# You Don't Know Node

# You Don't Know Node, v2

## Quick Intro to Core Node

# Turn OFF laptops, phones, distractors and LISTEN

# Who am I? ¯_(ツ)_/¯

# Not Kyle Simpson

(Hint: He wrote "You Don't Know JS" series)

# My name is Azat Mardan and I the creator of Node University

# Azat Mardan and numbers

- 📚 14 books (not counting Korean, Chinese, Polish and Russian translations)
- 🎤 20+ conferences talks in 2016-17
- 👨‍💻 200+ blog posts on Webapplog: https://webapplog.com
- ⌨️ 239 top most active GitHub contributor, higher Paul Irish, Todd Motto, TJ Holowaychuk, John Papa, etc. (source)
- 🎓 19 online courses on Node University https://node.university












# Fun Facts

- Read ~270 books in last 4 years
- Check social media only once per week
- Prefer coffee with butter instead of milk
- Live in San Francisco Bay Area

# I know Node

- Storify - startup which we sold
- DocuSign - 50M users
- Capital One - Fortune 500

# I dislike compiled languages

Actually, just one. Java!

# My Mission is to Make a World a Better Place

# My Plan

Software helps people

+

Node is a good tool to build good software

=

I need to teach as many people Node as possible

# My Goal (for this talk)

Spike your interest in core Node features

# Starting with basics: Why Use Node?

Input/output is one of the most expensive type tasks (>CPU) 💰

# Node has non-blocking I/O




# Overview of Blocking vs Non-Blocking

This overview covers the difference between **blocking** and **non-blocking** calls in Node.js. This overview will refer to the event loop and libuv but no prior knowledge of those topics is required. Readers are assumed to have a basic understanding of the JavaScript language and Node.js callback pattern.

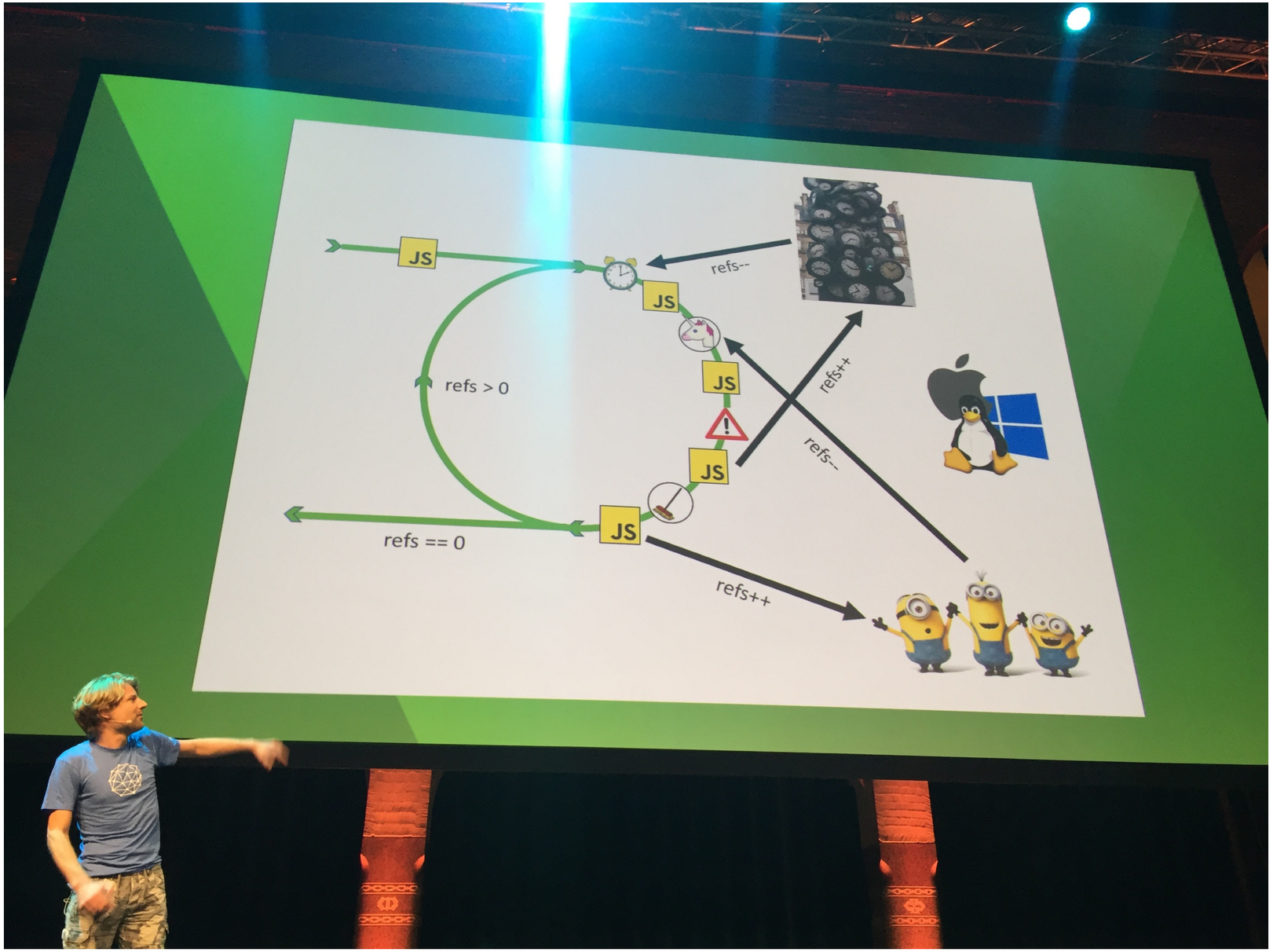
> "I/O" refers primarily to interaction with the system's disk and network supported by libuv.

## Blocking

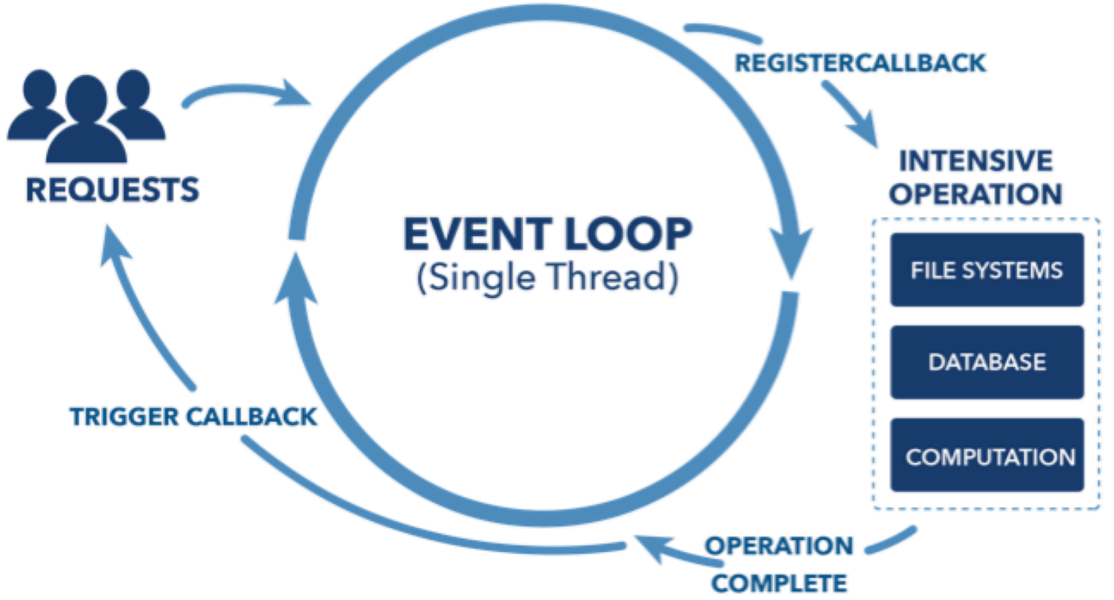
**Blocking** is when the execution of additional JavaScript in the Node.js process must wait until a non-JavaScript operation completes. This happens because the event loop is unable to continue running JavaScript while a **blocking** operation is occurring.

In Node.js, JavaScript that exhibits poor performance due to being CPU intensive rather than waiting on a non-JavaScript operation, such as I/O, isn't typically referred to as **blocking**. Synchronous methods in the Node.js standard library that use libuv are the most commonly used **blocking** operations. Native modules may also have **blocking** methods.

All of the I/O methods in the Node.js standard library provide asynchronous versions, which are **non-blocking**, and accept callback functions. Some methods also have **blocking** counterparts, which have names that end with `Sync`.



# TECH | NON-BLOCKING I/O



# Java Sleep

```
System.out.println("Step: 1");
System.out.println("Step: 2");
Thread.sleep(1000);
System.out.println("Step: 3");
```

# Node "Sleep"

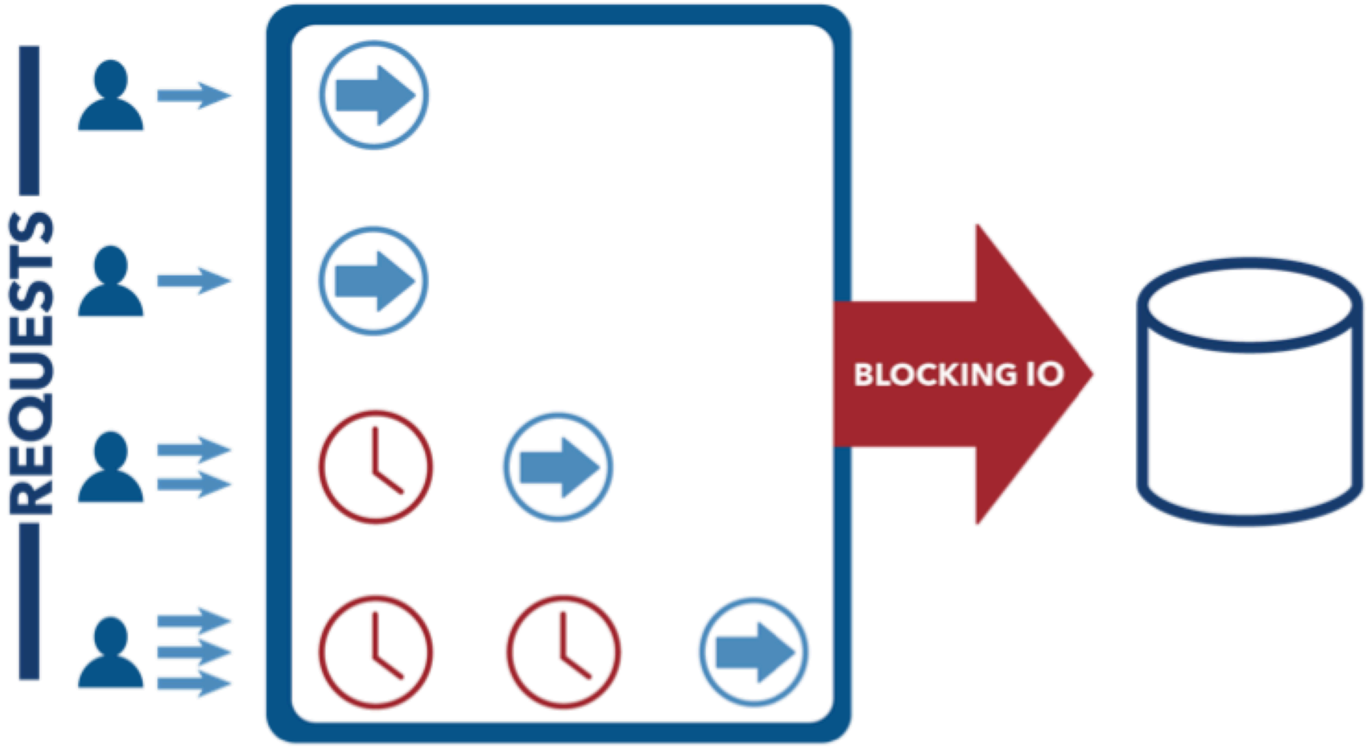
```
console.log('Step: 1')
setTimeout(function () {
  console.log('Step: 3')
}, 1000)
console.log('Step: 2')
```

# Process Multiple Tasks

```
console.log('Step: 1')
setTimeout(function () {
  console.log('Step: 3')
  // console.log('Step 5')
}, 1000);
console.log('Step: 2')
// console.log('Step 4')
```

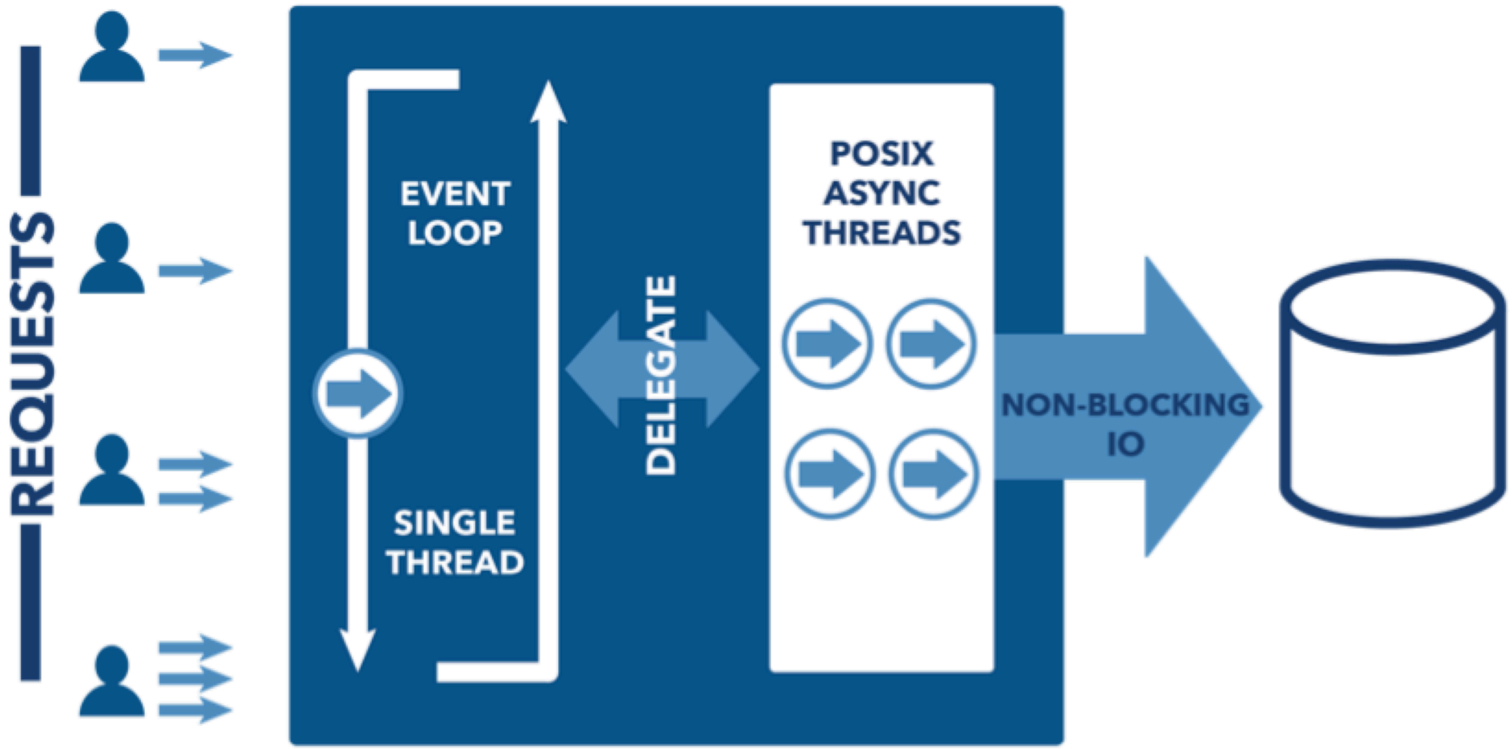
# Blocking Web Server

# BLOCKING I/O



# Non-Blocking Web Server

# TECH | NON-BLOCKING I/O



# [Multi-threading] is the software equivalent of a nuclear device because if it is used incorrectly, it can blow up in your face.

http://blog.codinghorror.com/threading-concurrency-and-the-most-powerful-psychokinetic-explosive-in-the-univ

# Blocking systems have to be multi-threaded

# Node is single threaded... and that's good! 😄

It's still possible to write blocking code in Node.js. 😳

# Blocking Node.js Code

```
// blocking.js
console.log('Step: 1')
for (var i = 1; i<1000000000; i++) {
  // This will take 100-1000ms
}
console.log('Step: 2')
```

# Blocking Node.js Code

```
var fs = require('fs')

var contents = fs.readFileSync('accounts.txt','utf8')
console.log(contents)
console.log('Hello Ruby\n')

var contents = fs.readFileSync('ips.txt','utf8')
console.log(contents)
console.log('Hello Node!')
//accounts.txt->Hello Ruby->ips.txt->Hello Node!
```

# Non-Blocking Node.js Code

```
var fs = require('fs')

fs.readFile('accounts.txt','utf8', function(error, contents){
   console.log(contents)
})
console.log('Hello Ruby\n')

fs.readFile('ips.txt','utf8', function(error, contents){
   console.log(contents)
})
console.log('Hello Node!')
//Hello Ruby->Hello Node->... accounts.txt->ips.txt or ips.txt->accounts.txt
```

# Node *typically* is much faster than other platforms

How many of you reach the performance limitations of apps built with blocking I/O systems?

# Probably not many

# My Fav Node Benefit

# JavaScript everywhere. One language to rule 'em all!

# When one language is used everywhere

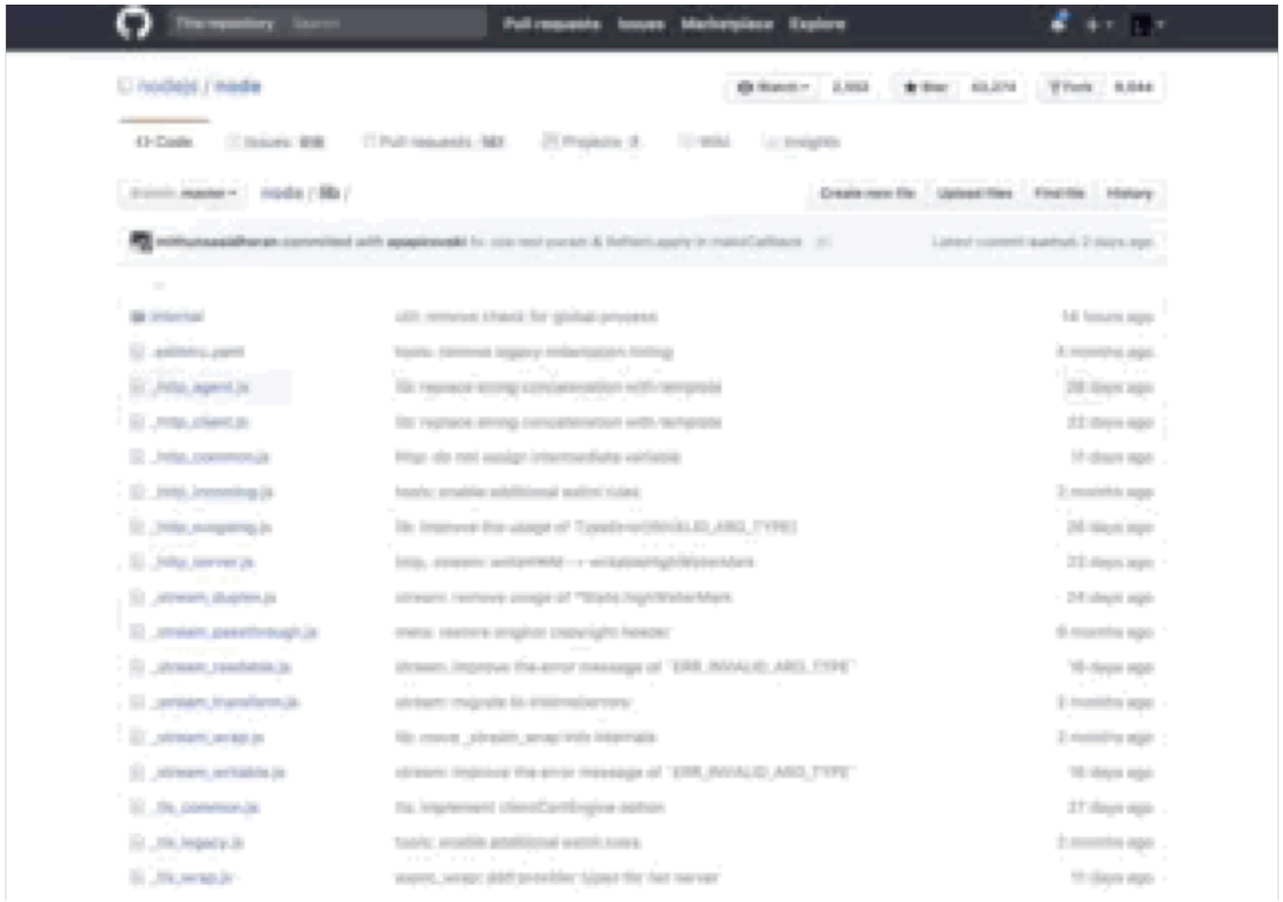
- Think faster
- Reuse code
- Learn quicker

# Most of Node is JavaScript

- Array
- String
- Primitives
- Functions
- Objects

# Node !== Browser JavaScript

# Node Core Modules



# How to create global variables (no `window` in Node), work with modules, get path to my script?

# `global`

Now available everywhere in your code

# It has properties!

```
global.__filename

global.__dirname
```

```
global.module
global.require()
```

# How do I...?

- Access CLI input?
- Get system info: OS, platform, memory usage, versions, etc.?
- Read env vars (passwords!)?

`global.process` or `process`

```
process.pid

process.versions

process.arch
```

# process.argv

# process.env

```
process.uptime()

process.memoryUsage()
```

```
process.cwd()
```

```
process.exit()
process.kill()
```

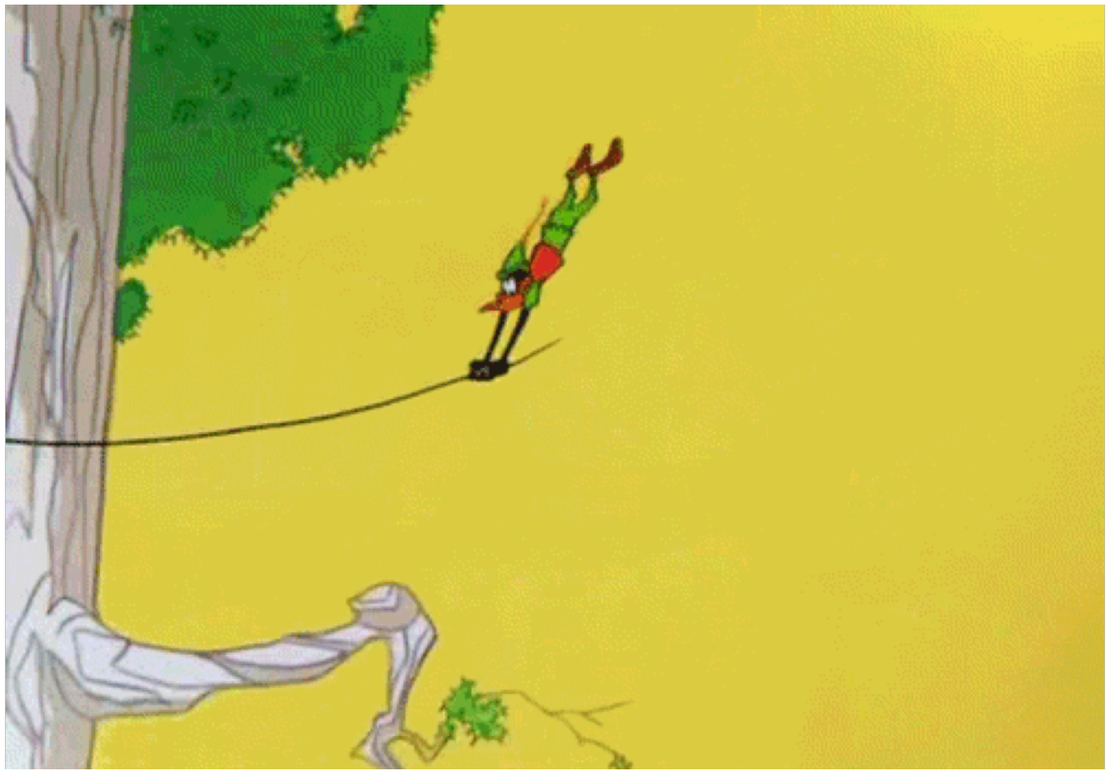
# Who likes and understands callbacks? 🙋‍♀️

# http://callbackhell.com

```
fs.readdir(source, function (err, files) {
  if (err) {
    console.log('Error finding files: ' + err)
  } else {
    files.forEach(function (filename, fileIndex) {
      console.log(filename)
      gm(source + filename).size(function (err, values) {
        if (err) {
          console.log('Error identifying file size: ' + err)
        } else {
          console.log(filename + ' : ' + values)
          aspect = (values.width / values.height)
          widths.forEach(function (width, widthIndex) {
            height = Math.round(width / aspect)
            console.log('resizing ' + filename + 'to ' + height + 'x' + height)
            this.resize(width, height).write(dest + 'w' + width + '_' + filename, function(err) {
              if (err) console.log('Error writing file: ' + err)
            })
          }.bind(this))
        }
      })
    })
  }
})
```

Callbacks are not very developmental scalable 😞

# Me When Working With Deeply Nested Callbacks



# Events

Events are part of core and supported by most of the core modules while more advanced patterns such as promises, generators, async/await are not.

# Events == Node Observer Pattern

- Subject
- Observers (event listeners) on a subject
- Event triggers

# Events

```
var events = require('events')
var emitter = new events.EventEmitter()
```

# Events

In node.js an event can be described simply as a string with a corresponding callback.

```
emitter.on('done', function(results) {
  console.log('Done: ', results)
})
```

# Using Event Emitters

```
var events = require('events')
var emitter = new events.EventEmitter()

emitter.on('knock', function() {
  console.log('Who\'s there?')
})

emitter.on('knock', function() {
  console.log('Go away!')
})

emitter.emit('knock')
```

# Inheriting from EventEmitter

```
// job.js
var util = require('util')
var Job = function Job() {
  // ...
  this.process = function() {
    // ...
    job.emit('done', { completedOn: new Date() })
  }
}

util.inherits(Job, require('events').EventEmitter)
module.exports = Job
```

# Inheriting from EventEmitter

```
// weekly.js
var Job = require('./job.js')
var job = new Job()

job.on('done', function(details){
  console.log('Job was completed at', details.completedOn)
  job.removeAllListeners()
})

job.process()
```

# Listeners

```
emitter.listeners(eventName)
emitter.on(eventName, listener)
emitter.once(eventName, listener)
emitter.removeListener(eventName, listener)
```

# Resources to Learn Node Patterns

- Node Patterns: From Callbacks to Observer: http://webapplog.com/node-patterns-from-callbacks-to-observer
- https://github.com/azat-co/node-patterns
- Node.js Design Patterns, Second Edition by Mario Casciaro, Luciano Mammino

# Problems with Large Data

- Speed: Too slow because has to load all
- Buffer limit: ~1Gb
- Overhyped (JK)

# Streams

## Abstractions for continuous chunking of data

# No need to wait for the entire resource to load

# Types of Streams

- Readable
- Writable
- Duplex
- Transform

# Streams Inherit from Event Emitter

# Streams are Everywhere!

- HTTP requests and responses
- Standard input/output (stdin&stdout)
- File reads and writes

# Readable Stream Example

`process.stdin`

Standard input streams contain data going into applications.

This is achieved via a read operation.

Input typically comes from the keyboard used to start the process.

To listen in on data from stdin, use the `data` and `end` events:

```
// stdin.js
process.stdin.resume()
process.stdin.setEncoding('utf8')

process.stdin.on('data', function (chunk) {
  console.log('chunk: ', chunk)
})

process.stdin.on('end', function () {
  console.log('--- END ---')
})
```

# Demo

```
$ node stdin.js
```

# New Interface `read()`

```
var readable = getReadableStreamSomehow()
readable.on('readable', () => {
  var chunk
  while (null !== (chunk = readable.read())) {
    console.log('got %d bytes of data', chunk.length)
  }
})
```

# Writable Stream Example

`process.stdout`

Standard output streams contain data going out of the applications.

This is done via a write operation.

Data written to standard output is visible on the command line.

# Writable Stream

To write to `stdout`, use the `write` function:

```
process.stdout.write('A simple message\n')
```

# What about HTTP?

```
const http = require('http')
var server = http.createServer( (req, res) => {
  req.setEncoding('utf8')
  req.on('data', (chunk) => {
    transform(chunk) // This functions is defined somewhere else
  })
  req.on('end', () => {
    var data = JSON.parse(body)
    res.end()
  })
})

server.listen(1337)
```

# Pipe

```
var r = fs.createReadStream('file.txt')
var z = zlib.createGzip()
var w = fs.createWriteStream('file.txt.gz')
r.pipe(z).pipe(w)
```

# What data type to use for binary data?

# Buffers

Binary data type, to create:

- `Buffer.alloc(size)`
- `Buffer.from(array)`
- `Buffer.from(buffer)`
- `Buffer.from(str[, encoding])`

Docs: http://bit.ly/1IeAcZ1

# Working with Buffer

```
// buf.js
var buf = Buffer.alloc(26)
for (var i = 0 ; i < 26 ; i++) {
  buf[i] = i + 97 // 97 is ASCII a
}
console.log(buf) // <Buffer 61 62 63 64 65 66 67 68 69 6a 6b 6c 6d 6e 6f 70 71 72 73 74 75 76 77 78 79 7a>
console.log(buf.toString('utf8')) // abcdefghijklmnopqrstuvwxyz
```

# Buffer Convertion

```
buf.toString('ascii') // outputs: abcdefghijklmnopqrstuvwxyz
buf.toString('ascii', 0, 5) // outputs: abcde
buf.toString('utf8', 0, 5) // outputs: abcde
buf.toString(undefined, 0, 5) // encoding defaults to 'utf8', outputs abcde
```

# Remember fs?

```
fs.readFile('/etc/passwd', function (err, data) {
  if (err) return console.error(err)
  console.log(data)
});
```

`data` is buffer!

# Demo

```
$ node server-stream
```

# Streams and Buffer Demo

```
// server-stream.js
app.get('/stream', function(req, res) {
  var stream = fs.createReadStream(largeImagePath)
  stream.pipe(res)
})

$ node server-stream
```

http://localhost:3000/stream
http://localhost:3000/non-stream

# Results in DevTools

`/stream` responds faster!

`X-Response-Time`
`~300ms vs. 3-5s`

# Stream Resources

Stream automated workshop: https://github.com/substack/stream-adventure

```
$ sudo npm install -g stream-adventure
$ stream-adventure
```

https://github.com/substack/stream-handbook

# How to scale a single threaded system?

# Cluster Usage

- Master: starts workers
- Worker: do the job, e.g., HTTP server

Number of processes = number of CPUs

# Clusters

```
var cluster = require('cluster')
var numCPUs = require('os').cpus().length
if (cluster.isMaster) {
  for (var i = 0; i < numCPUs; i++) {
    cluster.fork()
  }
} else if (cluster.isWorker) {
  // your server code
})
```

# Cluster Demo

1. Run `code/cluster.js` with node (`$ node cluster.js`).
2. Install `loadtest` with npm: `$ npm install -g loadtest`
3. Run load testing with: `$ loadtest  http://localhost:3000 -t 20 –c 10`

Press control+c on the server terminal

# Cluster Libraries

- Core cluster: lean and mean
- strong-cluster-control (https://github.com/strongloop/strong-cluster-control), or `$ slc run`: good choice
- pm2 (https://github.com/Unitech/pm2): good choice

# pm2

https://github.com/Unitech/pm2

http://pm2.keymetrics.io

Advantages:

- Load-balancer and other features
- 0s reload down-time, i.e., forever alive
- Good test coverage

# pm2 Demo: Typical Express Server

```
var express = require('express')
var port = 3000
global.stats = {}
console.log('worker (%s) is now listening to http://localhost:%s',
 process.pid, port)
var app = express()
app.get('*', function(req, res) {
  if (!global.stats[process.pid]) global.stats[process.pid] = 1
  else global.stats[process.pid] += 1;
  var l ='cluser '
    + process.pid
    + ' responded \n';
  console.log(l, global.stats)
  res.status(200).send(l)
})
app.listen(port)
```

# pm2 Demo

Using `server.js`:

```
$ pm2 start server.js -i 0
```

In a new window:

```
$ loadtest  http://localhost:3000 -t 20 -c 10
$ pm2 list
```

# Spawn vs Fork vs Exec

- `require('child_process').spawn()` - large data, stream, no new V8 instance
- `require('child_process').fork()` - new V8 instance, multiple workers
- `require('child_process').exec()` - buffer, async, all the data at once

# Spawn Example

```
fs = require('fs')
process = require('child_process')
var p = process.spawn('node', 'program.js')
p.stdout.on('data', function(data)) {
  console.log('stdout: ' + data)
})
```

# Fork Example

```
fs = require('fs')
process = require('child_process')
var p = process.fork('program.js')
p.stdout.on('data', function(data)) {
  console.log('stdout: ' + data)
})
```

# Exec Example

```
fs = require('fs')
process = require('child_process')
var p = process.exec('node program.js', function (error, stdout, stderr) {
  if (error) console.log(error.code)
})
```

# There are few more methods

- child_process.execFile()
- child_process.execSync()
- child_process.execFileSync()

# How to handle async errors?

# Handling Async Errors

Event Loop: Async errors are harder to handle/debug, because system loses context of the error. Then, application crashes.

Try/catch is not good enough.

# Synchronous Error in Node

```
try {
  throw new Error('Fail!')
} catch (e) {
  console.log('Custom Error: ' + e.message)
}
```

For sync errors try/catch works fine.

# Async Error Example

```
try {
  setTimeout(function () {
    throw new Error('Fail!')
  }, Math.round(Math.random()*100))
} catch (e) {
  console.log('Custom Error: ' + e.message)
}
```

The app crashes!

# Me When Async Error's Thrown

# Async Errors

How to deal with it?

# Best Practices for Async Errors?

- Listen to all “on error” events
- Listen to `uncaughtException`
- Use `domain` (soft deprecated) or AsyncWrap
- Log, log, log & Trace
- Notify (optional)
- Exit & Restart the process

# on('error')

Anything that inherits from or creates an instance of the above: Express, LoopBack, Sails, Hapi, etc.

```
server.on('error', function (err) {
  console.error(err)
})
```

# on('error') Chained Method Example

```
var http = require(‘http’)
var server = http.createServer(app)
  .on('error', function(e) {
    console.log(‘Failed to create server’)
    console.error(e)
    process.exit(1)
  })
```

# on(‘error’) Named Variable Example

```
var req = http.request(options, function(res) {
  // … processing the response
})

req.on('error', function(e) {
  console.log('problem with request: ' + e.message)
})
```

# uncaughtException

`uncaughtException` is a very crude mechanism for exception handling. An unhandled exception means your application - and by extension Node.js itself - is in an undefined state. Blindly resuming means anything could happen.

# uncaughtException

Always listen to `uncaughtException`!

```
process.on(‘uncaughtException’, handle)
```

or

```
process.addListener('uncaughtException', handle)
```

# uncaughtException Expanded Examples

```
process.on('uncaughtException', function (err) {
  console.error('uncaughtException: ', err.message)
  console.error(err.stack)
  process.exit(1)
})
```

or

```
process.addListener('uncaughtException', function (err) {
  console.error('uncaughtException: ', err.message)
  console.error(err.stack)
  process.exit(1)
```

# Domain

(Just out of curiosity)

# Domain Example

```
let domain = require('domain').create()
domain.on('error', function(error){
  console.log(error)
})
domain.run(function(){
  throw new Error('Failed!')
})
```

# Domain with Async Error Demo

## domain-async.js:

```
let d = require('domain').create()
d.on('error', function(e) {
    console.log('Custom Error: ' + e)
})
d.run(function() {
  setTimeout(function () {
    throw new Error('Failed!')
  }, Math.round(Math.random()*100))
})
```

# Source code for Domain

https://github.com/nodejs/node/blob/master/lib/domain.js

```
var _domain = [null];
Object.defineProperty(process, 'domain', {
  enumerable: true,
  get: function() {
    return _domain[0];
  },
  set: function(arg) {
    return _domain[0] = arg;
  }
});
```

# Domain overwrites uncaught exception

```
if (process.hasUncaughtExceptionCaptureCallback()) {
  throw new errors.Error('ERR_DOMAIN_CALLBACK_NOT_AVAILABLE');
}

process.on('removeListener', (name, listener) => {
  if (name === 'uncaughtException' &&
      listener !== domainUncaughtExceptionClear) {
    // If the domain listener would be the only remaining one, remove it.
    const listeners = process.listeners('uncaughtException');
    if (listeners.length === 1 && listeners[0] === domainUncaughtExceptionClear)
      process.removeListener(name, domainUncaughtExceptionClear);
  }
});
```

# C++ Addons

# How to Write C/C++ binding for your IoT, hardware, drone, smartdevice, etc.?

# Node and C++

## Create the `hello.cc` file:

```
#include <node.h>

namespace demo {

using v8::FunctionCallbackInfo;
using v8::HandleScope;
using v8::Isolate;
using v8::Local;
using v8::Object;
using v8::String;
using v8::Value;
```

# Node and C++

## Create the `hello.cc` file:

```
void Method(const FunctionCallbackInfo<Value>& args) {
  Isolate* isolate = args.GetIsolate();
  args.GetReturnValue().Set(String::NewFromUtf8(isolate, "capital one"));
}

void init(Local<Object> exports) {
  NODE_SET_METHOD(exports, "hello", Method);
}

NODE_MODULE(addon, init)

}  // namespace demo
```

# Creating `binding.gyp`

Create `binding.gyp`:

```
{
  "targets": [
    {
      "target_name": "addon",
      "sources": [ "hello.cc" ]
    }
  ]
}
```

# node-gyp

```
$ npm install -g node-gyp
```

https://github.com/nodejs/node-gyp

# Configuring and Building

```
$ node-gyp configure
$ node-gyp build
```

Check for compiled `.node` files in build/Release/

# C++ Addons Examples

https://github.com/nodejs/node-addon-examples

# Including Addon

Create `hello.js` and include your C++ addon:

```
var addon = require('./build/Release/addon')
console.log(addon.hello()) // 'capital one'
```

Run

```
$ node hello.js
```

# Moaaarr *core* Node

- NAPI
- Crypto
- HTTP/2
- Node modules
- npm commands and scripts

# 30-Second Summary

1. Event Emitters
2. Streams
3. Buffers
4. Clusters
5. C++ Addons
6. Domain

# There are big, big, big problems

- 2 days
- 5 days
- 8 days

# New information

- Repetition
- Immersion
- Practice

# Solution: You Don't Know Node Online Course


https://node.university/p/you-dont-know-node

# Sign up for Node University NOW!


Node.University is the ultimate resource for the best online Node education!

https://node.university 🚀

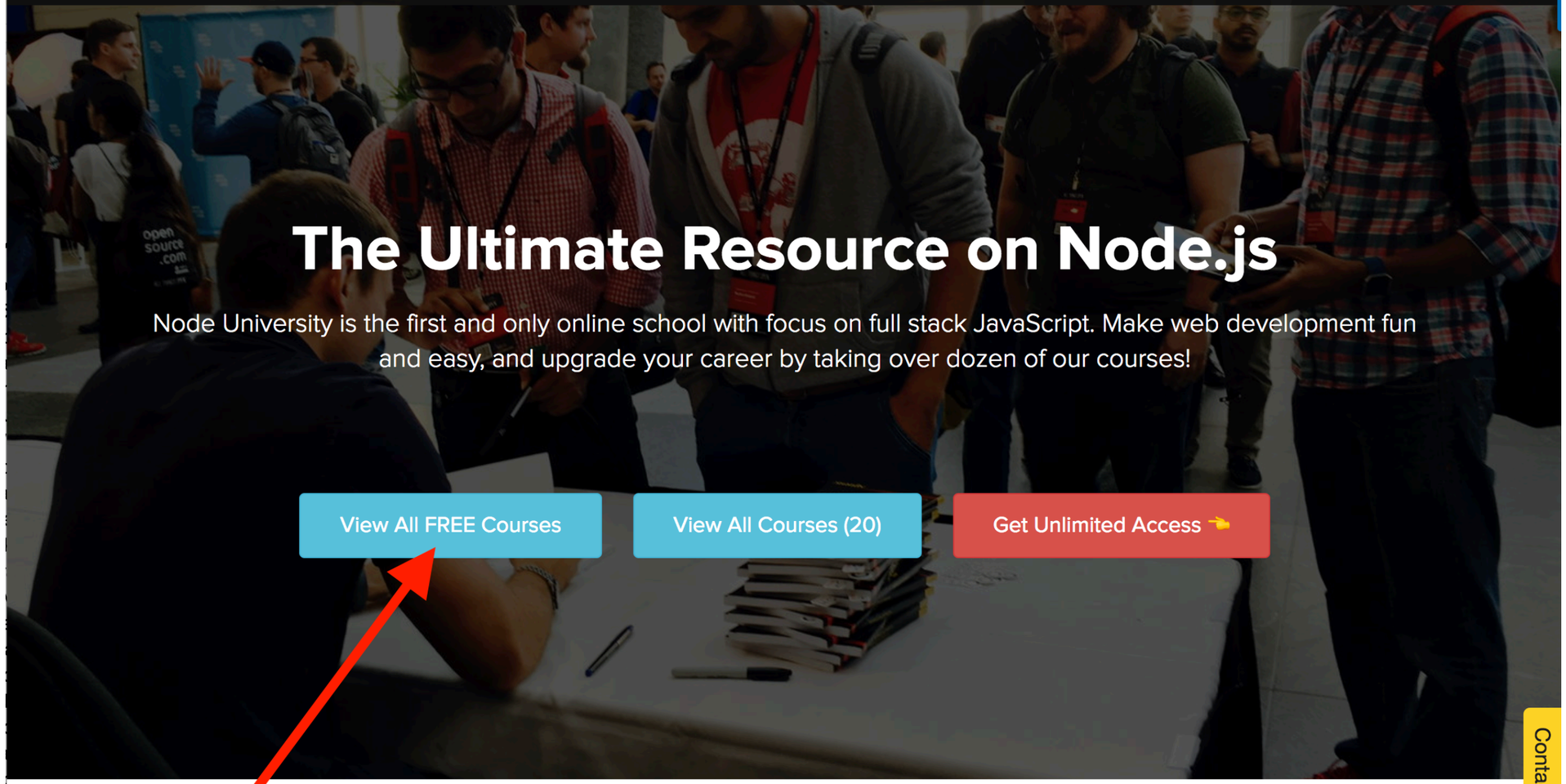
# This is how to do it

# Take out your laptops or phones  

Seriously. Do it now!

# Go to node.university

(https://node.university in Safari, Chrome, Edge)



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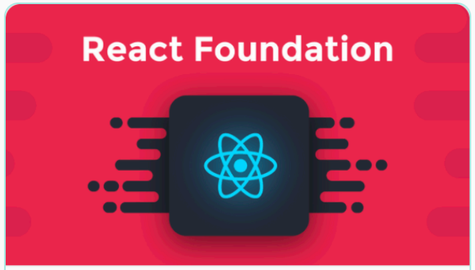


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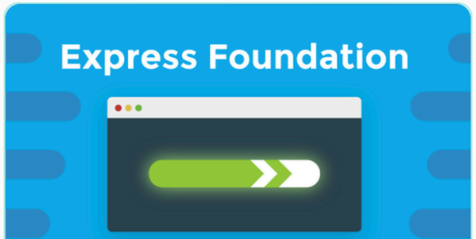


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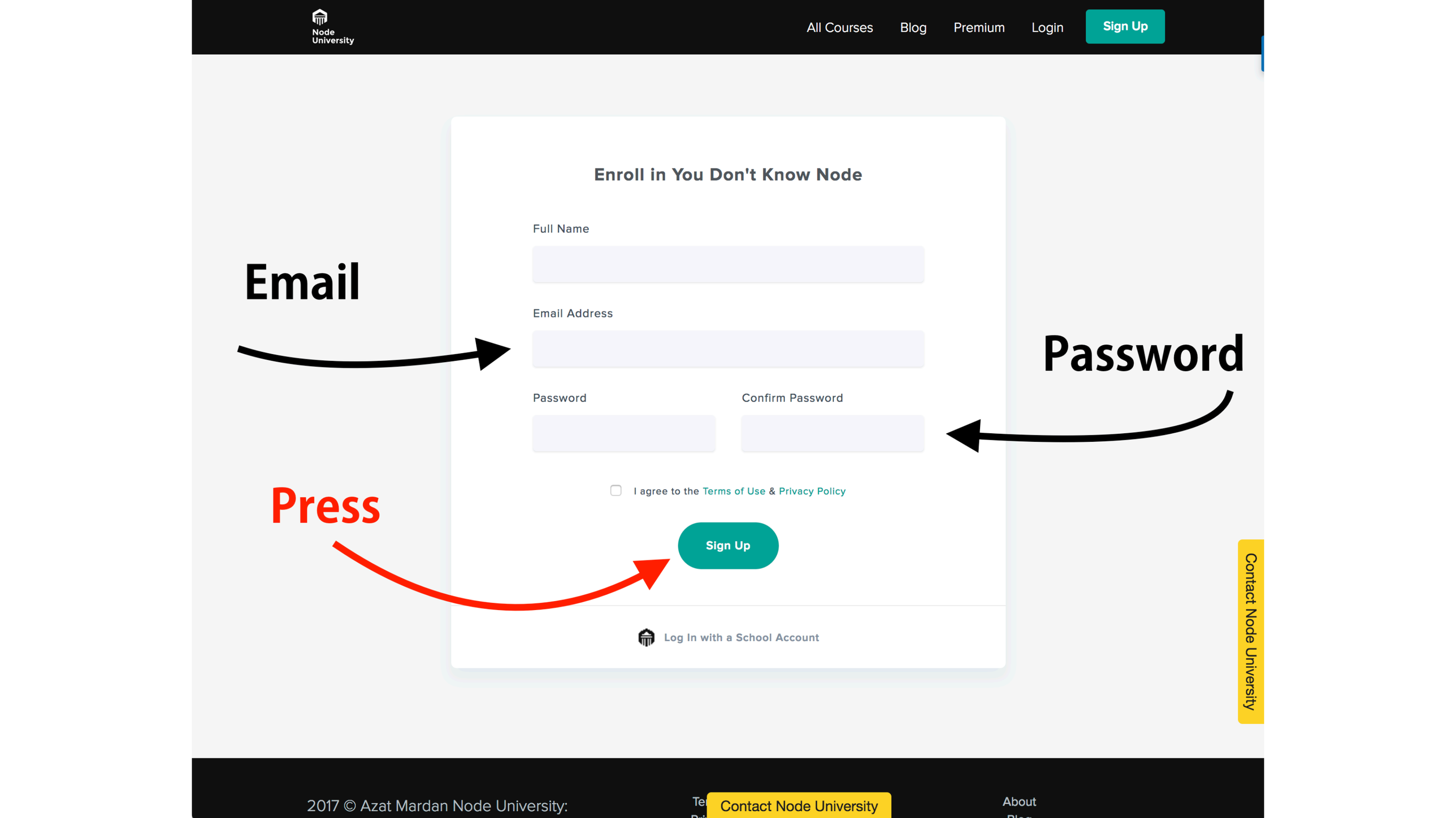
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# One Last Thing 👉

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**Atwood's Law**

Any application that *can* be written in JavaScript, *will* eventually be written in JavaScript.

# The End