Rewriting LuaJIT: Why and How?

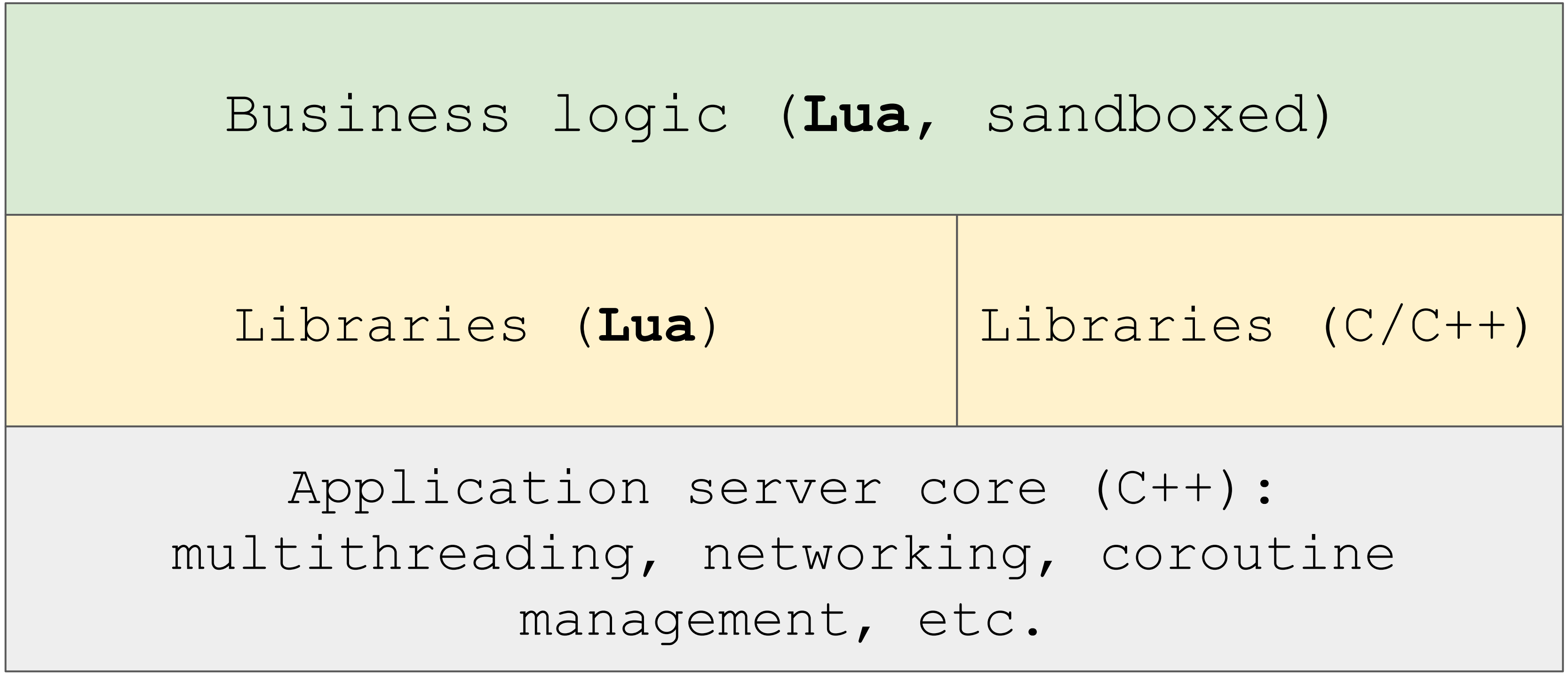
Anton Soldatov, IPONWEB

Lua Workshop
Kaunas, 06.09.2018

About IPONWEB

- Building platforms for real-time advertising
- Workloads up to 6M requests per second
- Lua is used for more than 10 years for implementing business logic in our projects

Lua in IPONWEB


Business logic (**Lua**, sandboxed)
Libraries (**Lua**)
Libraries (C/C++)
Application server core (C++): multithreading, networking, coroutine management, etc.

LuaJIT in IPONWEB

- Experience with LuaJIT 1.1 and 2.0

LuaJIT in IPONWEB

- Experience with LuaJIT 1.1 and 2.0
- Definitely benefit from the faster interpreter

LuaJIT in IPONWEB

- Experience with LuaJIT 1.1 and 2.0
- Definitely benefit from the faster interpreter
- Generally benefit from the JIT compiler

LuaJIT in IPONWEB

- Experience with LuaJIT 1.1 and 2.0
- Definitely benefit from the faster interpreter
- Generally benefit from the JIT compiler
  - ...but we do not avoid `pairs` at all costs

LuaJIT in IPONWEB

- Experience with LuaJIT 1.1 and 2.0
- Definitely benefit from the faster interpreter
- Generally benefit from the JIT compiler
  - ...but we do not avoid `pairs` at all costs
- Sandboxing partly reduces Lua/LuaJIT incompatibility tension

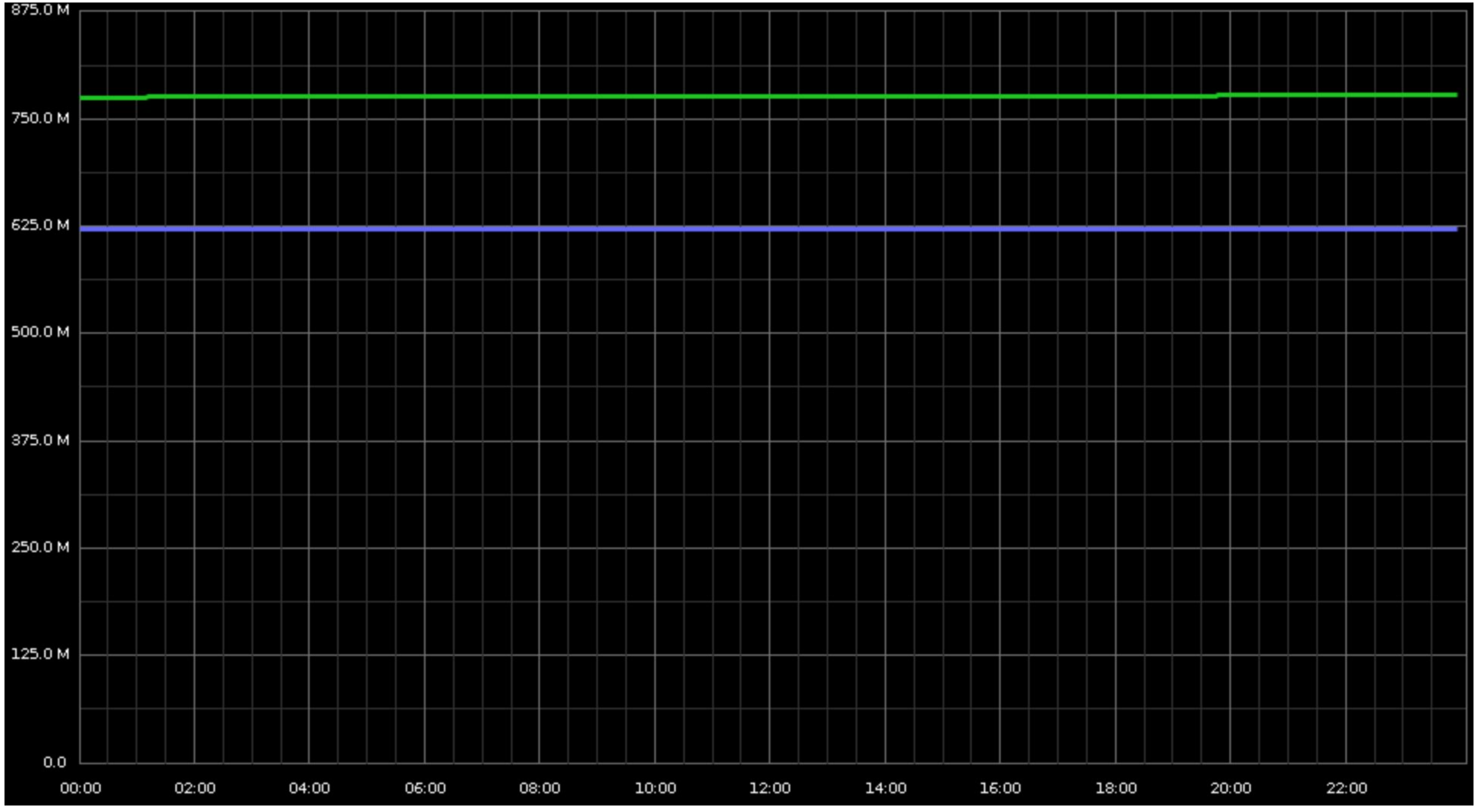
LuaJIT in IPONWEB

- Experience with LuaJIT 1.1 and 2.0
- Definitely benefit from the faster interpreter
- Generally benefit from the JIT compiler
  - ...but we do not avoid `pairs` at all costs
- Sandboxing partly reduces Lua/LuaJIT incompatibility tension
- Limited experience with FFI

Data feeds

- Inventory lists
- Rules for decision making

Data feeds: memory consumption



Our main issue with LuaJIT 2.0

We have eventually hit the memory limit on x86-64:

```
void *ptr = mmap((void *)MMAP_REGION_START,
                 size, MMAP_PROT,
                 MAP_32BIT|MMAP_FLAGS, -1, 0);
```

Tried a work-around with FFI

- Decompose feeds into simpler data structures
- Map into native memory
- Build accessors with FFI

Tried a work-around with FFI

- Decompose feeds into simpler data structures
- Map into native memory
- Build accessors with FFI
- Performance has degraded

Possible solutions

- Migrate to PUC-Rio Lua

Possible solutions

- Migrate to PUC-Rio Lua

- Migrate to LuaJIT 2.1

Possible solutions

- Migrate to PUC-Rio Lua
- Migrate to LuaJIT 2.1
- Start an own implementation

Implementation requirements

- Fix the memory limit
- Become not slower than LuaJIT 2.0
- Target only Linux x86-64

Implementation requirements

- Fix the memory limit
- Become not slower than LuaJIT 2.0
- Target only Linux x86-64
- No changes to the language
- Stay as close to Lua 5.1 as LuaJIT 2.0

Fixing the memory limit

- `TValue` is 16 bytes (`uint64_t` + `uint64_t`)

Fixing the memory limit

- `TValue` is 16 bytes (`uint64_t` + `uint64_t`)
- Support for true 64-bit pointers in both VM and JIT

Fixing the memory limit

- `TValue` is 16 bytes (`uint64_t` + `uint64_t`)
- Support for true 64-bit pointers in both VM and JIT
- `LJ_FR2` trick not needed

Fixing the memory limit

- `TValue` is 16 bytes (`uint64_t` + `uint64_t`)
- Support for true 64-bit pointers in both VM and JIT
- `LJ_FR2` trick not needed
- A multiplier of 2 was "baked" into the byte code to regain the SIB mode benefits

Fixing the memory limit: results

- About 30% faster than the FFI work-around for data feeds
- Approximately the same performance in most of other cases

Fixing the memory limit: timeline

- Q2 2015 – Decision to build a new implementation
- 2015-2016 – Development, stabilisation and validation; pilot migrations
- Q1 2017 – More than 95% production servers moved to the new implementation

Testing: What we started with

- Integrational tests with the application server
- Test stands

Testing: What was missing

- Language compliance tests

Testing: What was missing

- Language compliance tests
- There are test suites for some implementations, but they are scattered around

Testing: What was missing

- Language compliance tests
- There are test suites for some implementations, but they are scattered around
- Functional tests for the implementation

Testing: results

- Continuously write own tests

Testing: results

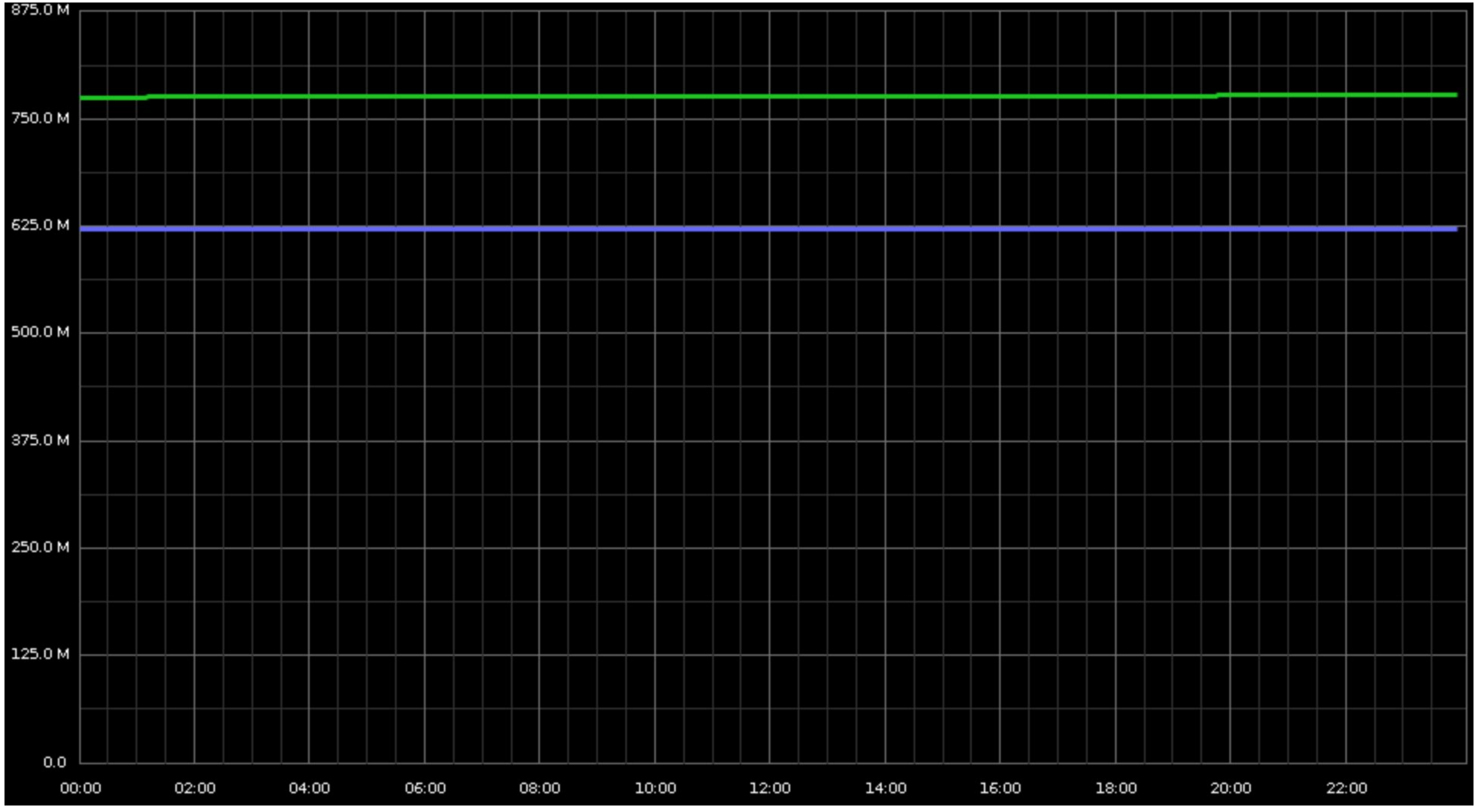
- Continuously write own tests
- Integrate third party suites into the source tree:
    - Lua 5.1 official test suite
    - Mike Pall's test suite for LuaJIT
    - François Perrad's test suite shipped with lua-TestMore

Testing: results

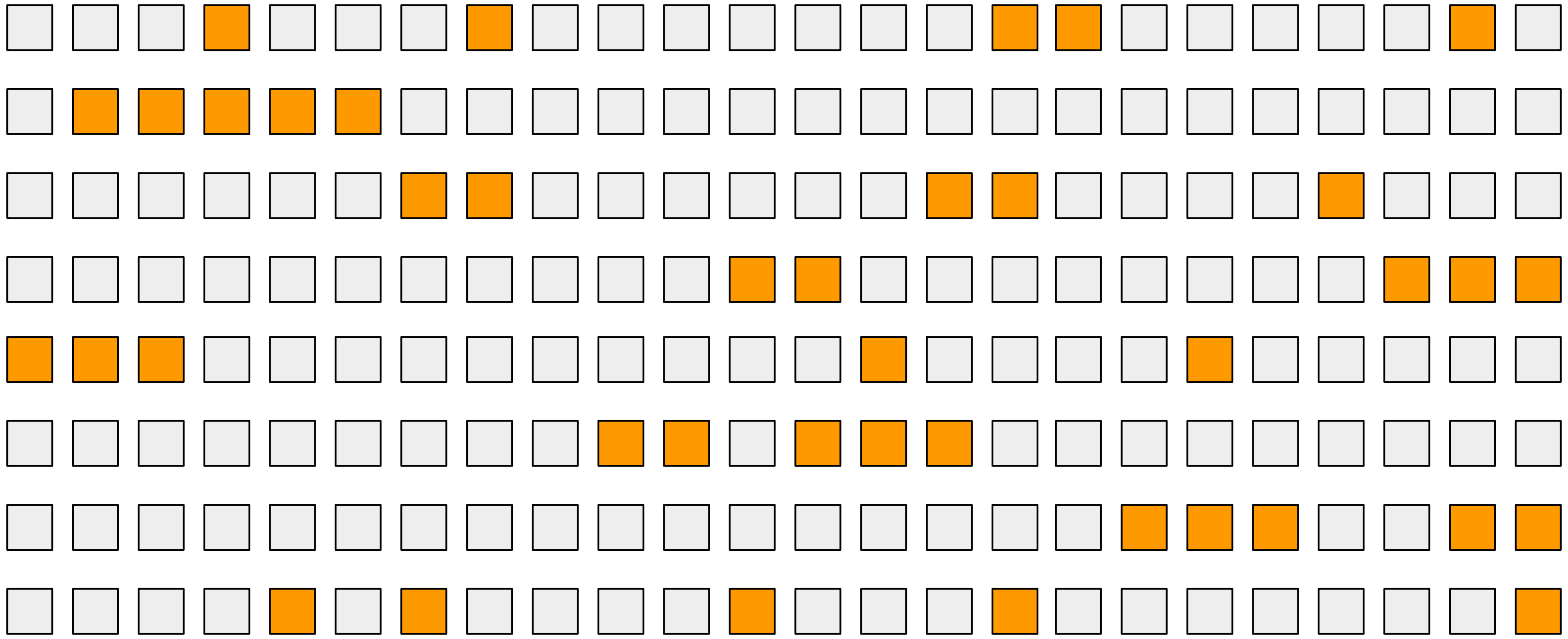
- Continuously write own tests
- Integrate third party suites into the source tree:
    - Lua 5.1 official test suite
    - Mike Pall's test suite for LuaJIT
    - François Perrad's test suite shipped with lua-TestMore
    - Part of Laurent Deniau's test suite from the MAD project

Extending the implementation

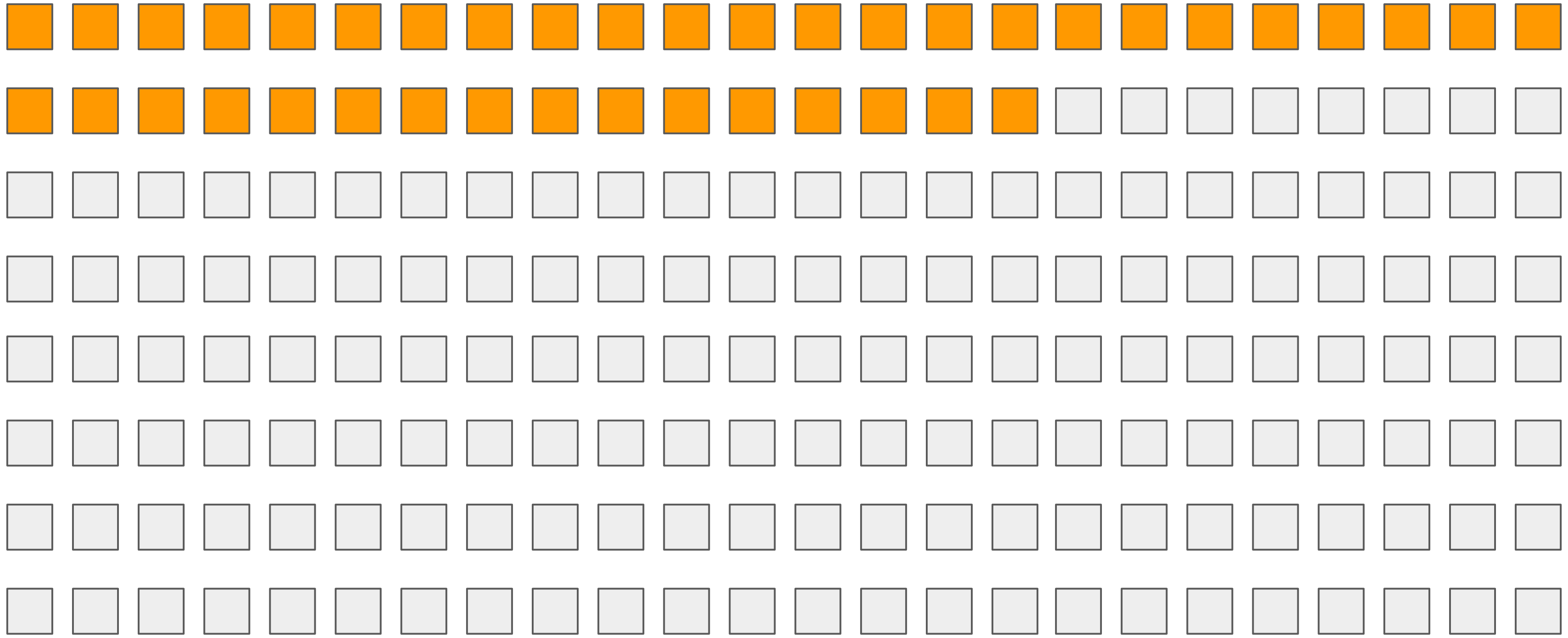
Data feeds: memory consumption



Objects from a data feed in memory



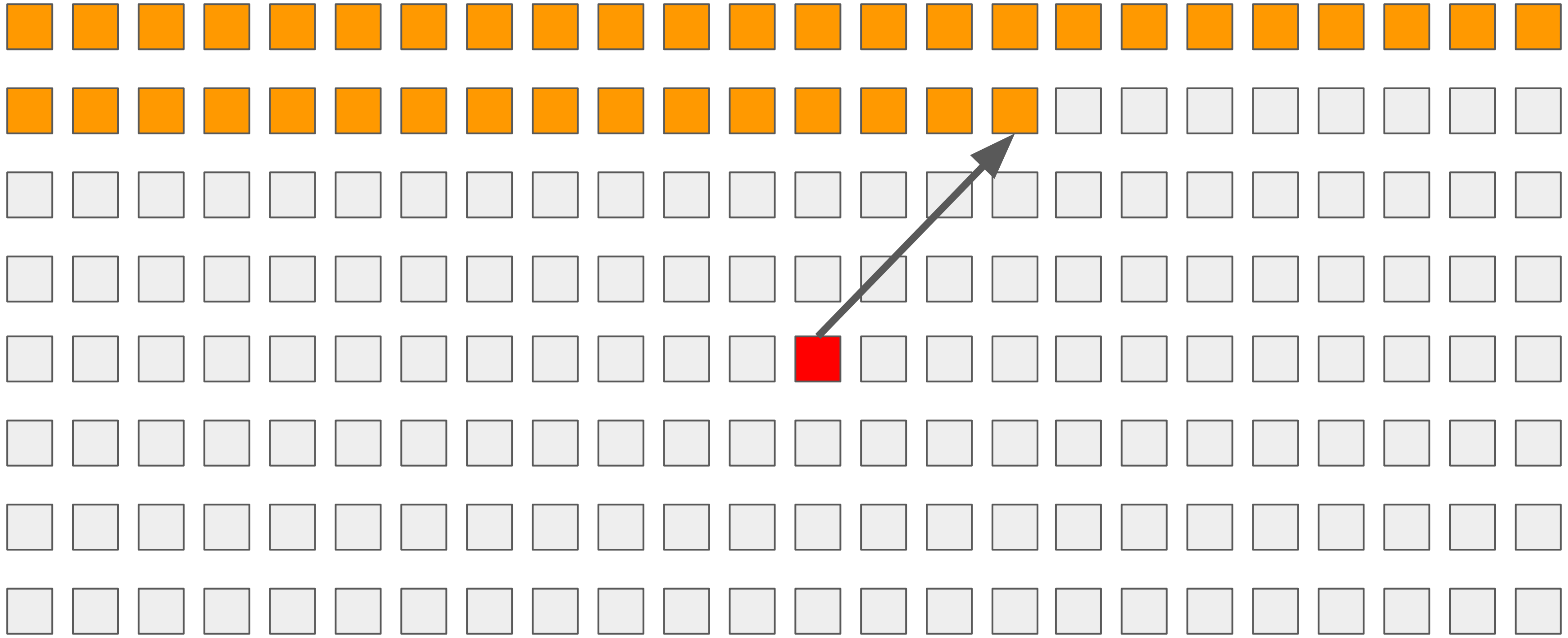
`ujit.seal(data)`



Properties of sealed objects

- GC traverses objects until the first sealed object
- Thus, all sealed objects must be **immutable**

`ujit.seal(data)`



```
seal = "seal per se" + immutable
```

Introducing immutable objects

```
local t = {foo = "bar"}
ujit.immutable(t)
```

`immutable`: Example 1

```lua
local t = ujit.immutable({{foo = "bar"}})

-- All of the following throw:

t[1].new = "baz" -- Add
t[1].foo = "baz" -- Modify
t[1].foo = nil   -- Remove
```

`immutable`: Example 2

```
ujit.immutable(_G)
```

Going further: more features

- Sharing read-only data between instances of the VM

Going further: more features

- Sharing read-only data between instances of the VM
- Interruptible coroutines (non-resumable and resumable)

Going further: more features

- Sharing read-only data between instances of the VM
- Interruptible coroutines (non-resumable and resumable)
- Extended Lua and C API for working with tables

Going further: more features

- Sharing read-only data between instances of the VM
- Interruptible coroutines (non-resumable and resumable)
- Extended Lua and C API for working with tables
- Tweaks in the compiler

Going further: tools

- Sampling profiler
- bit.ly/dumpanalyze – a tool for analyzing debugging info produced by the JIT compiler (`-jdump` in LuaJIT)

Conclusions

- It is possible to build an implementation of Lua based on LuaJIT, but your motivation should be strong enough
- Be prepared to multiple challenges (and fun) while reworking the core
- Be prepared to more challenges when it comes to testing and tools

Thank you! Questions?

Links

- bit.ly/dumpanalyze
- bit.ly/iow-lua-moscow-2017
- bit.ly/iow-hl-2016 (in Russian)
- bit.ly/iow-hl-2017 (in Russian)

- asoldatov@iponweb.net
- https://t.me/igelhaus