# Porting Node

*The Journey from Lake JavaScript to The Strait of Lua*

# The Plan

# We Want to Swap Engines

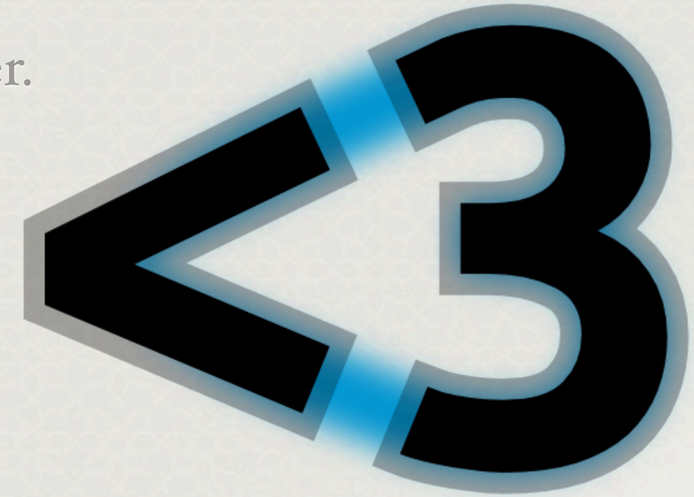
- As of node.js v0.6.x, node is just V8 bindings to libuv right?
- So let's just swap V8 with another engine. LuaJit looks nice.
- This should be quick and easy. Let's port the boat!

# Boating in Lake JavaScript

- C Libraries
  - **libuv** - Provides non-blocking, callback based I/O and timers.
  - **http_parser** - Fast event-based HTTP protocol parser.
  - **openssl** - Provides crypto primitives.
  - **zlib** - Provides compression and decompression.
- Scripting Language Virtual Machine
  - **Google V8** - Runs JavaScript code.

# Navigating The Strait of Lua

- C Libraries
  - **libuv** - Provides non-blocking, callback based I/O and timers.
  - **http_parser** - Fast event-based HTTP protocol parser.
  - **openssl** - Provides crypto primitives.
  - **zlib** - Provides compression and decompression.
- Scripting Language Virtual Machine
  - **LuaJit** - Runs Lua code.



# Why Bother Porting the Canoe?

- LuaJit is much lighter than V8 in embedded situations.
- I don't like C++ for addons, I prefer straight C.
- Lua has coroutines! (an alternative to callbacks)
- LuaJit has really fast FFI built-in
- I wanted to make other things than websites.

# Begin the Journey

# Learning libUV

- Cloned the repo at https://github.com/joyent/libuv.git
  - Read `include/uv.h`
- Joined `#libuv` on freenode IRC.
- Work with @piscisaureus and @bnoordhuis.

# TCP Server

```c
int main() {

  /* Initialize the tcp server handle */
  uv_tcp_t* server = malloc(sizeof(uv_tcp_t));
  uv_tcp_init(uv_default_loop(), server);

  /* Bind to port 8080 on "0.0.0.0" */
  printf("Binding to port 8080\n");
  if (uv_tcp_bind(server, uv_ip4_addr("0.0.0.0", 8080))) {
    error("bind");
  }

  /* Listen for connections */
  printf("Listening for connections\n");
  if (uv_listen((uv_stream_t*)server, 128, on_connection)) {
    error("listen");
  }

  /* Block in the main loop */
  uv_run(uv_default_loop());
  return 0;
}
```

```c
/* Callback for new tcp client connections */
static void on_connection(uv_stream_t* server, int status) {
  uv_tcp_t* client;

  if (status) error("on_connection");

  client = malloc(sizeof(uv_tcp_t));
  uv_tcp_init(uv_default_loop(), client);

  /* Accept the client */
  if (uv_accept((uv_stream_t*)server, (uv_stream_t*)client)) {
    error("accept");
  }

  printf("connected\n");

  /* Start reading data from the client */
  uv_read_start((uv_stream_t*)client, on_alloc, on_read);
}
```

# TCP Server Continued

```c
/* Callback on data chunk from client */
static void on_read(uv_stream_t* stream,
                    ssize_t nread, uv_buf_t buf) {
  if (nread >= 0) {
    printf("chunk: %.*s", (int)nread, buf.base);
  } else {
    uv_err_t err = uv_last_error(uv_default_loop());
    if (err.code == UV_EOF) {
      printf("eof\n");
      uv_close((uv_handle_t*)stream, on_close);
    } else {
      fprintf(stderr, "read: %s\n", uv_strerror(err));
      exit(-1);
    }
  }
  free(buf.base);
}
```

```c
/* Helper for exiting on errors */
static void error(const char* name) {
  uv_err_t err = uv_last_error(uv_default_loop());
  fprintf(stderr, "%s: %s\n", name, uv_strerror(err));
  exit(-1);
}

/* Hook to allocate data for read events */
static uv_buf_t on_alloc(uv_handle_t* handle,
                         size_t suggested_size) {
  return uv_buf_init(malloc(suggested_size),
                     suggested_size);
}

static void on_close(uv_handle_t* handle) {
  free(handle);
  printf("disconnected\n");
}
```

# Learning Lua

- Bought Programming in Lua 2nd Edition.
  - Read it all!
- Joined the lua-l mailing list
- Joined #lua on freenode irc
- Bookmarked the HTML manual http://www.lua.org/manual/5.1/

# Prototype Some APIs

- Can node-style APIs work in the Lua language?
- Lua tables are similar to JS objects, but not the same.
- There is no inheritance. But there are metatables.
- Anything can be used as keys, including other tables or functions.
- Tables may not contain `nil` for keys or values.
- There is no `this`, but there is function calling sugar with `self`.

```lua
local Object = {}
Object.meta = {__index = Object}

-- Creates a new instance.
function Object:new(...)
  local obj = setmetatable({}, self.meta)
  if obj.initialize then
    obj:initialize(...)
  end
  return obj
end

-- Creates a new sub-class
function Object:extend()
  local sub = setmetatable({}, self.meta)
  sub.meta = {__index = sub}
  return sub
end
```

```lua
-- Create a class using Object
local Rect = Object:extend()
function Rect:initialize(w, h)
  self.w = w
  self.h = h
end
function Rect:getArea()
  return self.w * self.h
end

-- Create an instance it.
local rect = Rect:new(4, 5)
print(rect:getArea())
```

```lua
local Emitter = Object:extend()

-- Register an event listener
function Emitter:on(name, callback)
  -- Lazy create event types table.
  if not self.handlers then
    self.handlers = {}
  end
  local handlers = self.handlers

  -- Lazy create table for callbacks.
  if not handlers[name] then
    handlers[name] = {}
  end

  -- Store the callback as a key
  handlers[name][callback] = true
end
```

```lua
-- Remove an event listener
function Emitter:off(name, callback)
  -- Get the list of callbacks.
  local list = self.handlers and self.handlers[name]
  if not list then return end

  -- Delete the key by setting to nil.
  list[callback] = nil
end

-- Emit a named event.
function Emitter:emit(name, ...)
  -- Get the list of callbacks.
  local list = self.handlers and self.handlers[name]
  if not list then return end

  -- Call each one with the args.
  for callback in pairs(list) do
    callback(...)
  end
end
```

```javascript
// Load the net module
var net = require("net");

// Create a tcp server
net.createServer(function (client) {

  console.log("connected");

  client.on("data", function (chunk) {
    process.stdout.write(chunk);
  });

  client.on("end", function () {
    console.log("eof");
  });

  client.on("close", function () {
    console.log("disconnected");
  });

}).listen(8080, function () {
  console.log("Listening on port 8080");
});
```

```lua
-- Load the net module
local net = require "net"

-- Create a tcp server
net.createServer(function (client)

  print "connected"

  client:on("data", function (chunk)
    process.stdout:write(chunk)
  end)

  client:on("end", function ()
    print "eof"
  end)

  client:on("close", function ()
    print "disconnected"
  end)

end):listen(8080, function ()
  print "Listening on port 8080"
end)
```

# Faux Blocking in Luvit

```
fiber.new(function (wrap)
  -- Wrap some functions for sync-style calling
  local sleep = wrap(require('timer').setTimeout)
  -- Can wrap modules too
  local fs = wrap(require('fs'), true) -- true means to auto-handle errors

  local fd = fs.open(__filename, "r", "0644")
  local stat = fs.fstat(fd)
  local offset = 0
  repeat
    local chunk, length = fs.read(fd, offset, 40)
    offset = offset + length
  until length == 0
  sleep(1000)
  fs.close(fd)
  return fd, stat, offset
end, callback)
```

# LuaJit Bindings

- There are two ways to call C libraries from scripts in LuaJit:
  - One is the Application Program Interface.
    - Write special lua-callable C functions that wrap C libraries.
    - Works the same in LuaJit and stock Lua
  - Two is using LuaJit's FFI interface.
    - Write bindings in Lua, no compile step needed.

# Binding With LuaJit's FFI

*First declare the C API you want to call*

```
/* uvffi.h */
enum { MAX_TITLE_LENGTH = 8192 }
struct uv_err_s { int code; int sys_errno_; };
typedef struct uv_err_s uv_err_t;
uv_err_t uv_get_process_title(char* buffer, size_t size);
uv_err_t uv_set_process_title(const char* title);
const char* uv_strerror(uv_err_t err);
const char* uv_err_name(uv_err_t err);
```

```lua
ffi.cdef(fs.readFileSync("uvffi.h"))
local C = ffi.C
local uv = {}

local function uvCheck(err)
  if err.code == 0 then return end
  local name = ffi.string(C.uv_err_name(err))
  local message = ffi.string(C.uv_strerror(err))
  error(name .. ": " .. message)
end

function uv.getProcessTitle()
  local buffer = ffi.new("char[MAX_TITLE_LENGTH]")
  uvCheck(C.uv_get_process_title(buffer, C.MAX_TITLE_LENGTH))
  return ffi.string(buffer)
end

function uv.setProcessTitle(title)
  uvCheck(C.uv_set_process_title(title))
end
```

# Binding With Lua's API

```c
int luv_get_process_title(lua_State* L) {
  char title[8192];
  uv_err_t err = uv_get_process_title(title, 8192);
  if (err.code) {
    return luaL_error(L, "%s: %s", uv_err_name(err), uv_strerror(err));
  }
  lua_pushstring(L, title);
  return 1;
}

LUALIB_API int luaopen_uv_native (lua_State* L) {
  lua_newtable (L);
  lua_pushcfunction(L, luv_get_process_title);
  lua_setfield(L, -1, "getProcessTitle");
  return 1;
}
```

# C Bindings Won

- When I started, LuaJit FFI didn't support callbacks.
  - Even after callbacks were added, they didn't support passing struct values (only references).
- Rackspace was using stock Lua for their Agent program.

# libUV Callbacks

```
typedef uv_buf_t (*uv_alloc_cb)(uv_handle_t* handle, size_t suggested_size);
typedef void (*uv_read_cb)(uv_stream_t* stream, ssize_t nread, uv_buf_t buf);
typedef void (*uv_read2_cb)(uv_pipe_t* pipe, ssize_t nread, uv_buf_t buf,
    uv_handle_type pending);
typedef void (*uv_write_cb)(uv_write_t* req, int status);
typedef void (*uv_connect_cb)(uv_connect_t* req, int status);
typedef void (*uv_shutdown_cb)(uv_shutdown_t* req, int status);
typedef void (*uv_connection_cb)(uv_stream_t* server, int status);
typedef void (*uv_close_cb)(uv_handle_t* handle);
typedef void (*uv_timer_cb)(uv_timer_t* handle, int status);
typedef void (*uv_exit_cb)(uv_process_t*, int exit_status, int term_signal);
typedef void (*uv_fs_cb)(uv_fs_t* req);
```

# Through the Thicket

# Bind all the other UV Functions

**FS** - Has open, close, read, write, unlink, mkdir, rmdir, readdir, stat, fstat, rename, fsync, fdatasync, ftruncate, sendfile, chmod, utime, futime, lstat, link, symlink, readlink, fchmod, chown, and fchown.

**UV** - Has run, ref, unref, updateTime, now, hrtime, getFreeMemory, getTotalMemory, loadavg, uptime, cpuInfo, interfaceAddresses, execpath, getProcessTitle, setProcessTitle, handleType and activateSignalHandler.

# Bind all the libUV Types

- **Handle** - Has close.
  - **Stream** - Has shutdown, listen, accept, readStart, readStop, and write.
    - **Tcp** - Has nodelay, keepalive, bind, getSockName, getPeerName, connect, and writeQueueSize.
    - **Udp** - Has bind, setMembership, getsockname, send, recvStart and recvStop.
  - **Pipe** - Has open, bind, and connect.
  - **Tty** - Has setMode, getWinsize and resetMode.
  - **Timer** - Has start, stop, again, setRepeat, getRepeat and getActive.
  - **Process** - Has spawn, kill and getPid.
  - **Watcher** - has newFsWatcher.

# Callbacks are Hard (in C)

- Unlike JavaScript, Lua, and Candor, C has no anonymous functions.
- It also does not have closures.
- Since callbacks are global and shared, state needs to be stored somewhere.
- The `uv_handle_t` and `uv_req_t` base types have a `void* data` property.
- Using this we can store anything in custom structs.

# Memory Management is Hard

- In C of course we have to manage everything manually. That's expected.
- LibUV does not assume much and stays out of the way.
- However, sometimes a pending C callback will need a script object that has no roots in any script.
- Doing this properly without being too greedy or too loose is tricky.
- The recent libUV refcount refactor helps.

# Status Check

- Just binding libuv to Lua is over 12,000 lines of C code!
- We still need to write bindings for http_parser, c-ares, openssl and zlib.
- As you might have noticed, libuv is a very different API than node.
- We need a sugar layer written in Lua. (over 5,000 lines of Lua code)
- Building this cross-platform is a real pain.
- Lua does not have JSON built in, nor does it fit 100% with the language.

# Saved by the Community

- Rackspace wanted to build something like Lua for their monitoring agent. So we joined forces.
- Others joined as well from all over the world. (even as far as Russia and New Zealand)
- The community helped finish out the project.
  - Maintain a windows build.
  - Write bindings for c-ares, openssl, zlib, and fix my udp bindings.
  - Co-Designed the object system and much of the lua sugar layer.

# The Destination is in Sight

- In initial testing Luvit was 4x faster than node.js in http hello world.
- Luvit also used 20x less ram than node in the same test.
- Most the basic functionality was in place and APIs were starting to converge with node's.
- We made a webpage http://luvit.io, a mailing list luvit @ google groups, an irc room #luvit @ freenode.
- We made a few releases with pre-built binaries for many platforms.

# Lessons Learned

- Lua as a language is compatible with Node.js API patterns.
- LuaJit uses a lot less ram than V8.
- Calling C code in luajit is much faster than in V8.
- Though as the script code grows, V8 tends to be faster.
- Coroutines allow faux-blocking using the native language features.
- Streaming JSON is really cool.  But LTIN is  more natural for Lua!

# Lessons Learned

- Small codebases make developers happy. Luvit would build in 4 seconds on my desktop.
- Node's require system and especially path resolving algorithm is worth copying.
- JavaScript is hard to beat for web development. It's a requirement for the browser, so it's natural for the server.
- Lua rocks for other types of development, especially with FFI.

# Lessons Learned

Open Source collaboration makes it possible to build *anything*.

# Final Destination

*Now where do we go from here?*

# Do it Again!

- Choose your pet scripting language and bind it to libUV.
- Explore the strengths of the new platform.
- Share what you learned.
- Contribute back.

# Candor.IO

- Candor is a new programming language by Fedor Indutny.
- It was called Dot, but I proposed the new name Candor.
- Candor is to JavaScript as C is to C++.
- Except it's implemented in C++.
- Candor.IO is libUV bindings to the language.

# Prototype Candor APIs

```
new = (prototype, args...) {
  obj = clone prototype
  obj:initialize(args...)
  return obj
}

Rectangle = {}
Rectangle.getArea = (self) {
  return self.w * self.h
}
Rectangle.initialize = (self, w, h) {
  self.w = w
  self.h = h
}
p("Rectangle", Rectangle)
```

```
Square = clone Rectangle
Square.initialize = (self, s) {
  self.w = s
  self.h = s
}
p("Square", Square)

rect = new(Rectangle, 3, 5)
p("rect", rect)
print("Rectangle 3x5 = " + rect:getArea())

square = new(Square, 4)
p("square", square)
print("Square 4x4 = " + square:getArea())
```

# Write Candor Bindings

```
using namespace candor;

static Value* luv_timer_stop(uint32_t argc, Value* argv[]) {
  assert(argc == 1);
  Object* obj = argv[0]->As<Object>();
  uv_timer_t* handle = UVData::ObjectTo<uv_timer_t>(obj);
  int status = uv_timer_stop(handle);
  return Number::NewIntegral(status);
}

static Handle<Object> module;
Object* uv_timer_module() {
  if (!module.IsEmpty()) return *module;
  module.Wrap(Object::New());
  module->Set("create", Function::New(luv_create_timer));
  return *module;
}
```

# Calling libuv from Candor

```
// Load the libraries we need
prettyprint = global.prettyprint
require = global.require
exit = global.exit
lastError = require('uv').lastError
Timer = require('timer')

// Helper to check uv return values.
check = (status) {
  if (!status) return
  err = lastError()
  prettyprint(err)
  exit(err.code)
}
```

```
// setTimeout, then stop and close
timer = Timer.create()
check(timer:start(1000, 0, () {
  prettyprint("onTimeout", timer)
  check(timer:stop())
  timer:close(() {
    prettyprint("close", timer)
  })
}))
```

# LuvMonkey

- Porting Node.js to SpiderMonkey.
- This means JavaScript 1.8.5 vs EcmaScript 5 in V8.
- Generators are already implemented.
- VM competition for Node.js is a good thing.

```c
static JSBool luv_run(JSContext *cx, unsigned argc, jsval *vp) {
  uv_run(uv_default_loop());
  JS_SET_RVAL(cx, vp, JSVAL_VOID);
  return JS_TRUE;
}

static JSFunctionSpec luv_functions[] = {
  JS_FS("run", luv_run, 0, JSPROP_ENUMERATE),
  JS_FS_END
};

JSBool luv_init(JSContext *cx, unsigned argc, jsval *vp) {
  JSObject* uv = JS_NewObject(cx, NULL, NULL, NULL);
  if (!JS_DefineFunctions(cx, uv, luv_functions)) {
    return JS_FALSE;
  }
  JS_SET_RVAL(cx, vp, OBJECT_TO_JSVAL(uv));
  return JS_TRUE;
}
```

# Thank You for the Journey.