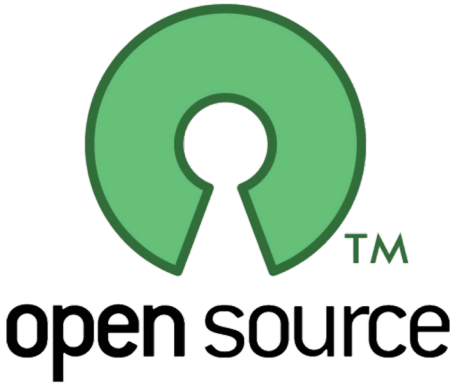
ROME - APRIL 13/14 2018

{codemotion}

Node.js Native AddOns from zero to hero

Nicola Del Gobbo

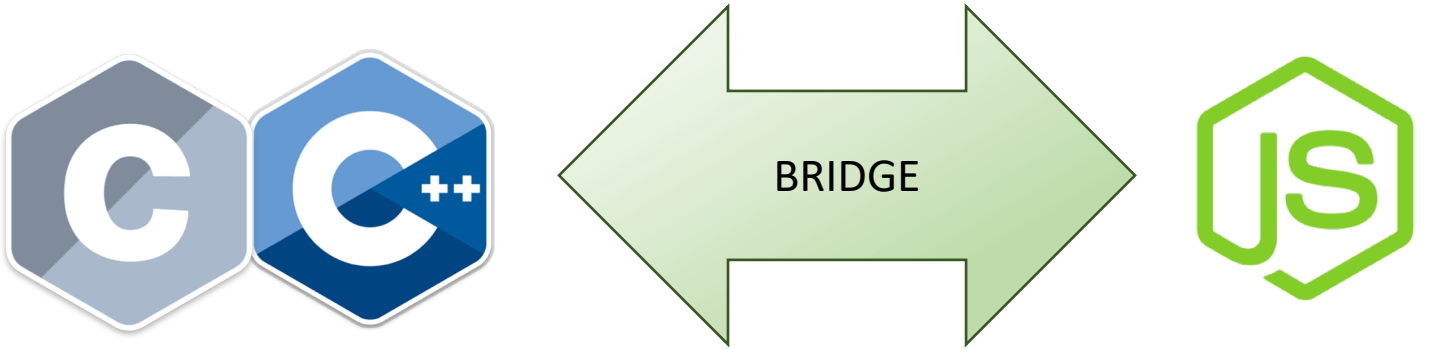
Who is Nicola Del Gobbo?



N-API TEAM

What is Node.js Native Addon?

C / C++ code called from JavaScript



Native environment

JavaScript

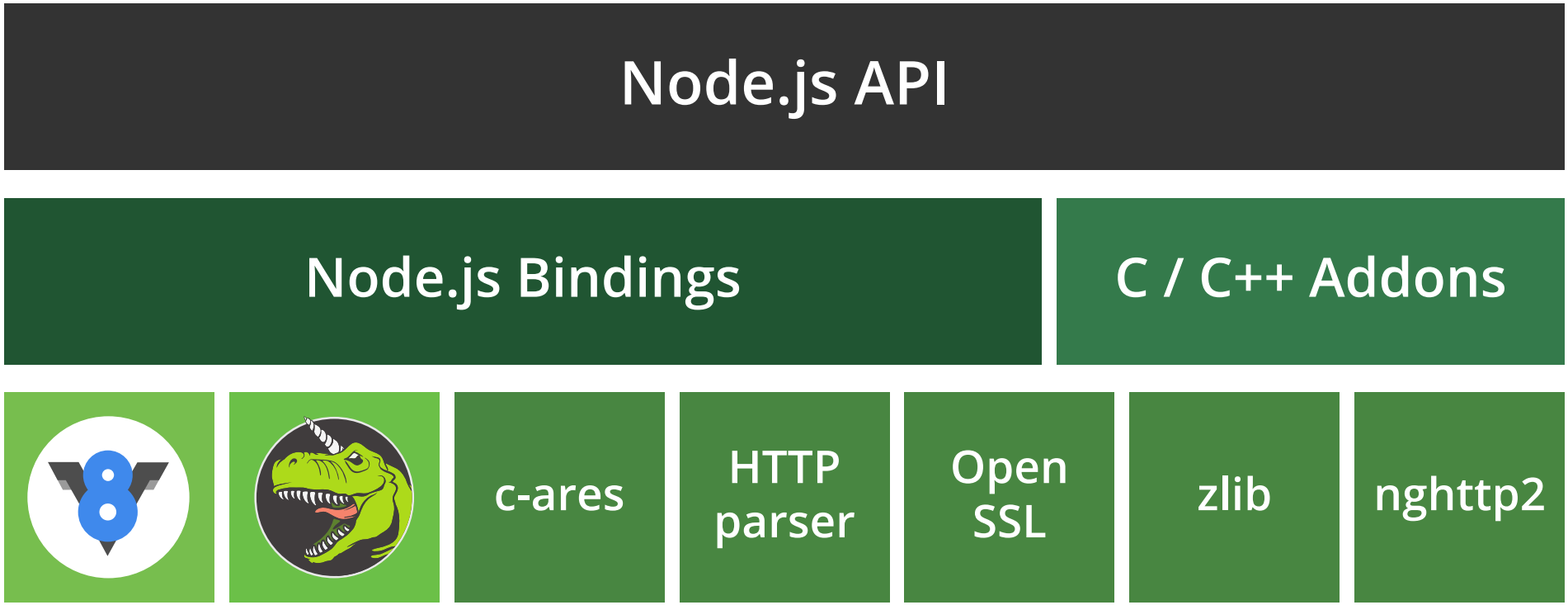
From Node.js documentation

*Node.js Addons are **dynamically-linked shared objects**, written in **C++**, that can be loaded into Node.js using the **require()** function, and used just as if they were an ordinary Node.js module.*

*They are used primarily to provide an **interface** between **JavaScript** running in Node.js and **C/C++** libraries.*

How is it possible?

All the **magic** is behind the **Node.js** architecture



Why?

Performance

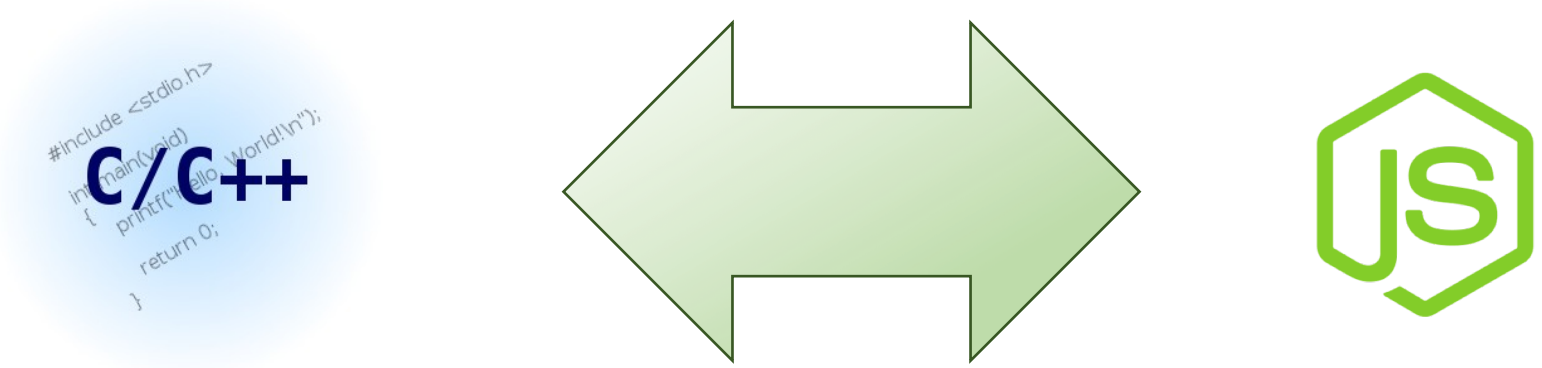
In general **C / C++** code performs better than JavaScript code, but it's not always true.

- **Image** processing (in average 6 times faster)
- **Video** processing
- **CRC** cyclic redundancy check (in average 125 times faster)
- **Compression**
- **Scientific calculus**
- **Algorithms that execute CPU heavy tasks**

Why?

Integrate legacy application

You have the source code of an **old C / C++** application and want to expose something of its functionalities



Why?

You don’t find what fits your specific needs on **npm**

Sometimes completely implementing the module in **JavaScript** is not the right solution

Think at libraries like:

ImageMagick

Ghostscript

FFmpeg

TensorFlow

…

Why?

Better error handling

Even if you will use **an old C / C++** library you will get an error code that explains the error that just happened

In **new C / C++** library you have the **exception**

You don’t have to parse some string to identify if there was an error and what kind of it

Problems

Fragmentation API

The API to implement native add-ons have been changed across different version of Node.js

Most of the changes were on **V8 API** and **ObjectWrap API**

0.8 - 0.10.x - 0.12.x - 1.x - 2.x - 3.x - 4.x - 5.x - 6.x - 7.x - 8.x - 9.x

For more info http://v8docs.nodesource.com/

Problems

Need an adapter to stay compatible across different version of Node.js

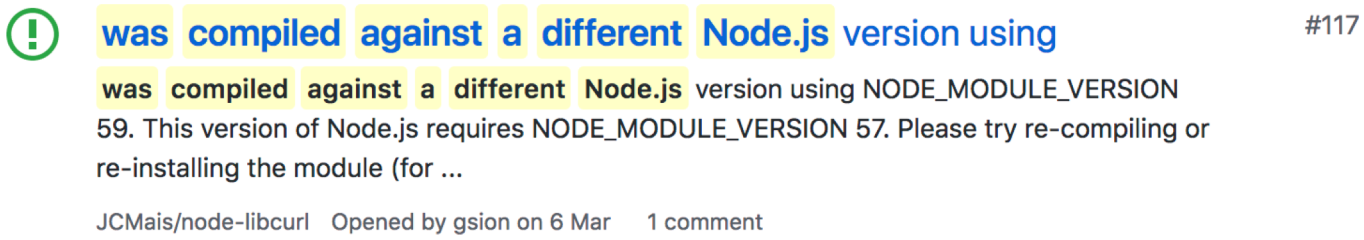
- **NAN** - Native Abstraction for Node.js
  - **API compatibility**
  - Strong bonded with **V8 API**
  - You have to recompile your native add-ons switching to different version of Node.js

Problems

End user

```
| was compiled against a different Node.js version using
| NODE_MODULE_VERSION 51. This version of Node.js requires
| NODE_MODULE_VERSION 57. Please try re-compiling or re-installing
| the module (for instance, using `npm rebuild` or `npm install`).
```

Mantainers



Problems

Write portable C / C++ code

Your native code **must compile and run** on different:

ARCHITECTURE

PLATFORM

COMPILER

Problems

Documentation

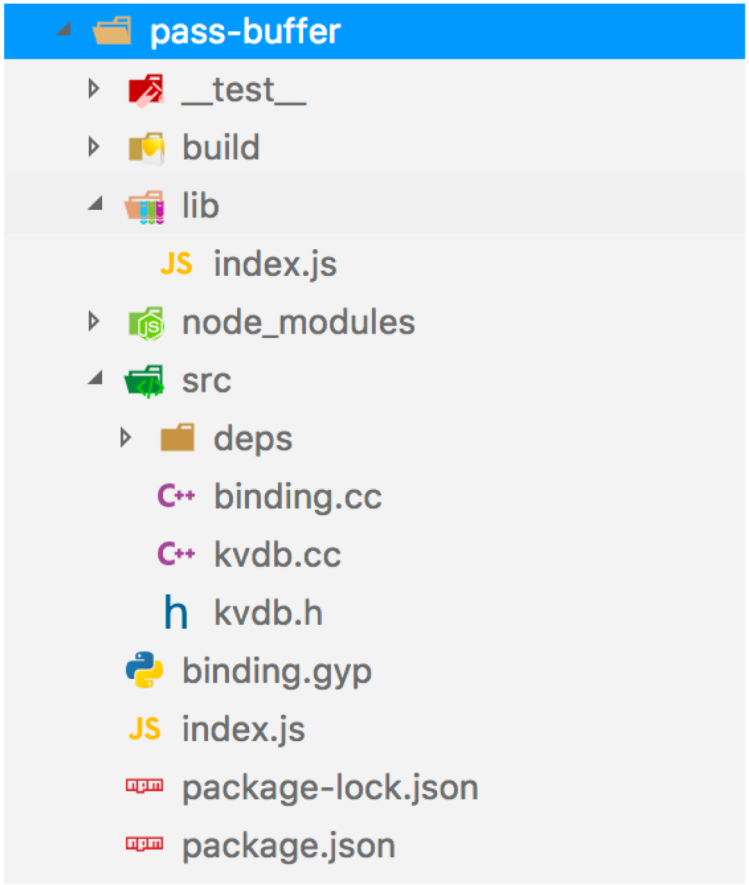
- **C / C++** libraries that you are integrating are not well documented
- There are good **references** but not so much practical guide focusing on complex concepts about native add-ons

N-API

N-API will be a game changer on the native add-on development

- **API** and **ABI** compatibility
- **Isolated** from **V8** (VM agnostic)
- New **ES6** types
- C / C++ (only header wrapper)
- **Conversion** tool that helps to migrate from **NAN**
- **Generator** (help with initial scaffolding)
- Pre-builds (**node-pre-gyp** - **prebuildify**)

How to organize your project



Example: the JavaScript part

```
{
  "name": "echo-example",
  "version": "0.0.0",
  "description": "Node.js Addons - echo example",
  "main": "index.js",
  "private": true,

  npm will build the add-on automatically

  "gypfile": true,

  "scripts": {
    "start": "node index.js"
  },
  "dependencies": {
    "node-addon-api": "*",
    "bindings": "*"
  }
}
```

Example: the JavaScript part

1

Import the add-on

```
const addon = require('bindings')('echo')
```

2

Call the add-on's function

```
let myEcho = addon.echo('Hey coders!')
console.log(myEcho)
```

Example: the **binding.gyp**

```
{
  "targets": [
    {
      "target_name": "echo",
      "sources": [
        "src/addon.cc"
      ],
      'cflags!': [ '-fno-exceptions' ],
      'cflags_cc!': [ '-fno-exceptions' ],
      'include_dirs': ["<!@(node -p \"require('node-addon-api').include\")"],
      'dependencies': ["<!(node -p \"require('node-addon-api').gyp\")"],
      'conditions': [
        ['OS=="win"', {
          "msvs_settings": {
            "VCCLCompilerTool": {
              "ExceptionHandling": 1
            }
          }
        }],
        ['OS=="mac"', {
          "xcode_settings": {
            "CLANG_CXX_LIBRARY": "libc++",
            'GCC_ENABLE_CPP_EXCEPTIONS': 'YES',
            'MACOSX_DEPLOYMENT_TARGET': '10.7'
          }
        }]
      ]
    }
  ]
}
```

Name used to register the addon

Example: the C / C++ part

```
Napi::Value Echo(const Napi::CallbackInfo& info) {
    Napi::Env env = info.Env();
```

3

Validate your input - Execute operations on them - Return results

```
    if (info[0].IsString()) {
        std::string in = info[0].As<Napi::String>();
        return Napi::String::New(env, in);
    } else {
        throw Napi::Error::New(env, "The argument must be a string");
    }
}
```

2

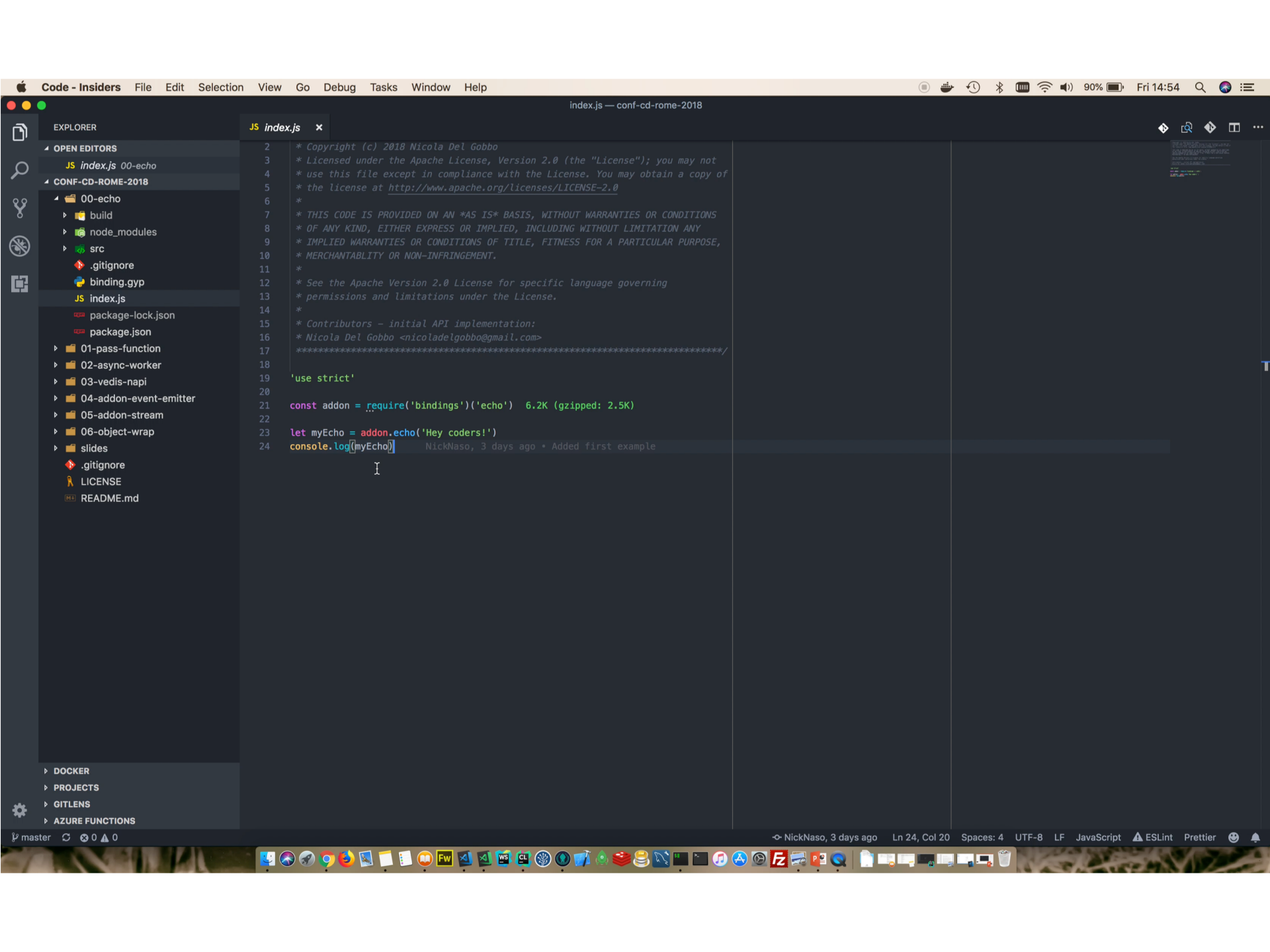
Export objects and functions

```
// Init
Napi::Object Init(Napi::Env env, Napi::Object exports) {
    exports.Set(Napi::String::New(env, "echo"), Napi::Function::New(env, Echo));
    return exports;
}
```

1

Registration and Initialization

```
NODE_API_MODULE(NODE_GYP_MODULE_NAME, Init);
```


Code - Insiders File Edit Selection View Go Debug Tasks Window Help
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EXPLORER
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index.js 00-echo
CONF-CD-ROME-2018
00-echo
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package-lock.json
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01-pass-function
02-async-worker
03-vedis-napi
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'use strict'
const addon = require('bindings')('echo') 6.2K (gzipped: 2.5K)
let myEcho = addon.echo('Hey coders!')
console.log(myEcho)
NickNaso, 3 days ago • Added first example
master
NickNaso, 3 days ago
Ln 24, Col 20
Spaces: 4
UTF-8
LF
JavaScript
ESLint
Prettier

Asynchronous code

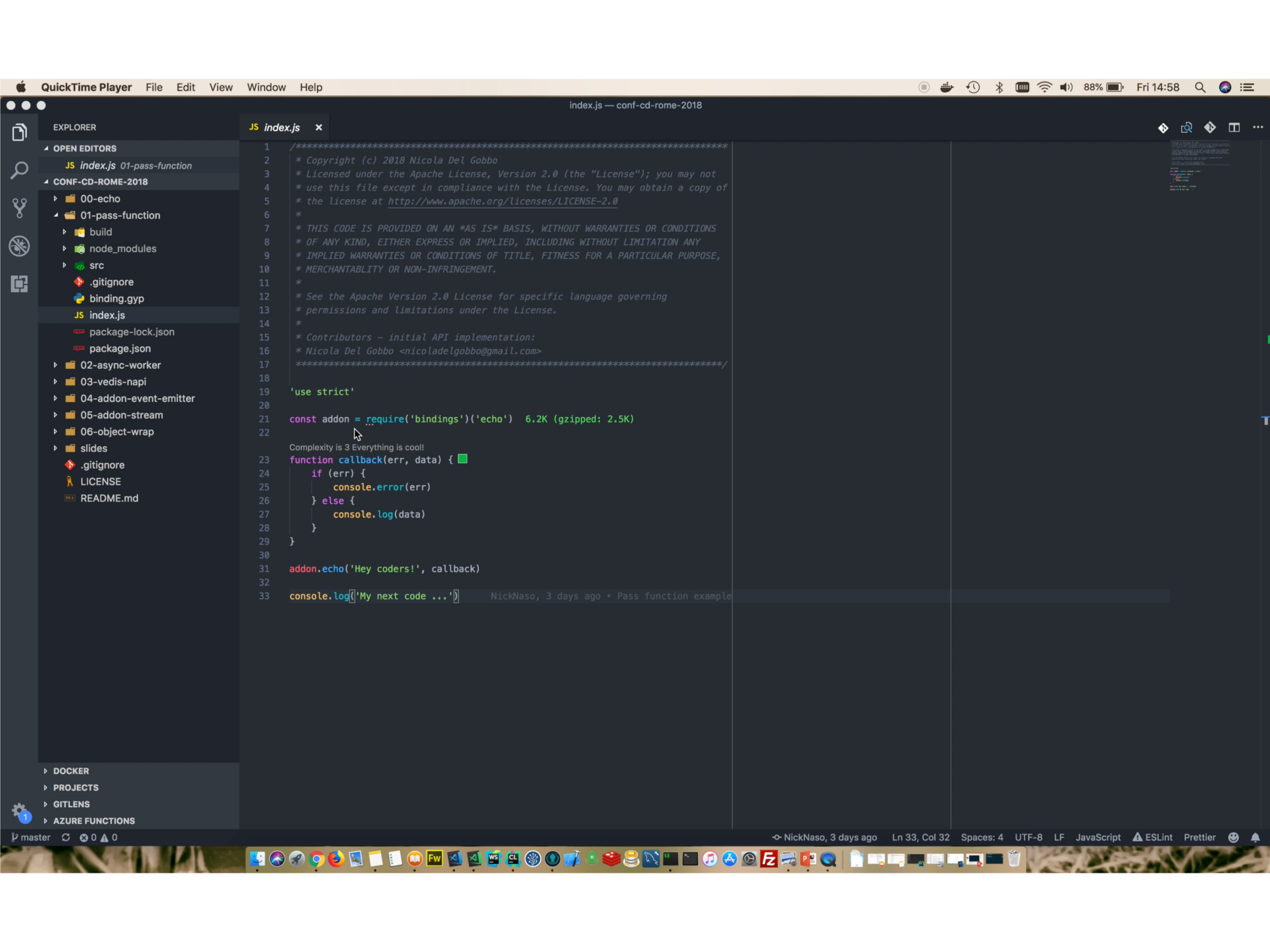
```
const addon = require('bindings')('echo')

function callback(err, data) {
    if (err) {
        console.error(err)
    } else {
        console.log(data)
    }
}

addon.echo('Hey coders!', callback) 2

console.log('My next code ...') 1
```

Asynchronous code

```
void Echo(const Napi::CallbackInfo& info) {
    Napi::Env env = info.Env();
    // You need to check the input data here
    Napi::Function cb = info[1].As<Napi::Function>();
    std::string in = info[0].As<Napi::String>();
    // std::this_thread::sleep_for(std::chrono::seconds(1));
    // In case of error
    // Napi::Error::New(env, "Error ...").Value()
```

Call a callback and return the result back

```
    cb.Call({env.Null(), Napi::String::New(env, in)});
}
```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CONF-CD-ROME-2018
00-echo
01-pass-function
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package-lock.json
package.json
02-async-worker
03-vedis-napi
04-addon-event-emitter
05-addon-stream
06-object-wrap
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***/
'use strict'
const addon = require('bindings')('echo') 6.2K (gzipped: 2.5K)
Complexity is 3 Everything is cool!
function callback(err, data) {
if (err) {
console.error(err)
} else {
console.log(data)
}
}
addon.echo('Hey coders!', callback)
console.log('My next code ...')
NickNaso, 3 days ago • Pass function example
master
NickNaso, 3 days ago
Ln 33, Col 32
Spaces: 4
UTF-8
LF
JavaScript
ESLint
Prettier

Asynchronous code

Preserve reference to function we want call

Create worker threads using libuv

Handle the results

AsyncWorker

```
class EchoWorker : public Napi::AsyncWorker {
    public:
        EchoWorker(Napi::Function& callback, std::string& echo)
        : Napi::AsyncWorker(callback), echo(echo) {}

        ~EchoWorker() {}

    // This code will be executed on the worker thread
    void Execute() {
        // Need to simulate cpu heavy task
        std::this_thread::sleep_for(std::chrono::seconds(1));
        // std::cout << echo << std::endl;
    }

    void OnOK() {
        Napi::HandleScope scope(Env());
        Callback().Call({Env().Null(), Napi::String::New(Env(), echo)});
    }


    private:
        std::string echo;
};
```

1 **This code will be executed on the Worker Thread**

2 **When the Execute method ends its computation the results will be reassembled and passed to JS context**

AsyncWorker

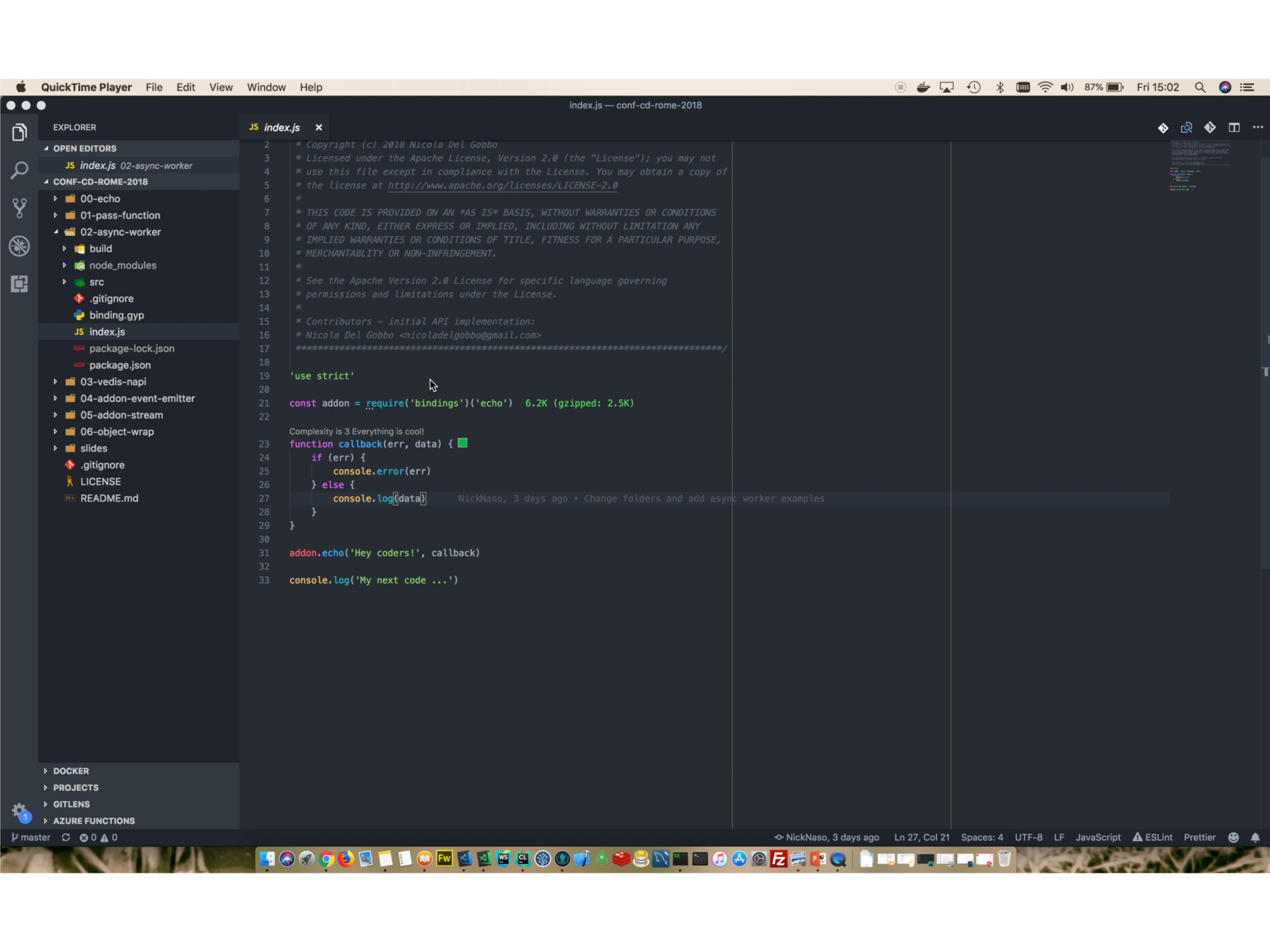
```
Napi::Value Echo(const Napi::CallbackInfo& info) {
    // You need to check the input data here
    Napi::Function cb = info[1].As<Napi::Function>();
    std::string in = info[0].As<Napi::String>();

    EchoWorker* wk = new EchoWorker(cb, in);
    wk->Queue();

    return info.Env().Undefined();
}
```

1 **Create AsyncWorker**

2 **Return immediately**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03-vedis-napi
04-addon-event-emitter
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Complexity is 3 Everything is cool!
function callback(err, data) {
if (err) {
console.error(err)
} else {
console.log(data)
NickNaso, 3 days ago • Change folders and add async worker examples
}
}
addon.echo('Hey coders!', callback)
console.log('My next code ...')
master
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JavaScript
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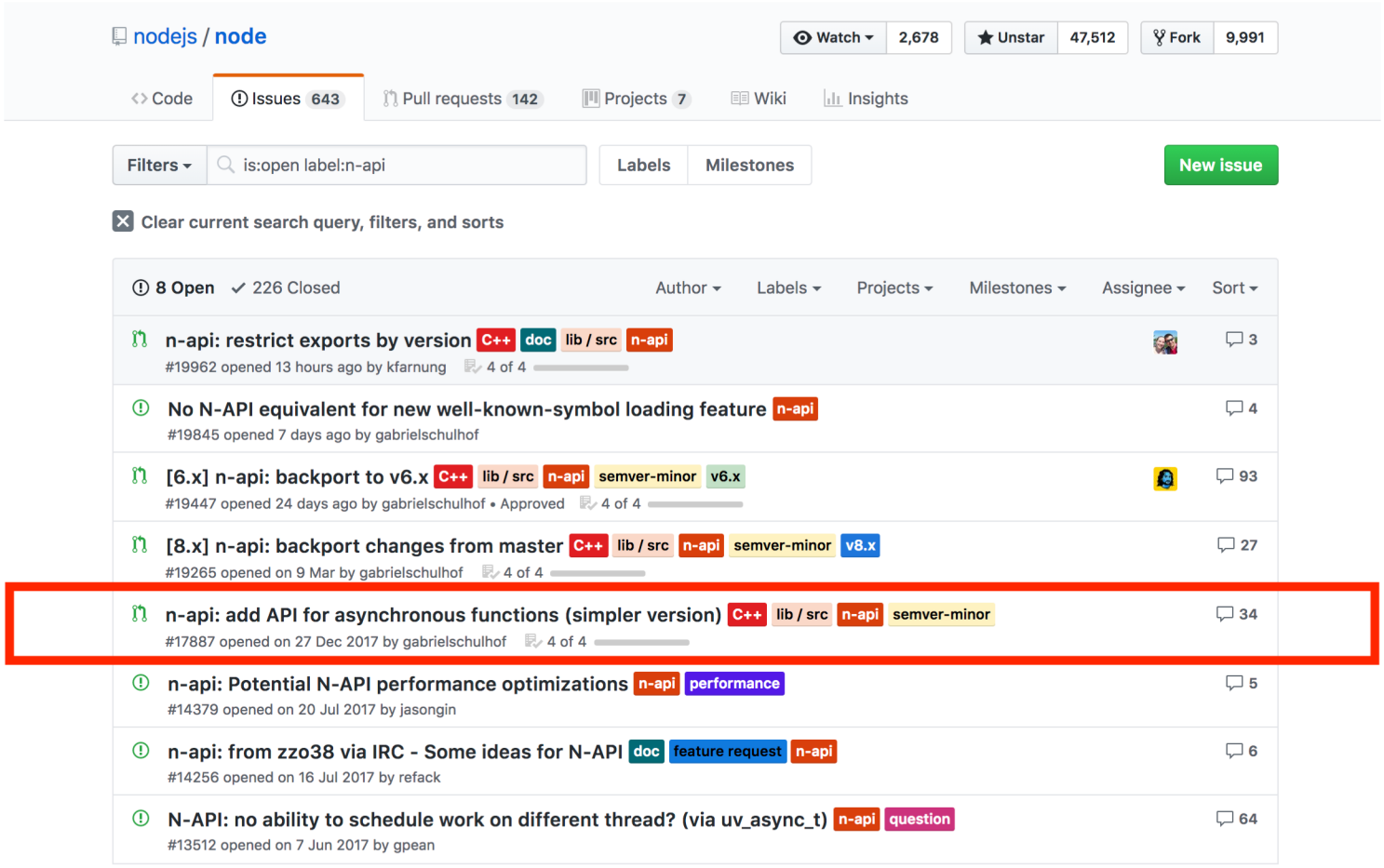
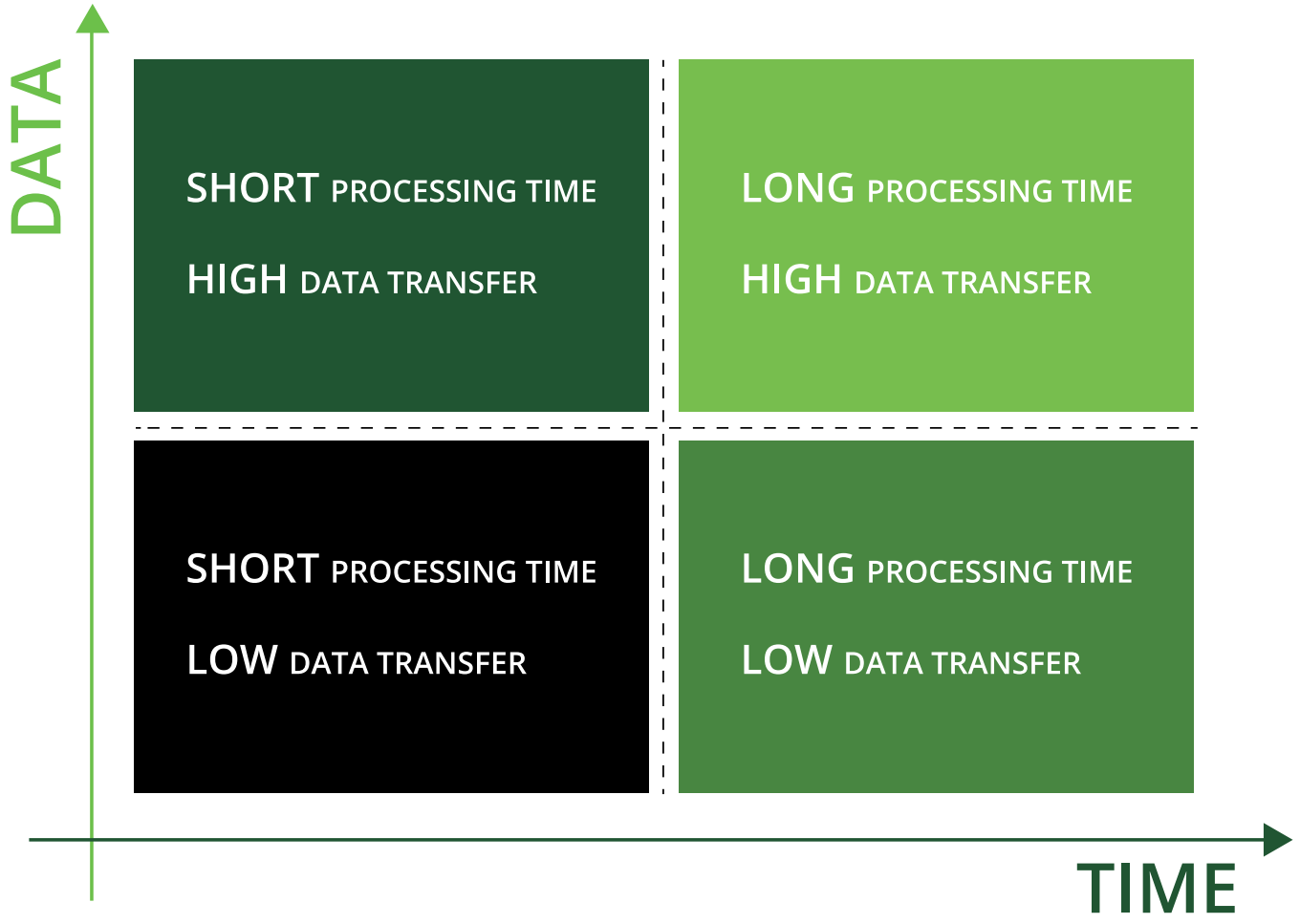
AsyncWorker

You cannot call JavaScript function from the Worker Thread until this PR will be landed



Which kind of add-on should you implement?



TIME: Amount of processing time spent on the **C++** code

DATA: Amount of data flowing between **C++** and **JavaScript**

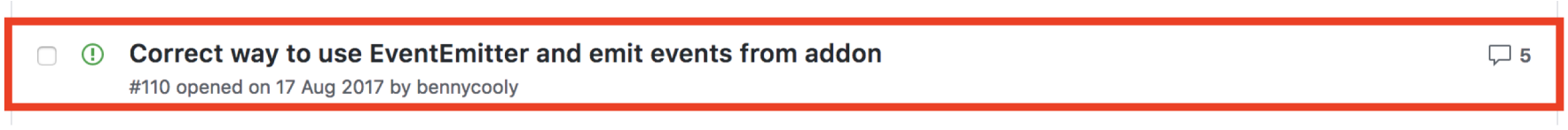
ObjectWrap API

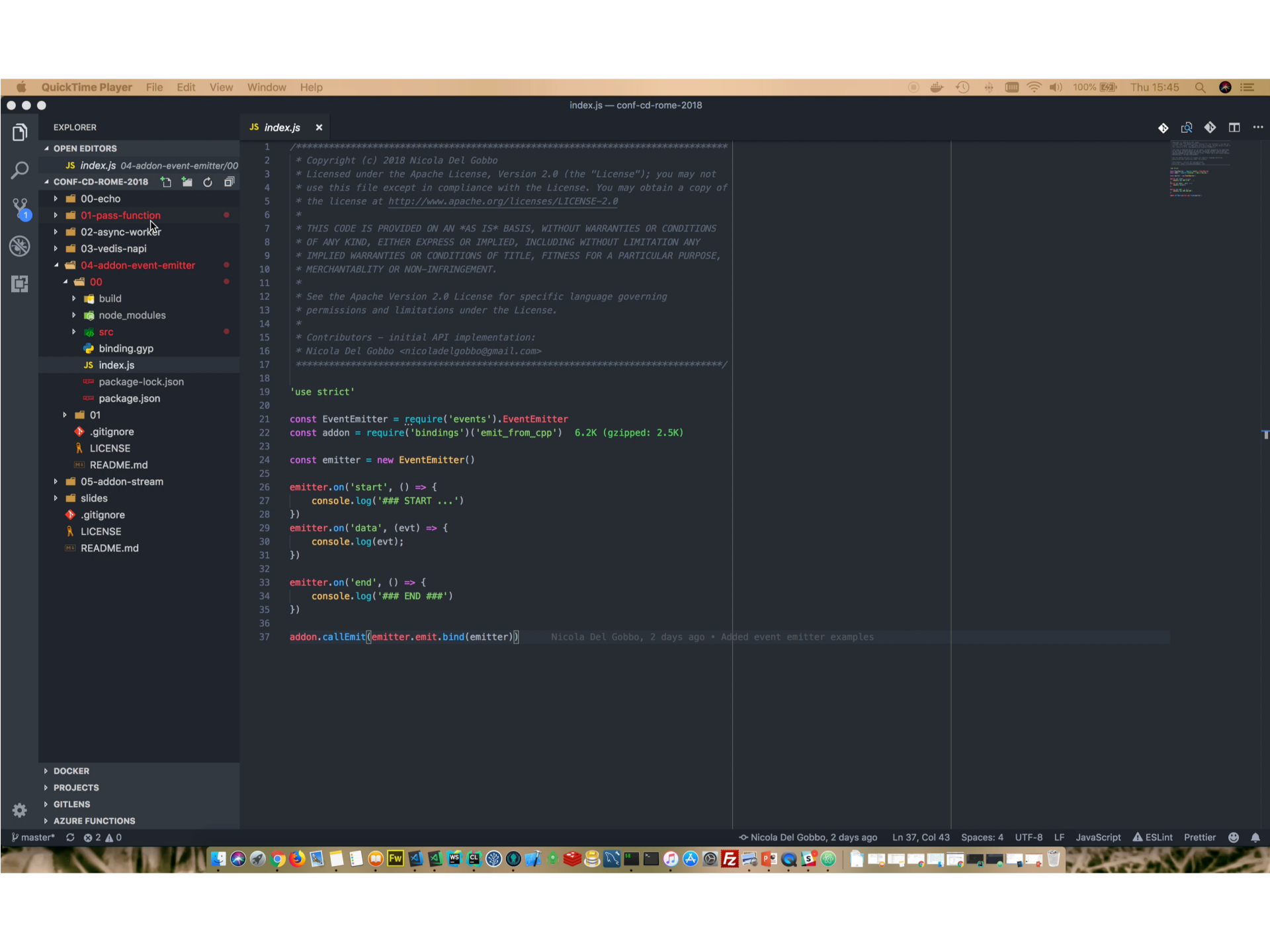
- **ObjectWrap** is a way to expose your C++ code to JavaScript
- You have to extend **ObjectWrap** class that includes the plumbing to connect JavaScript code to a C++ object
- Classes extending **ObjectWrap** can be instantiated from JavaScript using the **new** operator, and their methods can be **directly invoked from JavaScript**
- Unfortunately, the ***wrap*** part really refers to a way to group methods and state
- It's **your responsibility write custom code to bridge** each of your C++ class methods.

Event Emitter

Much of the Node.js core API modules are built aroud an idiomatic asynchronous event-driven architecture in which certains kinds of objects (called **emitter**) periodically emit named events that cause Function objects ("listeners") to be called.

- Emit event from **C++**
- Implement a native add-on object that inherits from Event Emitter

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03-vedis-napi
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*****/
'use strict'
const EventEmitter = require('events').EventEmitter
const addon = require('bindings')('emit_from_cpp') 6.2K (gzipped: 2.5K)
const emitter = new EventEmitter()
emitter.on('start', () => {
console.log('### START ...')
})
emitter.on('data', (evt) => {
console.log(evt);
})
emitter.on('end', () => {
console.log('### END ###')
})
addon.callEmit(emitter.emit.bind(emitter))
Nicola Del Gobbo, 2 days ago • Added event emitter examples
master*
Nicola Del Gobbo, 2 days ago
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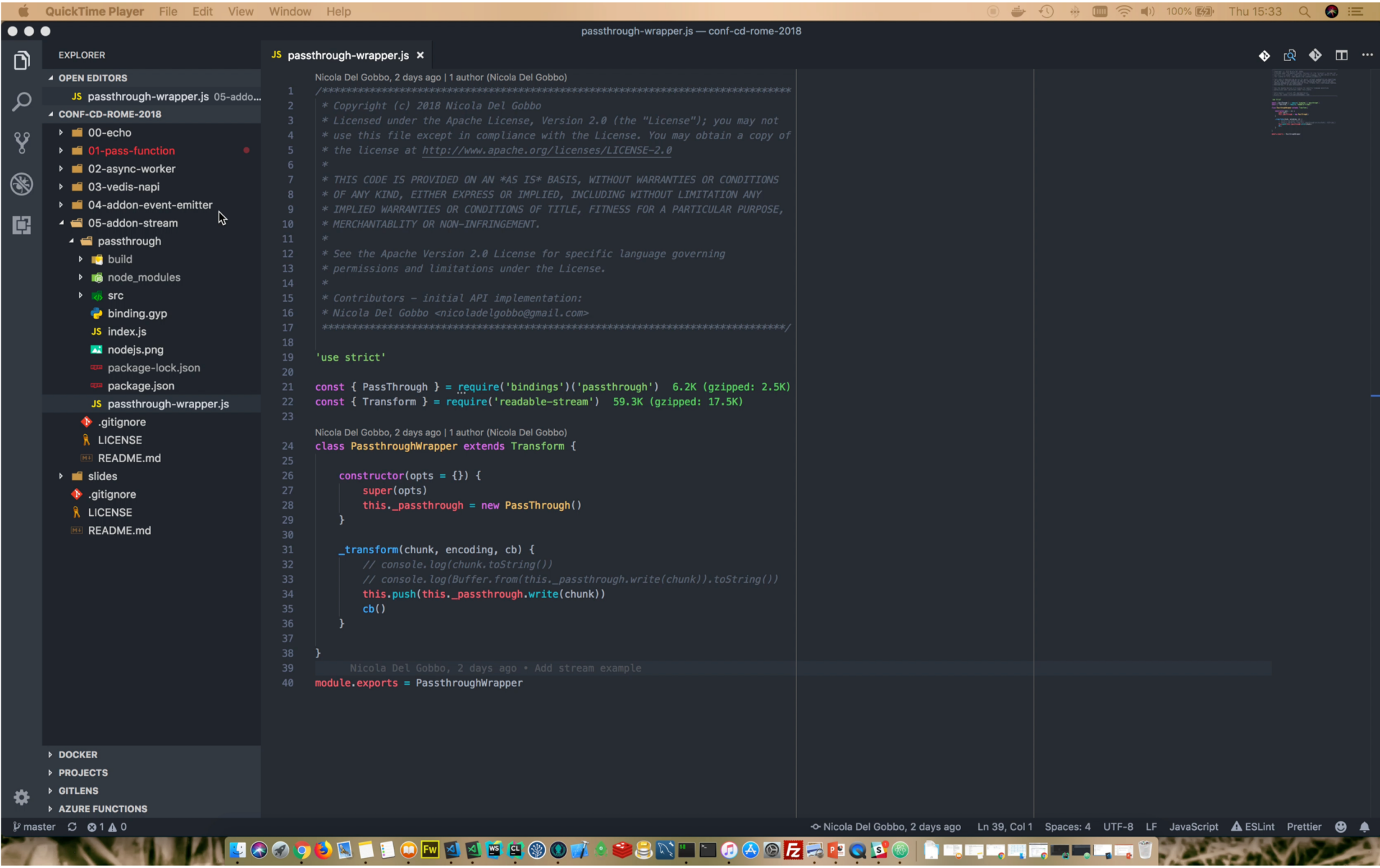
Stream

A stream is an abstract interface for working with streaming data in Node.js. The stream module provides a base API that makes it easy to build objects that implement the stream interface.

Using **Transform** stream to pass and get back data from a native add-on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passthrough-wrapper.js — conf-cd-rome-2018
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00-echo
01-pass-function
02-async-worker
03-vedis-napi
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*/
'use strict'
const { PassThrough } = require('bindings')('passthrough') 6.2K (gzipped: 2.5K)
const { Transform } = require('readable-stream') 59.3K (gzipped: 17.5K)
Nicola Del Gobbo, 2 days ago | 1 author (Nicola Del Gobbo)
class PassthroughWrapper extends Transform {
constructor(opts = {}) {
super(opts)
this._passthrough = new PassThrough()
}
_transform(chunk, encoding, cb) {
// console.log(chunk.toString())
// console.log(Buffer.from(this._passthrough.write(chunk)).toString())
this.push(this._passthrough.write(chunk))
cb()
}
}
Nicola Del Gobbo, 2 days ago • Add stream example
module.exports = PassthroughWrapper
master
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Lessons learned

- Create **simple interface** between C / C++ and JavaScript
- Think **carefully at JavaScript** interface
- Use **ObjectWrap** API to return C / C++ object to JavaScript
- Validate the **types** on the native side
- Expose **only the functionalities you need**
- **Don’t block the event loop**, stay **asynchronous**: this is a must if you will use the add-ons in high performance services
- Use **Buffer** to pass big quantity of data

Present and future

- The largest number of native add-ons is written using **NAN**
- N-API will be go out of experimental very soon
- Backports for 8.x
- Backports for 6.x
- Documentation for **node-addon-api**
- Porting preexistentes native addon-ons to N-API
- Investigate how to use prebuild with N-API

Implement key value database

Binding to **Vedis** an embeddable datastore **C** library

```
const { Database } = require('bindings')('kvdb')

const mydb = new Database('test', './tmp-sync')
console.log(mydb.db_name)

mydb.putKeySync("username", "NickNaso");
console.log(mydb.getKeySync("username"));
```

```
mydb.putKey('password', 'keeplooking', function (err) {
    if (err) {
        console.error(err)
    } else {
        console.log("Value stored")
    }
})

mydb.getKey('username', function(err, value) {
    if (err) {
        console.error(err)
    } else {
        console.log('Value from my async API')
        console.log(value)
    }
})
```

Thanks!

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Don’t be afraid sometimes it’s a good thing dirty your hands with a little of C++

All examples and materials are here

https://github.com/NickNaso/conf-cd-rome-2018