 0;
31  }
```

System Calls

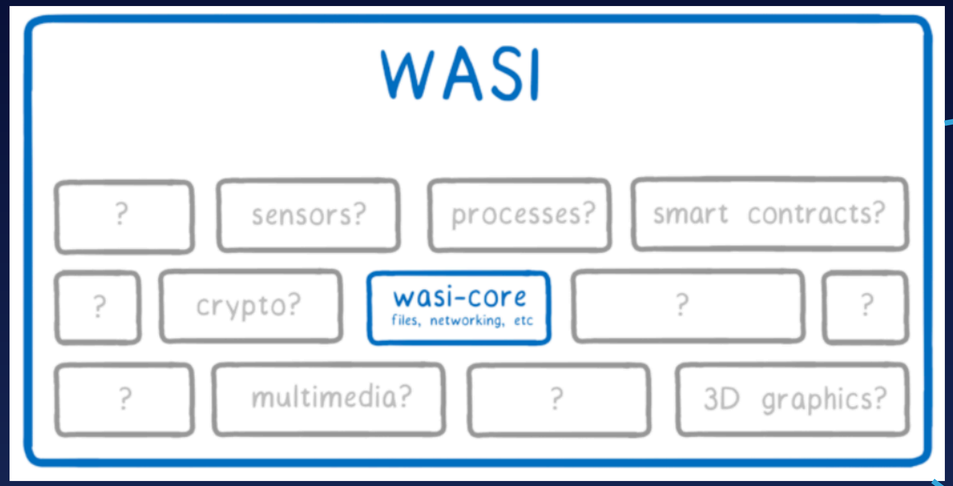
File / Socket / Memory / Pr

WASI - 接口抽象（wasi-libc）

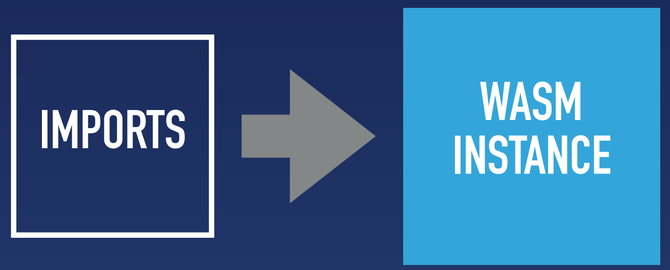
```
130  #else
131    __wasi_fdflags_t fs_flags = oflag & 0xfff;
132    __wasi_rights_t fs_rights_base = max & fsb_cur.fs_rights_inheriting;
133    __wasi_rights_t fs_rights_inheriting = fsb_cur.fs_rights_inheriting;
134    __wasi_fd_t newfd;
135    error = __wasi_path_open(fd, lookup_flags, path, strlen(path),
136                             (oflag >> 12) & 0xfff,
137                             fs_rights_base, fs_rights_inheriting, fs_flags,
138                             &newfd);
```

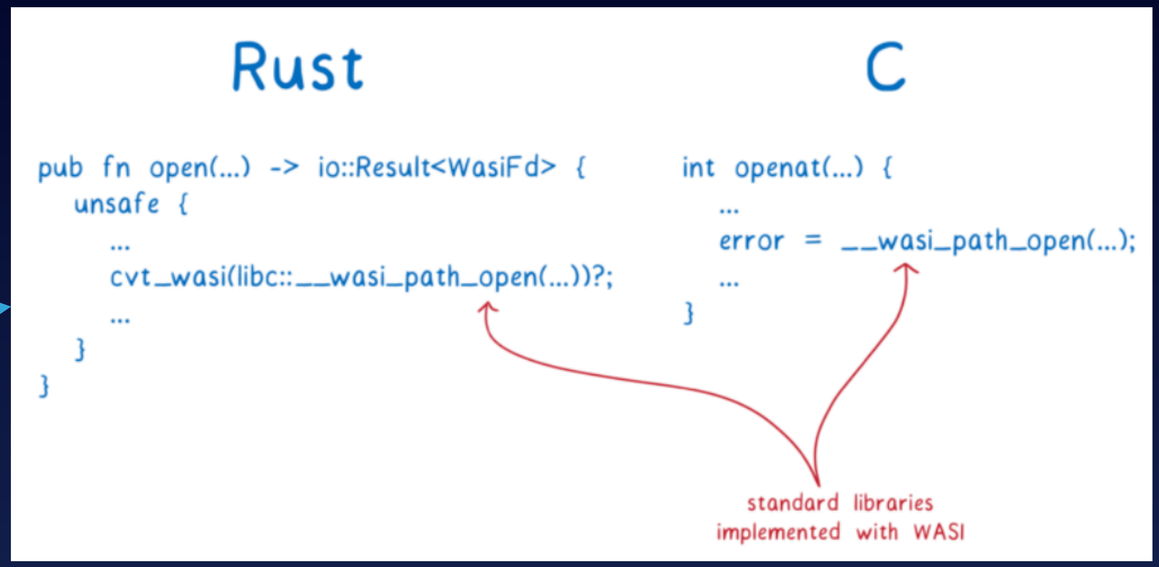
__wasi_* → WASI 标准

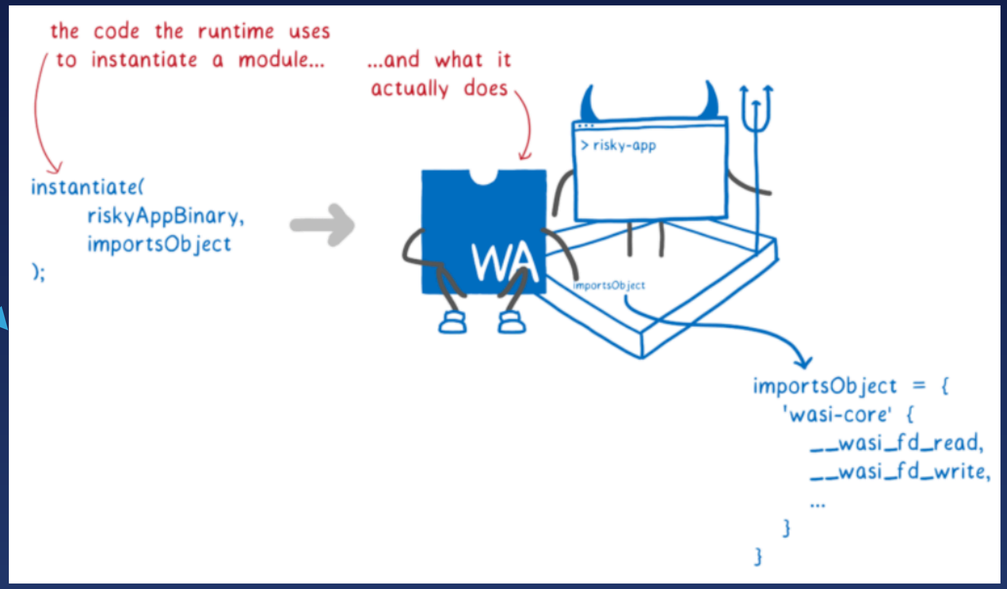
WASI - 接口调用关系



__wasi_path_open







WASI - 宿主实现细节

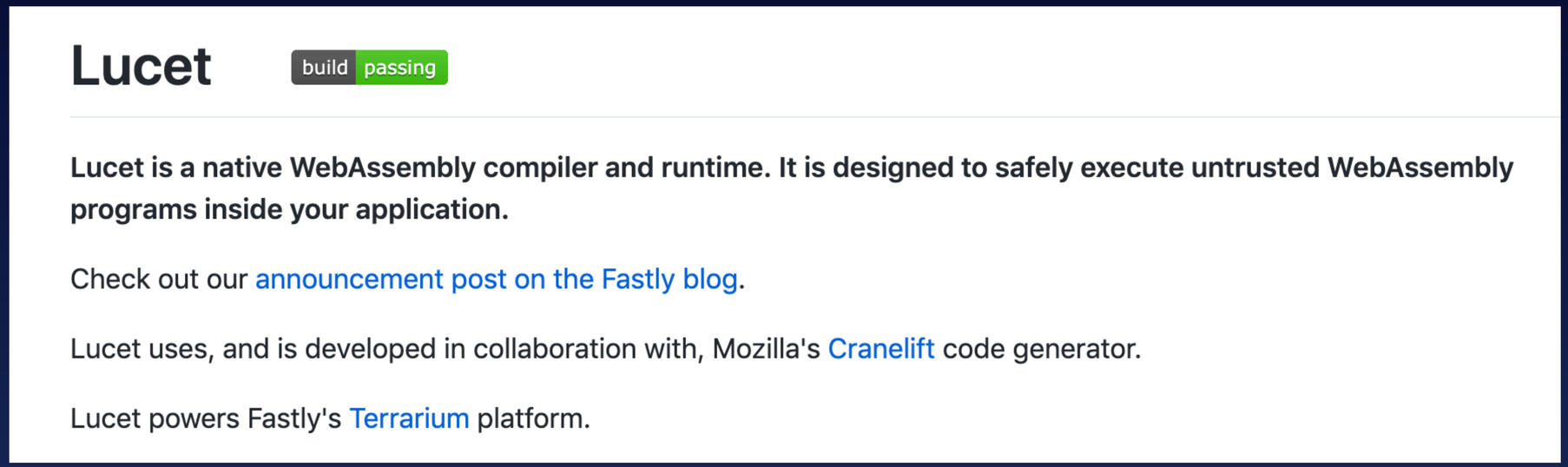
```c
__wasi_errno_t __wasi_path_open(
    __wasi_fd_t dirfd,
    __wasi_lookupflags_t dirflags,
    const char *path,
    size_t path_len,
    __wasi_oflags_t oflags,
    __wasi_rights_t fs_rights_base,
    __wasi_rights_t fs_rights_inheriting,
    __wasi_fdflags_t fs_flags,
    __wasi_fd_t *fd
) __WASI_SYSCALL_NAME(path_open) __attribute__((__warn_u
```

wasm-libc 函数定义

```rust
#[no_mangle] pub unsafe extern "C"
fn __wasi_path_open(
    &mut vmctx,
    dirfd: wasm32::__wasi_fd_t,
    dirflags: wasm32::__wasi_lookupflags_t,
    path_ptr: wasm32::uintptr_t,
    path_len: wasm32::size_t,
    oflags: wasm32::__wasi_oflags_t,
    fs_rights_base: wasm32::__wasi_rights_t,
    fs_rights_inheriting: wasm32::__wasi_rights_t,
    fs_flags: wasm32::__wasi_fdflags_t,
    fd_out_ptr: wasm32::uintptr_t,
) -> wasm32::__wasi_errno_t {
    wasi_path_open(vmctx, dirfd, dirflags, path_ptr, path_len,
        oflags, fs_rights_base, fs_rights_inheriting, fs_flags,
        fd_out_ptr)
}
```

Lucet 宿主函数实现（Rust）

WASI - Lucet 宿主实现



一个 WebAssembly Compiler

&& (WASI)

一个 WebAssembly Runtime

WASI - Lucet 一个例子 - C/C++

宿主依赖的

文件操作

```c
#include <stdio.h>
int main(int argc, char** argv) {
    FILE * file;
    if ((file = fopen("lucent-wasi", "w+"))) {
        fputs("Hello GMTC!\n", file);
    }
    return 0;
}
```

WASI - Lucet 一个例子 - 编译和运行

```
wasm32-unknown-wasi-clang hello.c -o hello.wasm

lucetc-wasi hello.wasm -o hello.so

lucet-wasi hello.so --dir .::
```

指定目录映射关系

WASI - Lucet 一个例子 - WAT 细节

```
(import "wasi_unstable" "fd_prestat_get" (func $__wasi_fd_prestat_get (type 2)))
(import "wasi_unstable" "fd_prestat_dir_name" (func $__wasi_fd_prestat_dir_name (type 0)))
(import "wasi_unstable" "environ_sizes_get" (func $__wasi_environ_sizes_get (type 2)))
(import "wasi_unstable" "environ_get" (func $__wasi_environ_get (type 2)))
(import "wasi_unstable" "args_sizes_get" (func $__wasi_args_sizes_get (type 2)))
(import "wasi_unstable" "args_get" (func $__wasi_args_get (type 2)))
(import "wasi_unstable" "proc_exit" (func $__wasi_proc_exit (type 3)))
(import "wasi_unstable" "fd_fdstat_get" (func $__wasi_fd_fdstat_get (type 2)))
(import "wasi_unstable" "path_open" (func $__wasi_path_open (type 4)))
(import "wasi_unstable" "fd_close" (func $__wasi_fd_close (type 5)))
(import "wasi_unstable" "fd_fdstat_set_flags" (func $__wasi_fd_fdstat_set_flags (type 2)))
(import "wasi_unstable" "fd_seek" (func $__wasi_fd_seek (type 6)))
(import "wasi_unstable" "fd_read" (func $__wasi_fd_read (type 7)))
(import "wasi_unstable" "fd_write" (func $__wasi_fd_write (type 7)))
(func $__wasm_call_ctors (type 8))
```

Wasm 总结建议

找到性能瓶颈，选择性使用

做好降级方案，保证可用性

Wasm 观望建议

持续加码，未来可期

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