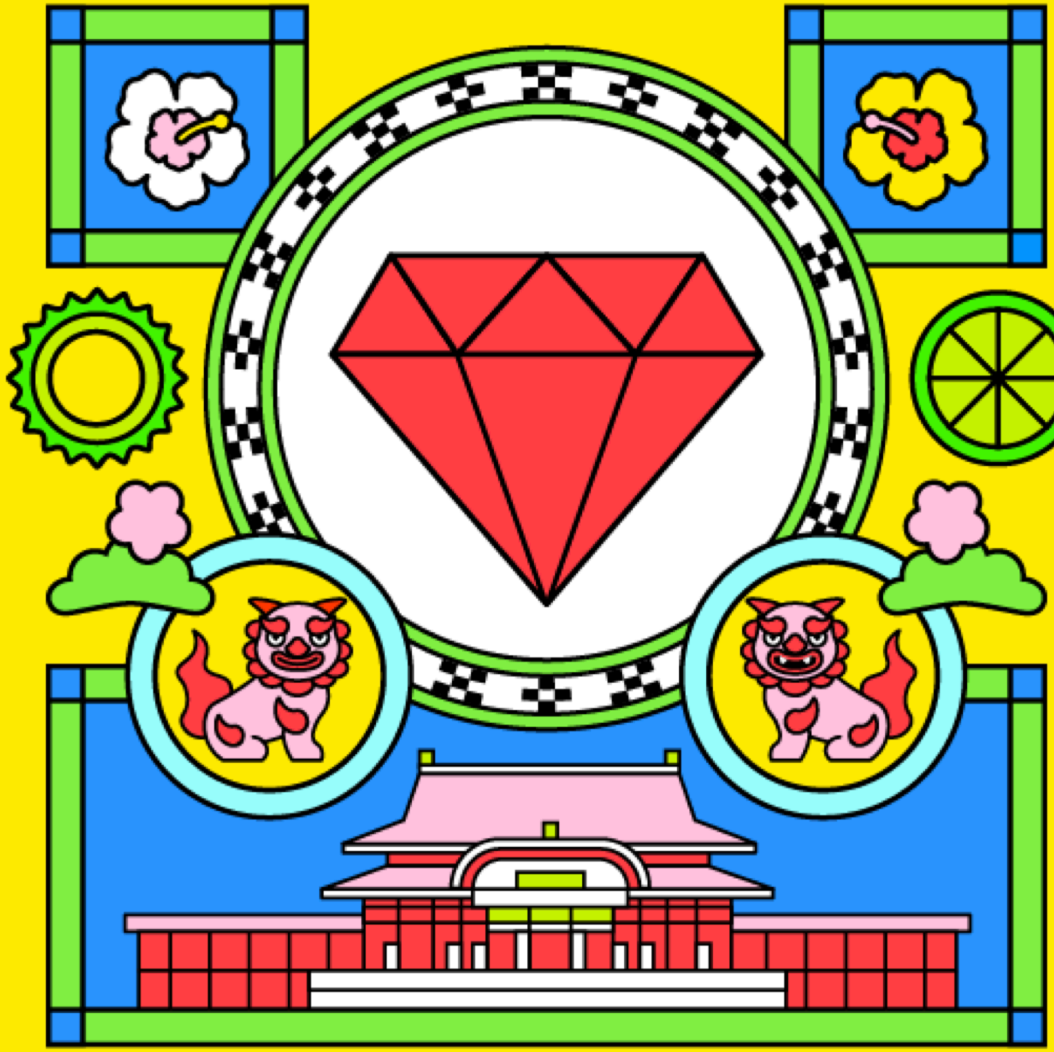
RubyKaigi 2024

MAY15-17
@NAHA,OKINAWA



An mruby for WebAssembly

Presentation by Uchio Kondo

RubyKaigi
2024 MAY15-17
@NAHA,OKINAWA

self.introduce!

- Uchio Kondo
  - from Fukuoka.rb
- Infra Engineer @ Mirrativ, Inc.
  - livestreaming & "live" gaming
- Translator of "Learning eBPF"

Ruby and WebAssembly

Code sample background rule:

```
Ruby.has :red, :background
```

```
(window.JavaScript || TypeScript).then("yellow");
```

```
Rust::<BackGround>::purple().unwrap();
```

```
other_lang { "Lua" = green.background, "and" = so.on }
```

Other code or command sample has default gray back

Ruby for WebAssembly(WASM)?

- It's `ruby.wasm`, You know.
- A CRuby(MRI) That is compiled into wasm
  - C-based code -> Ruby runtime on wasm
  - WASI support

Showing another approach

- 🌺 **mruby/edge** is yet another "Ruby on wasm"
- 🌺 It is a basically mruby
    - ✦ but specialized for WebAssembly use case

So, What is mruby/edge?

mruby/edge getting started

🌺 mruby/edge consists of 2 components

- mruby/edge "core" crate
- the `mec` command (**m**ruby/**e**dge **c**ompiler)
- Install `mec` first!

```
$ cargo install mec
```

Prepare "Plain Old" Ruby script

```ruby
# fib.rb
def fib(n)
  case n
  when 0
    0
  when 1..2
    2
  else
    fib(n - 1) + fib(n - 2)
  end
end
```

Prepare RBS file for fib()

```
# fib.export.rbs
def fib: (Integer) -> Integer
```

※ We have another option, but recommend to make this

Compile it into... WASM file

```
$ mec --no-wasi fib.rb
...
running: `cd .. && rm -rf work-mrubyedge-bhuxkrgcgOe5TAmDWFiMkgF5uVbnS9lR`
[ok] wasm file is generated: fib2.wasm

$ file fib.wasm
fib.wasm: WebAssembly (wasm) binary module version 0x1 (MVP)
```

Note that it has exported function `fib`

```
$ wasm-objdump -x -j Export ./fib.wasm

fib.wasm:       file format wasm 0x1
module name: <mywasm.wasm>

Section Details:

Export[3]:
 - memory[0] -> "memory"
 - func[417] <fib.command_export> -> "fib"
```

Then we can try it using (e.g.) wasmedge

```
$ wasmedge ./fib.wasm fib 15
610

$ wasmedge ./fib.wasm fib 20
6765
# ...
```

Can this WASM available on a browser?

prepare `wasm.html` including:

```
<script async type="text/javascript">
  window.fire = function(e) {
    WebAssembly.instantiateStreaming(fetch("./fib.wasm"), {}).then(function (o) {
      let value = document.getElementById("myValue").value;
      let answer = o.instance.exports.fib(parseInt(value));
      document.getElementById("myAnswer").value = answer;
  });};
</script>
```

A working demo on the slide

calc fib

fib(20) = ?

So with mruby/edge we can...

- Create a WASM file from Ruby script
- **Export** a specific "function" on that WASM
- In addition, we can specify **import functions**

Today, I will present you mruby/edge

- But before we understand mruby/edge, we have to have a graps with 2 technologies...
  - WebAssembly
  - ... and mruby!
- So let's start the journey together!

A Tour of WebAssembly

How do you know WebAssembly?

- 🌺 Browser-based something...
- 🌺 C++? or Rust? can be executed via WASM...
- 🌺 Ruby or Python can run on browser by magical WASM power...
- 🌺 Google meet? or Unity web games? or some cool contents

WebAssembly in a nutshell

- WebAssembly is a stack-based virtual machine
  - That can run its instructions on browser --
  - -- or *everywhere*

WebAssembly is used in:

- For example:
  - Browsers
  - Server-side programmes
  - Load Balancer Plugins, Containers, Supervisor
- … everywhere!

WebAssembly as a embedded config

e.g. some of middlewares supports wasm configuration

- envoy
- fluent-bit
- Open Policy Agent ...

envoy

fluentbit

Both browsers and servers

As we have seen, one wasm binary can be executed both on browser and on terminal:

environment	sample
Browser	fib(20) = 6765

Terminal	`[udzura] /opt/ghq/github.com/udzura/slides/rubykaigi2024`
	`(*'-') < wasmedge ./fib.wasm fib 20`
	`6765`

WASM's interface

- WASM can:
  - *export* its functions to outer libraries (as a normal sharedlibs)
  - *import* functions from outer world

How to import and export function

```ruby
# rk2024.rb
def runit(arg)
  answer = arg + 42
  show_answer(answer)
end
```

```
# rk2024.export.rbs
def runit: (Integer) -> void
```

```
# rk2024.import.rbs
def show_answer: (Integer) -> void
```

Setting up this in browser

```
// Will be imvoked via main()
function show_answer(ans) {
  console.log("answer = ", ans);
}
// Specify what func to import
const importObject = {
  env: {show_answer: show_answer}
};
WebAssembly.instantiateStreaming(fetch("./rk2024.wasm"), importObject).then(
  (obj) => {
    // Call exported main() after load, with arg 21
    obj.instance.exports.runit(21);
  },
);
```

The result:

Note: modified version

Show anwser?

??

One more step into WebAssembly

WebAssembly is a binary with laid-out info

- magic: `0x00 0x61 0x73 0x6D`
- version: `0x01 0x00 0x00 0x00` (for v1)
- sections:
  - Known sections: type, import, function, table, memoty, export...
    - 12 kinds
  - Custom sections

Kind of WASM known sections (excerpt.) 1/2:

name	description
Type	Function signatures to use in wasm
Function	Function declaretions
Memory	Linear-memory descriptions
Global	Global declarations

Kind of WASM known sections (excerpt.) 2/2:

name	description
Export	Name of exports(functions, memory, globals...)
Import	Module and function names to import
Code	Bodies of functions
Data	Data initializers that will be loaded into the linear memory

Inspecting WASM code as WAT format:

```
$ wasm-objdump -d ./fib.wasm | less
...
0006ad func[12] <fib>:
 0006ae: 03 7f                      | local[2..4] type=i32
 0006b0: 01 7c                      | local[5] type=f64
 0006b2: 23 80 80 80 80 00          | global.get 0 <__stack_pointer>
 0006b8: 41 b0 02                   | i32.const 304
 0006bb: 6b                         | i32.sub
 0006bc: 22 01                      | local.tee 1
 0006be: 24 80 80 80 80 00          | global.set 0 <__stack_pointer>
 0006c4: 20 01                      | local.get 1
 0006c6: 41 38                      | i32.const 56
 0006c8: 6a                         | i32.add
 0006c9: 41 ff 80 c0 80 00          | i32.const 1048703
 0006cf: 41 83 02                   | i32.const 259
 0006d2: 10 a3 81 80 80 00          | call 163 <_ZN9mrubyedge4rite4rite4load17h9f737249e845f4b1E>
```

How to check "exported" `fib` signature

Check Type section, Function section

```
$ wasm-objdump -x -j Function ./fib.wasm | grep fib
 - func[12] sig=2 <fib>

$ wasm-objdump -x -j Type ./fib.wasm
Type[23]:
 - type[0] (i32, i32) -> nil
 - type[1] (i32, i32, i32) -> i64
 - type[2] (i32) -> i32
 # => Here's fib(i32) -> i32 !
 - type[3] (i32, i32, i32) -> i32
 ...
```

WASI (in preview1)

What is WASI

- An interface to "system" functionalities for WASM
- Accessing file, socket, randomness …
  - or raise/exit process thread, …
- Allow WASM programs to run on systems as usual middlewares

What is WASI in practice

Bunch of functions to "import"

```
$ mec fib.rb
$ wasm-objdump -x -j Import ./fib.wasm
...
Import[5]:
 - func[0] sig=7 <_ZN4wasi13lib_...> <- wasi_snapshot_preview1.fd_write
 - func[1] sig=5 <_ZN4wasi13lib_...> <- wasi_snapshot_preview1.random_get
 - func[2] sig=5 <__imported_wasi_...> <- wasi_snapshot_preview1.environ_get
 - func[3] sig=5 <__imported_wasi_...> <- wasi_snapshot_preview1.environ_sizes_get
 - func[4] sig=4 <__imported_wasi_...> <- wasi_snapshot_preview1.proc_exit
```

c.f. They're very like system calls:

- fd_write
  - `write(2)`
- random_get
  - `getrandom(2)`
- proc_exit
  - `_exit(2)` …

When you want to stub WASI…

🌺 Delve into bjorn3/browser_wasi_shim for example

```
let args = ["bin", "arg1", "arg2"]; //...
let wasi = new WASI(args, _env, _fds);
let wasm = await WebAssembly.compileStreaming(fetch("bin.wasm"));
let inst = await WebAssembly.instantiate(wasm, {
  // Here specifies the import object
  "wasi_snapshot_preview1": wasi.wasiImport,
});
wasi.start(inst);
```

More concrete examples

Delve into browser_wasi_shim for example

```
// NOTE: time is a pointer to feed result back
clock_time_get(id: number, precision: bigint, time: number): number {
  const buffer = new DataView(self.inst.exports.memory.buffer);
    if (id === wasi.CLOCKID_REALTIME) {
      buffer.setBigUint64(
        time,
        BigInt(new Date().getTime()) * 1_000_000n,
        true,
      );
    } else ...
  ...
  return 0
}
```

Sample use of "random"

```ruby
def test_random
  Random.rand(10)
end
```

```
$ mec random.rb
$ wasm-objdump -x ./random.wasm
...
Export[3]:
 - func[430] <test_random.command_export> -> "test_random"
...
Import[5]:
 - func[0] sig=5 <_ZN4wasi13lib_generated...> <- wasi_snapshot_preview1.random_get
 - func[1] ...
```

Prepare "random" on browser WASI

```
const wasiImport = {
  random_get: function(buf, buf_len) {
    let buffer8 = new Uint8Array(
      window.mywasm.exports.memory.buffer
    ).subarray(buf, buf + buf_len);
    for (let i = 0; i < buf_len; i++) {
      buffer8[i] = (Math.random() * 256) | 0;
    }
  },...};
const importObject = {"wasi_snapshot_preview1": wasiImport};
WebAssembly.instantiateStreaming(fetch("./random.wasm"), importObject).then(
  (obj) => { window.mywasm = obj.instance;
    for( var i = 0; i < 10; i++ ) {
      console.log("getrandom = ", window.mywasm.exports.test_random());
    }}
)
```

Result of "random" on browser WASI

Result of function invocation is at random:

```
getrandom = 5
getrandom = 9
getrandom = 1
getrandom = 6
getrandom = 9
getrandom = 1
getrandom = 5
getrandom = 2
getrandom = 1
getrandom = 6
```

The mruby VM

What do you know about VMs?

- The rest of the tour is about **mruby**'s **VM**
- But, what do you know abour mruby?
- ...And what the heck is "VM"s?

VM in a nutshell

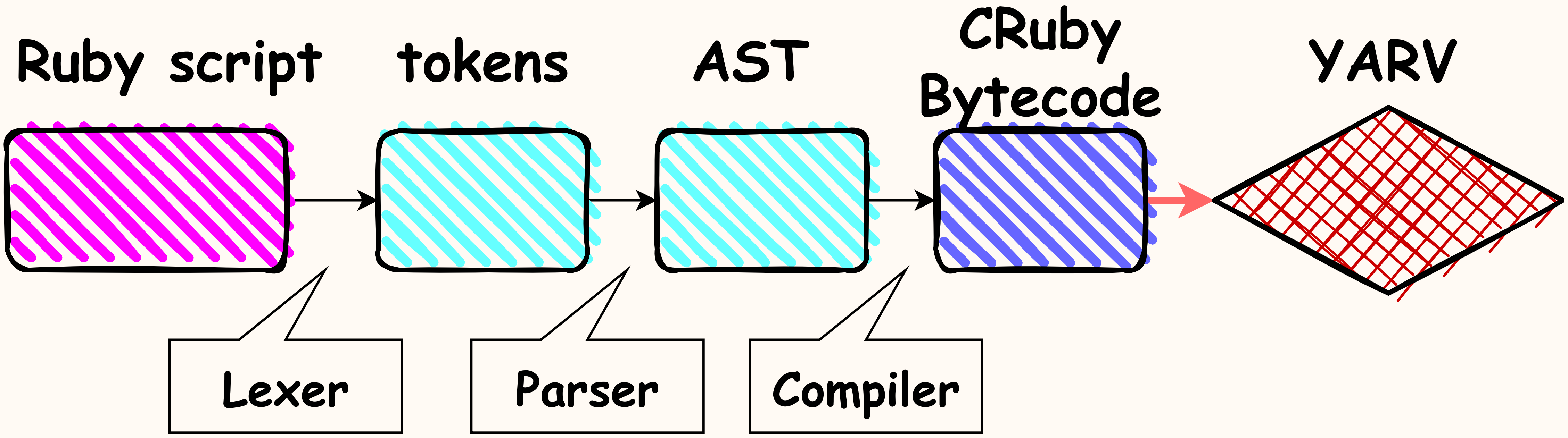
First, let's take a tour of VMs

- Some language has its VM
  - Java
  - Erlang / BEAM
  - Python, Lua...

CRuby's VM

- 🌺 CRuby has a stack machine VM since 1.9
- 🌺 So-called **YARV**

How CRuby works (simplified)



How to check CRuby insn:

🌺 Use `--dump=insns` to check "compiled" instructions:

```
# def hello; p 1 + 2; end
$ ruby --dump=insns test.rb
== disasm: #<ISeq:<main>@test.rb:1 (1,0)-(5,5)> (catch: FALSE)
0000 definemethod                           :hello, hello             (   1)[Li]
0003 putself                                                          (   5)[Li]
0004 opt_send_without_block                 <calldata!mid:hello, argc:0, FCALL|VCALL|ARGS_SIMPLE>
0006 leave

== disasm: #<ISeq:hello@test.rb:1 (1,0)-(3,3)> (catch: FALSE)
0000 putself                                                          (   2)[LiCa]
0001 putobject_INT2FIX_1_
0002 putobject                              2
0004 opt_plus                               <calldata!mid:+, argc:1, ARGS_SIMPLE>[CcCr]
0006 opt_send_without_block                 <calldata!mid:p, argc:1, FCALL|ARGS_SIMPLE>
0008 leave                                                            (   3)[Re]
```

Read the insns:

`0001 putobject_INT2FIX_1_`

- Putting `1`

`0002 putobject  2`

- Putting `2`

`0004 opt_plus`

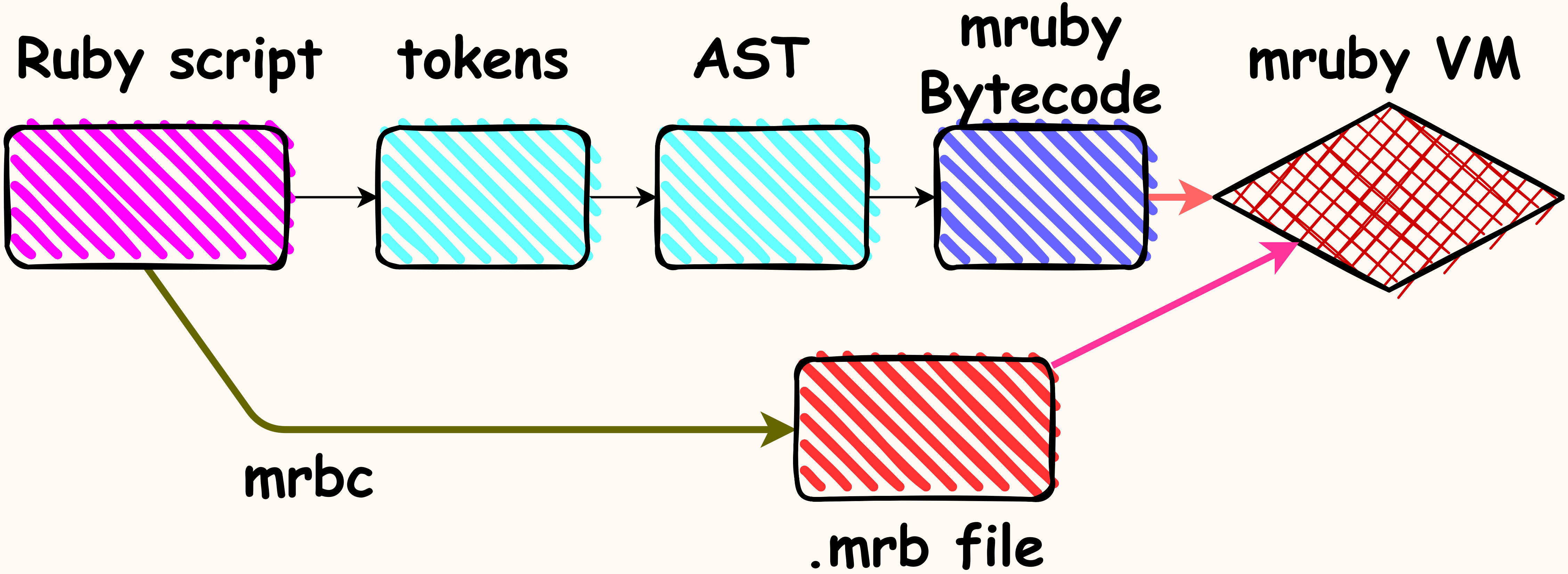
- Execute plus over `1 2` on stack
- then put result `3` back to stack

mruby in a nutshell

Describe mruby in short words

- One of Ruby implementations
  - Another approach to "Enjoy Programming" by Matz
- Features:
  - Register-based *VM* and bytecode
  - Smaller footprint
  - Composable runtime library...

... And mruby has its VM, too



How to dump mruby's instruction

```
$ mrbc -v test.rb     # ...snip
irep 0x60000080c0a0 nregs=3 nlocals=1 pools=0 syms=1 reps=1 ilen=15
file: test.rb
    1 000 TCLASS        R1
    1 002 METHOD        R2      I(0:0x60000080c0f0)
    1 005 DEF           R1      :hello
    5 008 SSEND         R1      :hello  n=0
    5 012 RETURN        R1
    5 014 STOP
irep 0x60000080c0f0 nregs=6 nlocals=2 pools=0 syms=1 reps=0 ilen=12
file: test.rb
    1 000 ENTER         0:0:0:0:0:0:0 (0x0)
    2 004 LOADI_3       R3      (3)
    2 006 SSEND         R2      :p      n=1
    2 010 RETURN        R2
```

c.f. Lua's VM

🌺 Lua's compiles inst set can be checked via `-l` flag

```lua
function hello(a, b)
  print(a + b)
end

hello(3, 5)
```

```
$ luac -l sample.lua
```

Dump of Lua's instruction

```
main <sample.lua:0,0> (8 instructions at 0x600000604000)
0+ params, 3 slots, 1 upvalue, 0 locals, 1 constant, 1 function
        1       [1]     VARARGPREP      0
        2       [3]     CLOSURE         0 0     ; 0x600000604080
        3       [1]     SETTABUP        0 0 0   ; _ENV "hello"
        4       [5]     GETTABUP        0 0 0   ; _ENV "hello"
        5       [5]     LOADI           1 3
        6       [5]     LOADI           2 5
        7       [5]     CALL            0 3 1   ; 2 in 0 out
        8       [5]     RETURN          0 1 1   ; 0 out
function <sample.lua:1,3> (5 instructions at 0x600000604080)
2 params, 4 slots, 1 upvalue, 2 locals, 1 constant, 0 functions
        1       [2]     GETTABUP        2 0 0   ; _ENV "print"
        2       [2]     ADD             3 0 1
        3       [2]     MMBIN           0 1 6   ; __add
        4       [2]     CALL            2 2 1   ; 1 in 0 out
        5       [3]     RETURN0
```

Difference between `{C,m}ruby`

- VM architecture
  - CRuby: stack-based machine
  - mruby: register-based machine
- mruby: Portable bytecode by default
  - mruby can handle compiled bytecode in first class
  - VM and bytecode can be combined into "one binary"

What is happy with a VM?

- Many merits
  - ✦ Tuning points
  - ✦ Cross-runtime portability
- Today focus on Cross-runtime

Do you know mruby/c ?

- Yet another... "mruby" for microcontrollers
  - ✦ First developed by Dr. Tanaka at Kyushu Institute of Technology
  - ✦ For use in limited environments such as ROS
  - ✦ Developed under support of Fukuoka Pref. and Shimane Pref. in Japan

mruby/c can also handle mruby's bytecode

```
$ git clone https://github.com/mrubyc/mrubyc.git
$ cd mrubyc
$ make mrubyc_bin
$ ./sample_c/sample_scheduler
Usage: ./sample_c/sample_scheduler <xxxx.mrb>
```

```
$ mrbc ./test.rb
$ # generated ./test.mrb
...
$ # result of `p 1 + 2`
$ ./sample_c/sample_no_scheduler ./test.mrb
3
```

FYI: PicoRuby uses mruby/c

- 🌺 Your keyboards can be on mruby VM

As you can imagine from the name…

- mruby/edge also accepts **mruby bytecode**!
- The next story is about how mruby/edge uses mruby bytecode

mruby/edge in Depth

mruby/edge also a mruby-compat VM

- Designed and specialized for running on WebAssembly
- 2 components
  - mruby/edge : Core VM to eval mruby bytecode
  - `mec` : The mruby/edge compiler cli

What is good in mruby/edge?

- 1: Binary size
  - ruby.wasm (Ruby 3.3.1): 18 MB
    - With all dependencies (w/o deps ~ 8 MB)
  - fib.wasm: (mec 0.3.1/mre 0.1.5) 174 KB
    - But it omits basic features of Ruby...

```
$ ls -l fib.wasm
-rwxr-xr-x  1 udzura  staff  178080  5 12 20:20 fib.wasm
```

What is good in mruby/edge?

2: First-class support of function import/export

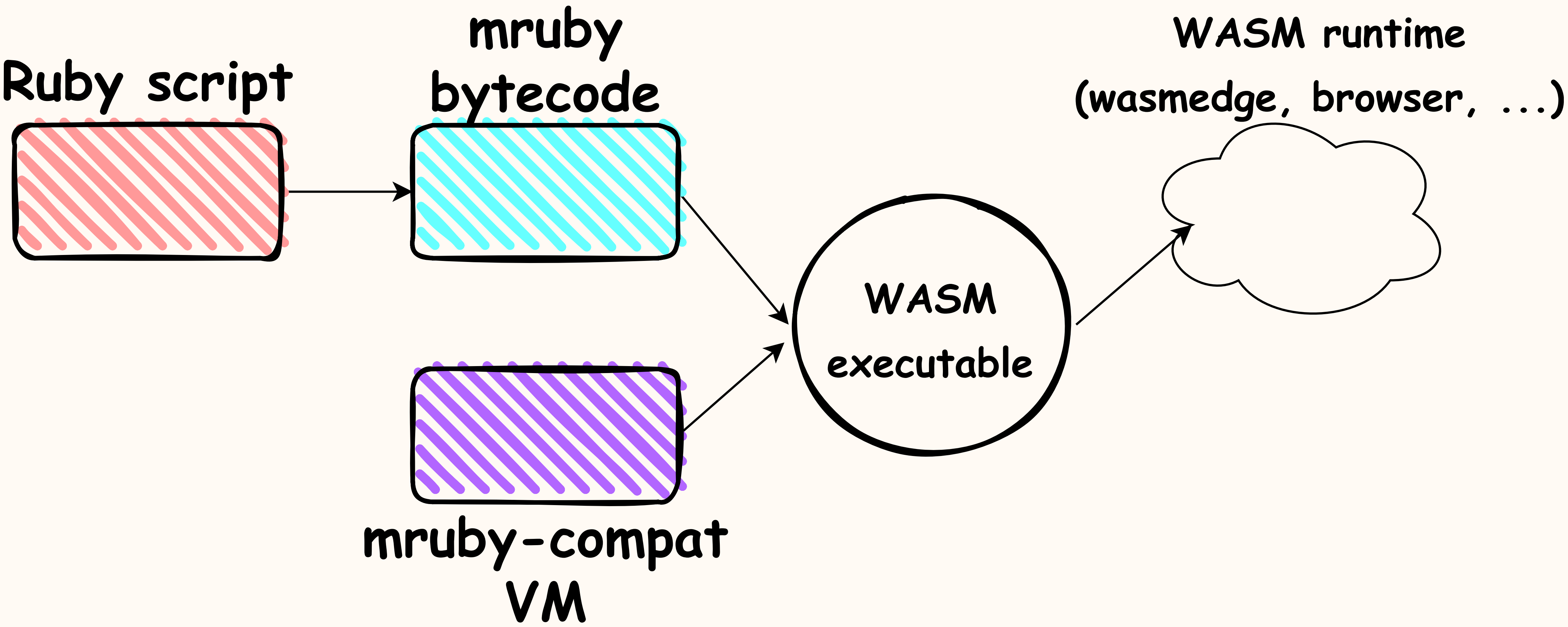
```
$ wasm-objdump -x -j Export fib.wasm

fib.wasm:       file format wasm 0x1
module name: <mywasm.wasm>

Section Details:

Export[4]:
 - memory[0] -> "memory"
 - func[414] <__mrbe_grow.command_export> -> "__mrbe_grow"
 - func[415] <fib.command_export> -> "fib"
 - func[416] <hello.command_export> -> "hello"
```

But the core motivation is?

🌺 Desire to implement **my own VM**!

- ✦ Love Rust's memory safety...
- ✦ but lots of `unsafe {}` for now :(

How it works


Ruby script
mruby
bytecode
mruby-compat
VM
WASM
executable
WASM runtime
(wasmedge, browser, ...)

Import/Export support

Import/Export requires "Types"

```
Type[24]:
 - type[3] (i32) -> i32

Function[412]:
 - func[17] sig=3 <fib>
 - func[415] sig=3 <fib.command_export>

Export[4]:
 - func[415] <fib.command_export> -> "fib"
```

So, `fib` has signature `(i32) -> i32`

How to detect the signature `(i32) -> i32` ?

This fib method has no type declaration, right?

```
def fib(n)
  if n < 1
    return 0
  elsif n < 3
    return 1
  else
    return fib(n-1)+fib(n-2)
  end
end
```

RBS file can be used for "declare" type

Prapere `file.export.rbs`

```
# Classes can be corresponded with Rust/wasm types
# e.g. Integer -> i32
#      Float   -> f32, ...
def fib: (Integer) -> Integer
```

Naming convention

🌺 When you want to compile `FILE.rb`:

- ✦ Prepare `FILE.export.rbs` to specify functions to export
- ✦ Prepare `FILE.import.rbs` to declare import functions

```
./
├── foobar.export.rbs
├── foobar.import.rbs
└── foobar.rb
```

Handling Strings

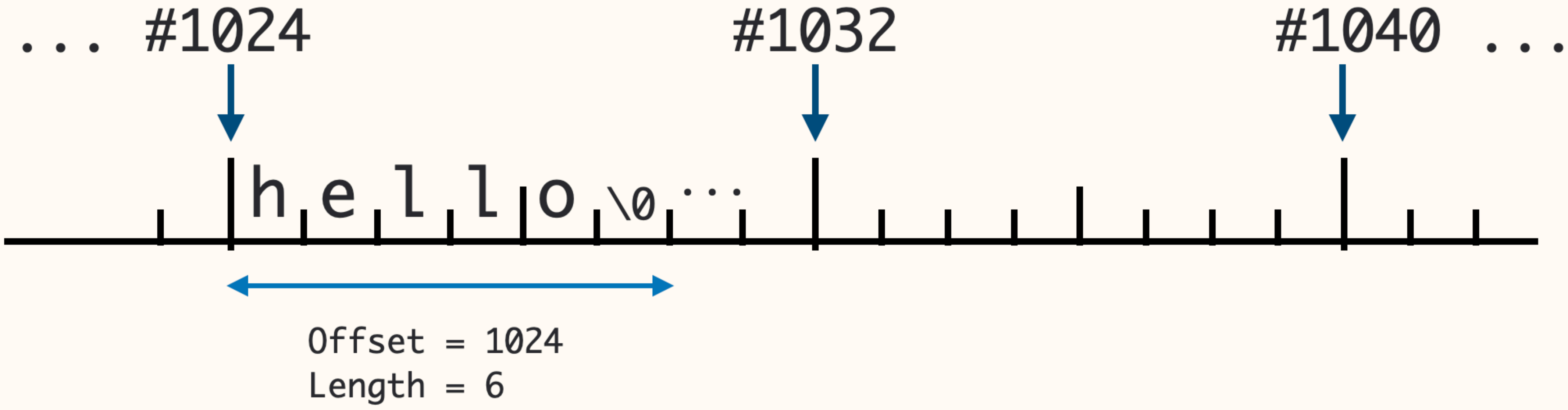
Handling Strings is something to be…

Understanding WASM memory model

- WASM instance has linear memory
- Basically WASM is **isolated** from host env memory
- Linear memory can be used:
  - for storing WASM runtime data
  - for sharing data between WASM and host

What we call "String" is...

Bytearray on wasm's linear memory



Pass String from outer world

🌺 When you want to pass string from browser to WASM, you must **copy bytes** one by one into WASM linear memory!

Pass String from outer world

```
function putSomeString(str) {
  // Requires start point of memory!
  var off = window.instance.exports.__some_malloc();
  off = off >>> 0;
  var len = str.length;
  var buffer = new Uint8Array(
    window.instance.exports.memory.buffer, off, len);
  for( var i = 0; i < length; i++ ) {
    buffer[i] = str.charCodeAt(i);
  }
  window.instance.exports.use_string_i_just_put(off, len);
}
```

Use that String in WASM module

Rust example

```
pub fn use_string_i_just_put(p: *const u8, len: usize) {
  let s = unsafe { // unsafe!
    let u8buf = std::slice::from_raw_parts(p, len);
    std::str::from_utf8(u8buf).unwrap()
  };
  println!("{}", s);
}
```

And passing String from WASM to JS

… Is vice versa

```
var off = window.instance.exports.get_my_string_from_wasm();
off = off >>> 0;
var len = getAnywayOrFixedLength(window.instance);
var buffer = new Uint8Array(
  window.instance.exports.memory.buffer, off, len);

console.log(String.fromCharCode.apply(null, buffer));
```

So, mruby/edge handles String for now...(1)

on export:

RBS def	Rust def	note
`def: foo(String) -> void`	`foo(*const u8, usize)`	
`def: bar() -> String`	`bar() -> *const u8`	(*1), (*2)

(*1) also export `__get__bar_size() -> u32` for getting buffer size

(*2) the buffer is forced to be ended with `\0` automatically

So, mruby/edge handles String for now...(2)

on import:

RBS def	Rust def	note
`def: foo(String) -> void`	`foo(*const u8, usize)`	
`def: bar() -> String`	`bar() -> *const u8`	(*3), (*4)

(*3) also export `__set__bar_size(u32)` to pass string's size
(*4) when `__set__bar_size()` not set, mruby/edge assumes the buffer to be ended with `\0`, and tries to detect its length

Sample code of passing string from JS

```
# @_wasm_expoert
def handle_msg: (String) -> void
# converted -> handle_msg(ptr, len)
```

```
var str = "The WASM Era's emerging"; var len = str.length;
var pageLen = Math.ceil(len+1/65536);
var off = window.instance.exports.__mrbe_grow(pageLen);
var buffer = new Uint8Array(
  window.instance.exports.memory.buffer, off, len);
for( var i = 0; i < length; i++ ) {
  buffer[i] = str.charCodeAt(i);
}
// Finally!
window.instance.exports.handle_msg()
```

Sample code of passing string to JS

```ruby
# @_wasm_import
def handle_wasm_msg: (String) -> void

# in Ruby script
str = "The WASM user's growing"
handle_wasm_msg(str)
# will pass -> handle_wasm_msg(off, len)
```

```javascript
function handle_wasm_msg(off, len) {
  let instance = window.instance;
  let buffer = new Uint8Array(instance.exports.memory.buffer, off, len);
  console.log(String.fromCharCode.apply(null, buffer));
}
```

Future plan...

🌺 Expecting **WASM Component Model** to solve this complication...

- ✦ The Canonical ABI supports `string`
- ✦ With Component Model, there will be better specification of types and better generators

FYI: WIT: Wasm Interface Type Format

```
package wasi:filesystem;

interface types {
  use wasi:clocks.wall-clock.{datetime};

  record stat {
    ino: u64,
    size: u64,
    mtime: datetime,
    // ...
  }

  stat-file: func(path: string) -> result<stat>;
}
```

Evaluation

Microbench challenge

- Using `fibonacci` example
  - ruby.wasm / mruby/edge
  - Purely JavaScript (browser only)
- Both browser and server-side(wasmedge)

mruby/edge (0.1.7) bench code:

```ruby
def fib(n)
  if n < 1
    return 0
  elsif n < 3
    return 1
  else
    return fib(n-1)+fib(n-2)
  end
end

def bench(num)
  # import these JS functions from browser, using performance.now()
  performance_start
  fib(num)
  performance_finish
end
```

Result:

target	test case	elapsed
mruby/edge	fib(15)	8.9 ms
mruby/edge	fib(20)	97.7 ms
mruby/edge	fib(25)	1024.2 ms
mruby/edge	fib(30)	11318.1 ms

※ Browser: Chrome 125.0.6422.41 on MBP-2021 M1 Max

ruby.wasm bench code:

Used `@ruby/3.3-wasm-wasi`

```ruby
def bench(num)
  console = JS.global[:console]
  performance = JS.global[:performance]
  p1 = performance.now
  n = fib(num)
  p2 = performance.now
  console.log("fib(#{num}) = #{n}")
  console.log("Elapsed #{p2.to_f - p1.to_f} ms")
end

bench(15) #...
```

Result:

target	test case	elapsed
ruby.wasm	fib(15)	0.2 ms
ruby.wasm	fib(20)	1.1 ms
ruby.wasm	fib(25)	12.8 ms
ruby.wasm	fib(30)	139.1 ms
ruby.wasm	fib(35)	1548.3 ms

cf. JavaScript bench code:

```
function fib(num) {
        if (num < 1) {
                return 0;
        }
        if (num < 3) {
                return 1;
        }

        return fib(num-1) + fib(num-2);
}
```

Result:

target	test case	elapsed
JavaScript	fib(15)	0.2 ms
JavaScript	fib(20)	0.2 ms
JavaScript	fib(25)	0.6 ms
JavaScript	fib(30)	6.8 ms
JavaScript	fib(35)	58.7 ms

Comparison:

test case	mruby/edge	ruby.wasm	JS	mre / r.w
fib(20)	97.7 ms	1.1 ms	0.2 ms	88.81818182
fib(25)	1024.2 ms	12.8 ms	0.6 ms	80.015625
fib(30)	11318.1 ms	139.1 ms	6.8 ms	81.3666427

mruby/edge is about x80 ~ x100 slower! Lots of room for growth!

Bench using wasmedge:

- ruby.wasm can create script-bundled wasm
- mruby/edge is called via --reactor

```
# ruby.wasm ruby-3.3-wasm32-unknown-wasip1
$ rbwasm pack ruby.wasm --dir ./src::/src --dir \
  ./ruby-3.3-wasm32-unknown-wasip1-full/usr::/usr -o bench.wasm
$ wasmedge bench.wasm /src/bench.rb

# mruby/edge 0.1.7
$ wasmedge --reactor bench.wasm bench 15
```

Code base (on server side):

```
def fib(n)
  # ...
end

def bench(num)
  start = Time.now.to_f
  p fib(num)
  fin = Time.now.to_f
  p (fin - start) * 1000
end

bench(15) # ...
```

Result (1):

target	test case	elapsed
mruby/edge	fib(15)	205.3 ms
mruby/edge	fib(20)	2229.6 ms
mruby/edge	fib(25)	24203.5 ms

Result (2):

target	test case	elapsed
ruby.wasm	fib(15)	16.8 ms
ruby.wasm	fib(20)	179.3 ms
ruby.wasm	fib(25)	1976.9 ms

Focus on bootstrap:

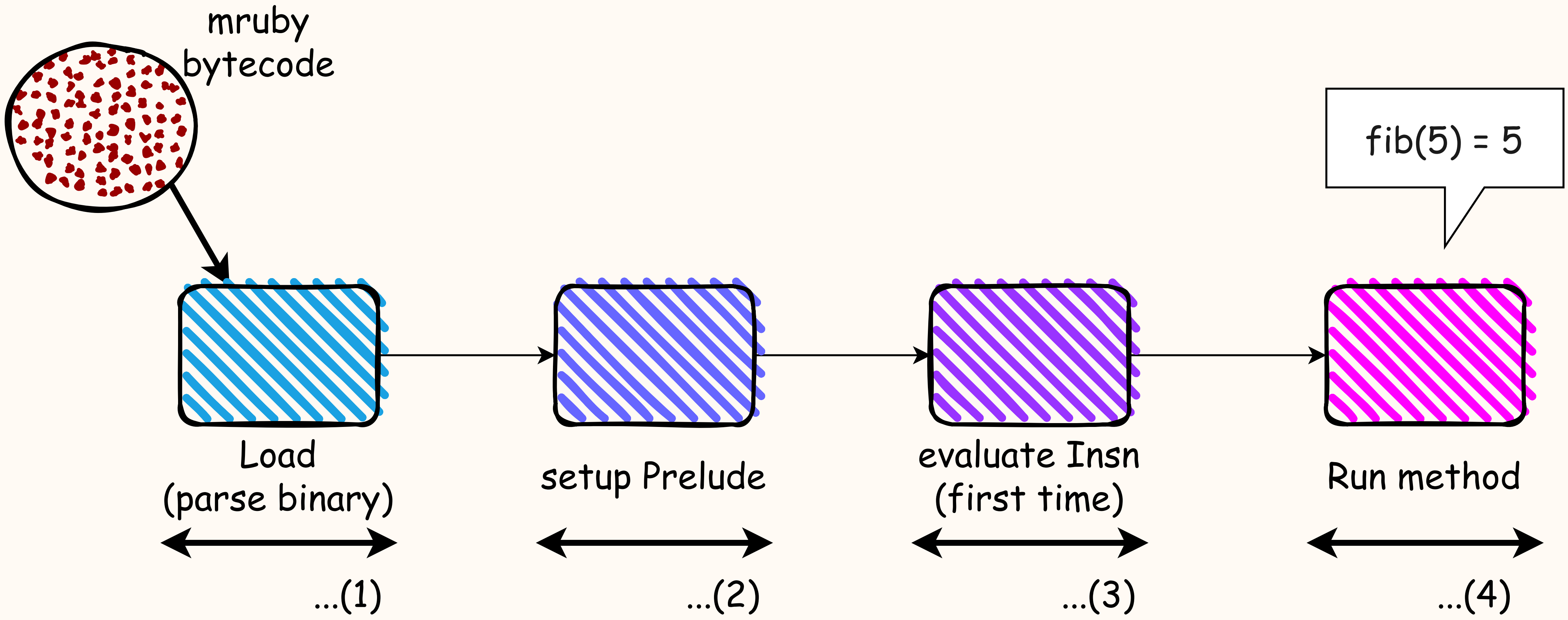
- mruby/edge is faster on bootstrap time, for now

```
$ time wasmedge --reactor bench2.wasm bench 15
610
200628000 # nanos
0.21s user 0.01s system 96% cpu 0.227 total

$ time wasmedge my-ruby-app.wasm /src/bench.rb
610
16.70217514038086
6.67s user 0.19s system 99% cpu 6.906 total
```

mruby/edge internal bench

- Bench of mruby/edge bootstrap process step by step
- Using `criterion` crate

mruby/edge initialization overview



Bench code sample

```rust
// e.g. benchmarking eval_insn()
fn bm0_eval(c: &mut Criterion) {
    let bin = include_bytes!("./fib.mrb");
    let rite = mrubyedge::rite::load(bin).unwrap();
    let mut vm = mrubyedge::vm::VM::open(rite);
    vm.prelude().unwrap();
    c.bench_function("Eval time", |b| {
        b.iter(|| {
            vm.eval_insn().unwrap();
        })
    });
}
```

Result

```
Load time                   time:   [148.22 ns 149.17 ns 150.19 ns]

Prelude time                time:   [629.93 ns 631.64 ns 633.60 ns]

Eval time                   time:   [1.9061 ns 1.9080 ns 1.9100 ns]

Fib 1                       time:   [758.75 ns 760.10 ns 761.40 ns]

# for comparison
Fib 5                       time:   [9.5152 µs 9.5342 µs 9.5528 µs]
```

Wrap up

What we learned:

- WebAssembly basics
- mruby && VM basics
- mruby/edge is combination of these

mruby/edge is still actively developed

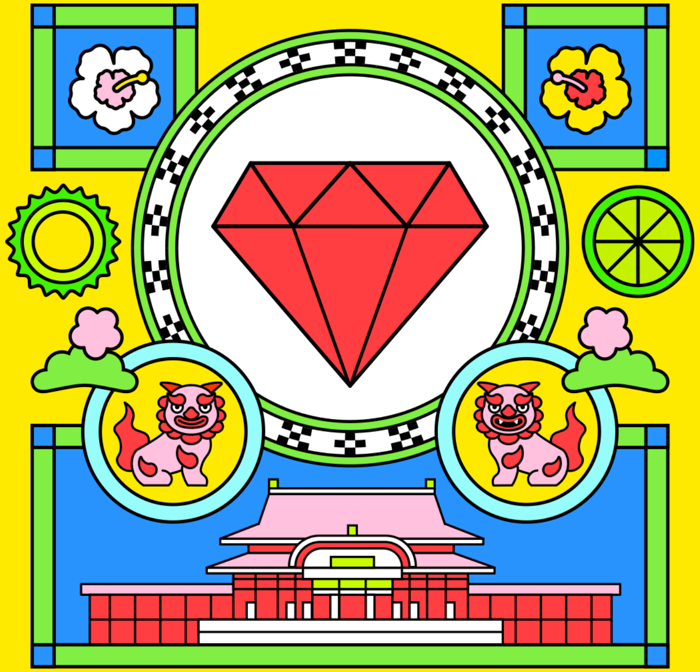
- Component Model support...
- Bunch of unsupported Ruby features...
- Better wrapper for users...
- Documents...
- Examples...

WASM is cool technology for embed use

- proxy-wasm, configs, containers...
- mruby/edge will help you to "embed" your Ruby code!

Thank you!

I hope you enjoy Kaigi && Okinawa



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