You Don't Know Node

Quick Intro to 5 Core Features

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Who is the instructor?

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About Instructor: Azat Mardan

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About Instructor: Azat Mardan

- Work: Technology Fellow at Capital One (kind of a big deal)
- Experience: FDIC, NIH, DocuSign, HackReactor and Storify
- Books: React Quickly, Practical Node.js, Pro Express.js, Express.js API and 8 others
- Teach: NodeProgram.com

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What to Expect from this Course

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Topics

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

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Why listen?

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- Better code
- DRY
- New approaches

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Starting with basics: Why Use Node?

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

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Node has non-blocking I/O

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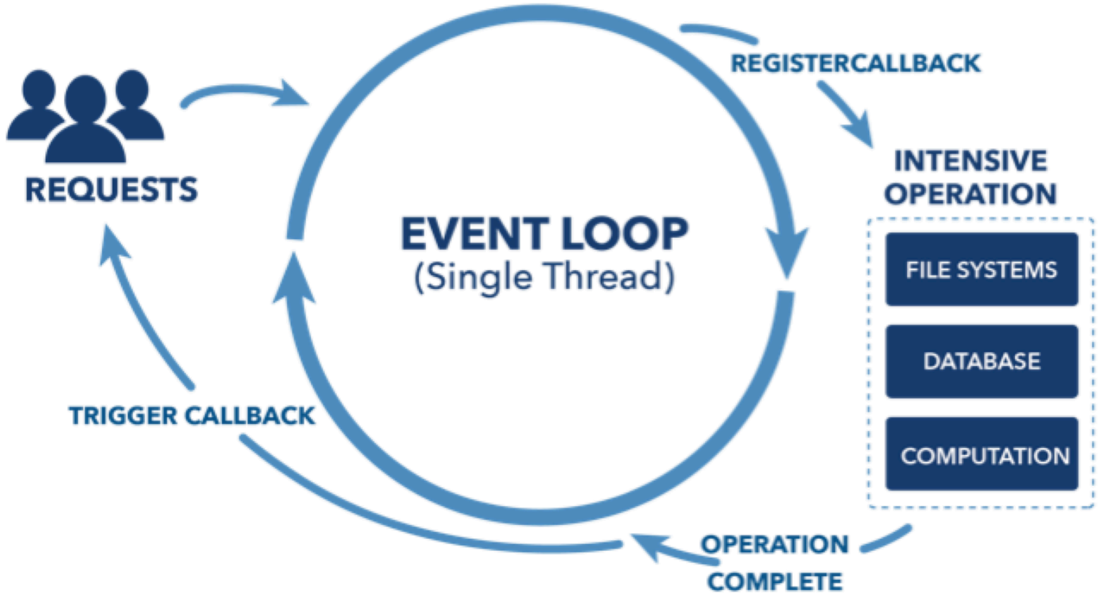
TECH | NON-BLOCKING I/O



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Java Sleep

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

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Node "Sleep"

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

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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')
```

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Blocking Web Server

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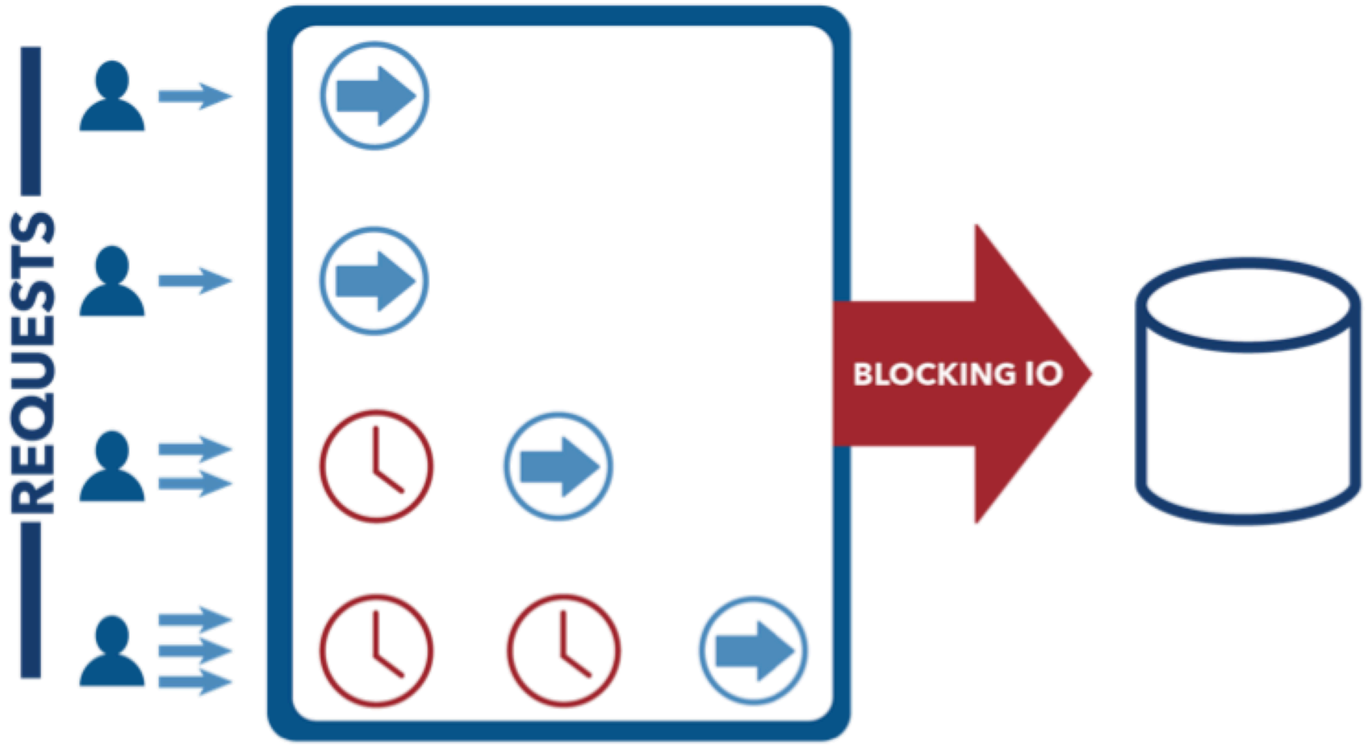
BLOCKING I/O



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Non-Blocking Web Server

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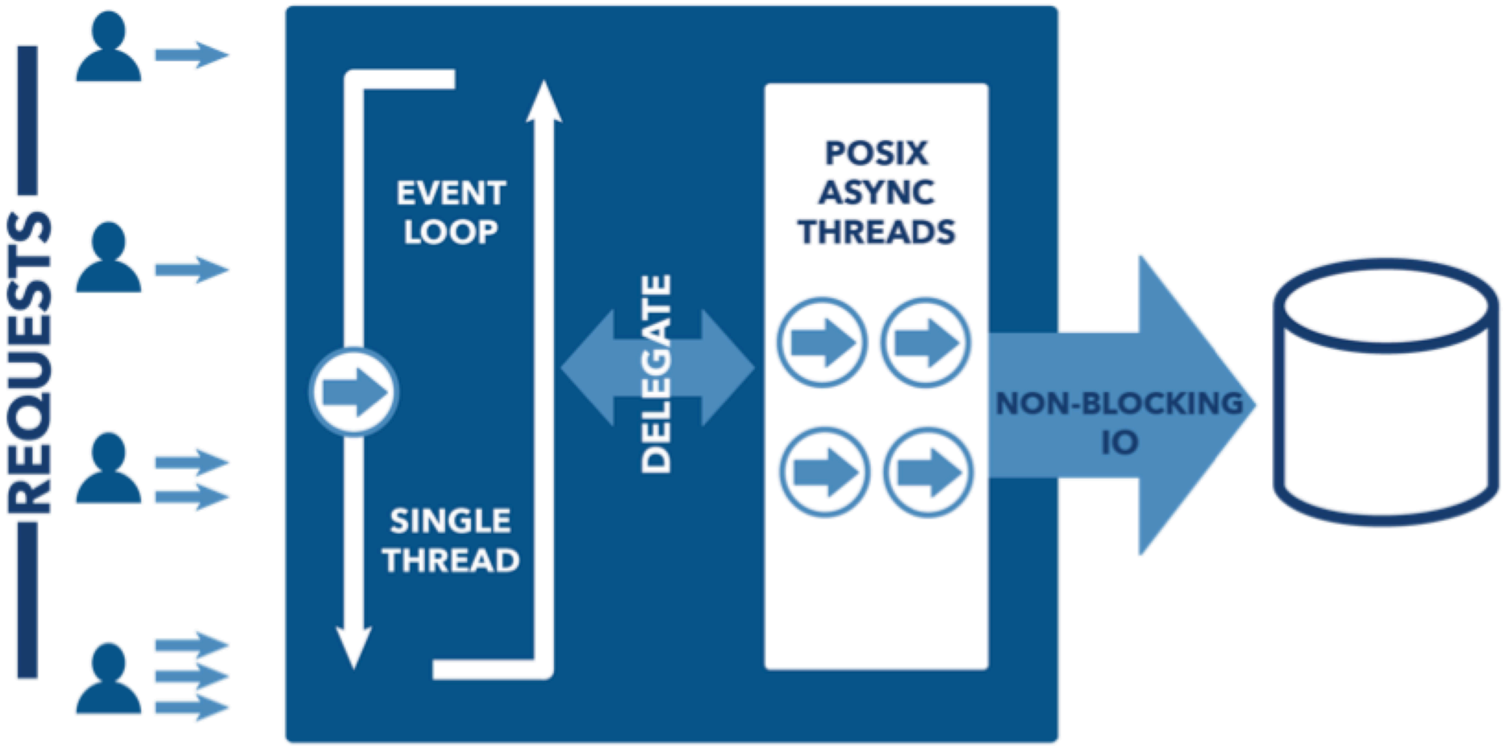
NON-BLOCKING I/O



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[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

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Blocking systems have to be multi-threaded

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Node is single threaded… and that's good! 😄

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

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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')
```

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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!
```

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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
```

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Node *typically* is much faster than other platforms

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

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Probably not many

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My Fav Node Benefit

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JavaScript everywhere. One language to rule 'em all!

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- Think faster
- Reuse code
- Learn quicker

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Most of Node is JavaScript

- Array
- String
- Primitives
- Functions
- Objects

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Node !== Browser JavaScript

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

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`global` or `GLOBAL`

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It has properties!

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```
global.__filename
global.__dirname
```

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global.module
global.require()

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How do I…?

» Access CLI input?

» Get system info: OS, platform, memory usage, versions, etc.?

» Read env vars (passwords!)?

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`global.process` or `process`

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```
process.pid
process.versions
process.arch
```

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process.argv

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process.env

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process.uptime()
process.memoryUsage()

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process.cwd()

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

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Event Emitters

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Who likes and understands callbacks?

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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))
        }
      })
    })
  }
})
```

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Callbacks are not very developmental scalable 😞

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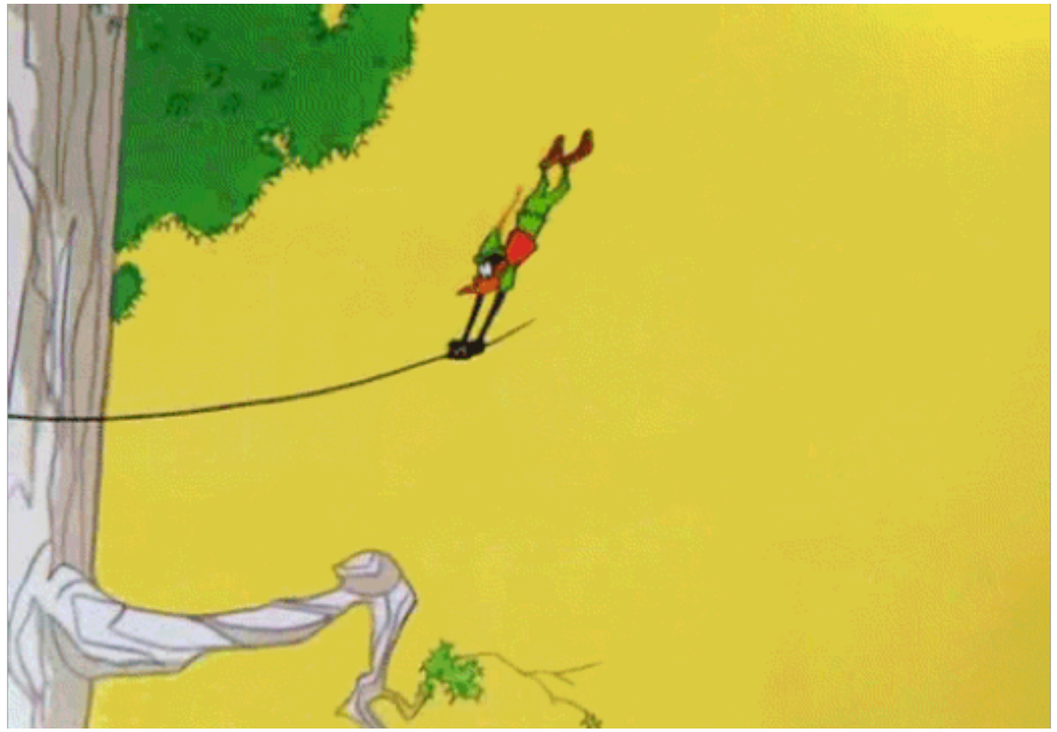
Me When Working With Deeply Nested Callbacks



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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.

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Events == Node Observer Pattern

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

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Events

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

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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)
})
```

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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')
```

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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
```

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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()
```

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Listeners

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

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Other Node Patterns

Node Patterns: From Callbacks to Observer: http://webapplog.com/node-patterns-from-callbacks-to-observer/

or

https://github.com/azat-co/node-patterns

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Stream

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Problems with Large Data

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

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Streams

Abstractions for continuous chunking of data

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No need to wait for the entire resource to load

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Types of Streams

- Readable
- Writable
- Duplex
- Transform

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Streams Inherit from Event Emitter

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Streams are Everywhere!

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

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Readable Stream Example

`process.stdin`

Standard input streams contain data going into applications.

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This is achieved via a read operation.

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

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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 ---')
})
```

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Demo

```
$ node stdin.js
```

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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)
  }
})
```

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Writable Stream Example

`process.stdout`

Standard output streams contain data going out of the applications.

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This is done via a write operation.

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

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Writable Stream

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

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

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What about HTTP?

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

server.listen(1337)
```

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Pipe

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

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What data type to use for binary data?

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Buffers

Binary data type, to create:

```
>> Buffer.alloc(size)

>> Buffer.from(array)

>> Buffer.from(buffer)

>> Buffer.from(str[, encoding])
```

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

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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
```

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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
```

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Remember fs?

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

`data` is buffer!

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Demo

```
$ node server-stream
```

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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

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Results in DevTools

`/stream` responds faster!

`X-Response-Time`

`~300ms vs. 3-5s`

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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

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Cluster

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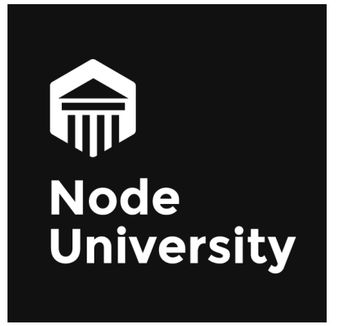

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Cluster Usage

» Master: starts workers

» Worker: do the job, e.g., HTTP server

Number of processes = number of CPUs

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Clusters

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

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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

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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

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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

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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)
```

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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
```

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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

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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)
})
```

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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)
})
```

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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)
})
```

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Async Errors

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How to handle async errors?

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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.

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Synchronous Error in Node

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

For sync errors try/catch works fine.

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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!

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Me When Async Error's Thrown

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Async Errors

How to deal with it?

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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

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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)
})
```

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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)
  })
```

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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)
})
```

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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.

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uncaughtException

Always listen to `uncaughtException`!

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

or

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

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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)
```

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Domain

This module is softly deprecated in 4.0 (most likey will be separate from core module), but there's no alternatives in core as of now.

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Domain Example

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

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Domain with Async Error Demo

domain-async.js:

```
var 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))
});
```

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You Don't Know Node

C++ Addons

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C++ Addons

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

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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;
```

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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
```

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Creating `binding.gyp`

Create `binding.gyp`:

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

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node-gyp

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

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

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Configuring and Building

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

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

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C++ Addons Examples

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

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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
```

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30-Second Summary

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

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One Last Thing

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CodingHorror.com

Atwood's Law

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

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