

Robust Error Handling in Node.js

Who are you?

- I'm Lewis, I like JavaScript, I work for Sentry
- Sentry is the open source crash reporting & error tracking service
- I maintain raven-node, the Sentry Node.js SDK.
 - It captures and reports about 100 million errors per week

**Why should you want
robust error handling
in Node?**

**This talk is for you
if...**

You've ever written code like this:

```
fs.readFile('myFile.txt', { encoding: 'utf8' }, function (err, data) {  
  console.log(data);  
});
```

Or this:

```
http.get(myUrl, function (res) {  
    doSomethingWith(res);  
});
```

Or even this:

```
try {  
    data = JSON.parse(userInput);  
} catch (e) {  
    // this should never happen  
}  
doSomethingWith(data);
```

"this should never happen"

Famous last words

We can do better!

This is a little better:

```
fs.readFile('myFile.txt', { encoding: 'utf8' }, function (err, data) {  
    if (err) return console.error(err);  
    doSomethingWith(data);  
});
```

**But we can do a lot
better**

Overview of topics

- Background and how Node is special/different
- Handle what you can, avoid what you can't
- The robust game plan to follow
- Exceptions, Callbacks, Promises, EventEmitters, and more
- Catching, reporting, shutting down, restarting gracefully

Error Mechanisms in Other Languages

- Python: `try/except` and `raise`
- Ruby: `begin/rescue` and `raise`
- PHP: `try/catch` and `throw`
- Lua: `pcall()` and `error()`

**So Node has some
similar thing, right?**

Well, sure, this works:

```
try {  
    throw new Error('boom!');  
} catch (e) {  
    console.log('Aha! I caught the error!');  
}
```


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```
$ node try-catch.js
```

Well, sure, this works:

```
try {  
    throw new Error('boom!');  
} catch (e) {  
    console.log('Aha! I caught the error!');  
}
```

```
$ node try-catch.js
```

```
> Aha! I caught the error!
```

But where try-catch comes up short:

```
try {  
  setTimeout(function () {  
    throw new Error('boom!');  
  }, 0);  
} catch (e) {  
  console.log('Aha! I caught the error!');  
}
```

But where try-catch comes up short:

```
try {  
  setTimeout(function () {  
    throw new Error('boom!');  
  }, 0);  
} catch (e) {  
  console.log('Aha! I caught the error!');  
}
```

```
$ node try-settimeout.js
```

But where try-catch comes up short:

```
try {  
  setTimeout(function () {  
    throw new Error('boom!');  
  }, 0);  
} catch (e) {  
  console.log('Aha! I caught the error!');  
}
```

```
$ node try-settimeout.js
```

```
/Users/lewis/dev/node-error-talk/try-settimeout.js:3
```

```
    throw new Error('boom!');  
    ^
```

```
Error: boom!
```

```
    at Timeout._onTimeout (/Users/lewis/dev/node-error-talk/try-settimeout.js:3:11)
```

```
    at ontimeout (timers.js:365:14)
```

```
    at tryOnTimeout (timers.js:237:5)
```

```
    at Timer.listOnTimeout (timers.js:207:5)
```

Why?

- Try-catch is synchronous, setTimeout is asynchronous
- Callback is queued and will throw the error later
- Catch block is no longer waiting to catch the exception
- Run-to-completion semantics & event loop are behind this

How Node is Different

- Other languages:
 - Each process handles one request at a time
 - Everything is synchronous, try/catch works fine
 - Easy to keep one request from blowing everything up
- Node: single process, cooperative concurrency, asynchronous I/O
 - Handles multiple requests at the same time in the same thread
 - Try/catch doesn't work well in asynchronous world
 - Any one request blowing up could mess up the others

What this means for us

- We need other mechanisms to handle asynchronous errors
- We can't try/catch and throw exceptions for everything
- An error in one request can take down the entire server
- We have to be extra careful to keep things online
- Our program can end up in unknown states
 - Only correct thing to do might be shut down!

Errors vs Exceptions

What's the difference, anyway?

Errors

Error is just a special class in JavaScript

- You can pass an Error object around like any other value
- Runtime errors throw an Error object
- Has a message and a stack property
- Also RangeError, ReferenceError, SyntaxError, others

```
var myError = new Error('my error message');
```

Exceptions

Exception: what happens when you throw something

- Usually you throw an Error object
- Call stack unwinds looking for a catch block
- You can throw anything, not just Error objects...but don't
- If an exception is unhandled, Node will shut down

```
throw new Error('something bad happened!');  
throw 'something bad happened' // avoid this
```

Stack trace example

```
function a() {  
  // call stack here is [a]  
  b();  
}  
  
function b(x) {  
  // call stack here is [b, a]  
  try {  
    c()  
  } catch (e) {  
    console.log(e.stack);  
  }  
}  
  
function c() {  
  // call stack here is [c, b, a]  
  throw new Error('boom');  
}  
  
a();
```

Error: boom

at c (/Users/lewis/dev/node-error-talk/try-catch.js:14:9)

at b (/Users/lewis/dev/node-error-talk/try-catch.js:7:5)

at a (/Users/lewis/dev/node-error-talk/try-catch.js:2:3)

at Object.<anonymous> (/Users/lewis/dev/node-error-talk/try-catch.js:17:1)

...

<more node core module frames>

This is useful! We want to see it!

Errors vs Exceptions in Async Node Land

- We're generally not going to throw Exceptions
- We're going to pass Error objects around a lot

Three core guidelines

**Always know when
your errors happen**

Avoid patterns like:

```
function (err, result) {  
  if (err) { /* drat, ignore */ }  
}
```

```
try { ... } catch (e) {  
  // this should never happen  
}
```

```
Promise.catch(function (reason) {  
  // surely this won't happen  
});
```

```
req.on('error', function (err) {  
  // oh well, not gonna do anything  
});
```

**Handle what you can,
avoid what you can't**

Operational Errors vs Programming Errors

- Operational error: recoverable - expect and handle these
 - Typically an Error object being passed around
- Programming error: nonrecoverable - try to avoid these
 - Typically an Exception thrown

Operational Errors to Expect

- Network timeouts
- Database is down
- Disk got full
- 3rd party API returning errors
 - us-east-1 S3
- Unexpected or missing user inputs (JSON.parse)

Programming Errors to Avoid

- Silently ignoring/swallowing errors instead of handling them
- Classic JavaScript errors
 - `TypeError: undefined is not a function`
 - `TypeError: Cannot read property 'x' of undefined`
 - `ReferenceError: x is not defined`
- Invoking a callback twice
- Using the wrong error mechanism in the wrong place

What to do with each:

- Operational errors
 - Known; handle manually wherever they may occur
 - Recoverable if handled correctly
 - We don't have to shut down everything just because S3 is down
 - Avoid assuming anything is reliable outside your own process
- Programming errors
 - Unknown; catch with global error handler
 - Nonrecoverable: we're gonna have to abandon ship
 - No amount of additional code can fix a typo
 - Use a linter to help avoid many common problems

**Don't keep running in
an unknown state**

Don't keep running in an unknown state

- State shared across multiple requests: less isolation
- Unexpected error in one request can pollute state of others
- Polluted state can lead to undefined behavior
 - Memory leaks, infinite loops, security issues
- Only way to get back to a known good state: bail out, restart

**This leads us to the
game plan**

The game plan

1. Always know when errors happen: don't ignore!
2. Handle what you can, avoid what you can't
3. Know and use different mechanisms for effective handling
4. Have a global catch-all for the errors you couldn't handle
5. Use a process manager so shutting down is no big deal
6. Accept when it's time to pack up shop, clean up, shut down

**3. Know and use
different mechanisms
for effective handling**

Error Mechanisms in Node

- Try/Catch - `throw` and `try/catch`
- Callbacks - `err` first argument and `if (err)`
- Promises - `reject(err)` and `.catch()`
- EventEmitters - `error` events and `.on('error')`
- Express - `next(err)` and error-handling middleware

Callbacks & Try-catch

```
function readAndParse(file, callback) {  
  fs.readFile(file, { encoding: 'utf8' }, function (err, data) {  
    if (err) return callback(err);  
    try {  
      callback(null, JSON.parse(data));  
    } catch (e) {  
      callback(e);  
    }  
  });  
}
```

Promises

```
var p = new Promise(function (resolve, reject) {  
  fs.readFile('data.txt', function (err, data) {  
    if (err) return reject(err);  
    resolve(data);  
  });  
});  
p.then(parseJson)  
  .then(doSomethingElse)  
  .catch(function (reason) {  
    // if readFile or JSON parsing or something else failed,  
    // we can handle it here  
  });
```

EventEmitters

- Servers, sockets, requests, streams
 - Long-lived objects with asynchronous stuff going on
- They can emit error events: listen for them!
- If an error event is emitted without an error listener...
 - The Error object will be thrown instead!
 - How operational errors become programming errors

EventEmitter Request Example

```
var req = http.get(url, function (res) {  
    doSomething(res);  
});  
  
req.on('error', function (err) {  
    // we caught the request error, let's recover  
})
```


Express Error Middleware

```
app.post('/login', function (req, res, next) {  
  db.query('SELECT ...', function (err, user) {  
    if (err) return next(err);  
  });  
});
```

```
app.use(function (req, res, next, err) {  
  // spit out your own error page, log the error, etc  
  next();  
});
```

**4. Have a global
catch-all for the errors
you couldn't handle**

Basic Global Error Handler

```
process.on('uncaughtException', function (err) {  
    console.log('Uncaught exception! Oh no!');  
    console.error(err);  
    process.exit(1);  
});
```

5. Use a process manager so shutting down is no big deal

Process managers and Node

- Run multiple server processes
 - One of them dying won't take us offline
 - Node cluster module
- Process managers: systemd, pm2, forever, naught
 - Will automatically restart processes when they die
 - Some provide further Node-specific functionality

Example with naught

```
var server = http.createServer(...);

process.on('uncaughtException', function (err) {
  console.log('Uncaught exception! Oh no!');
  console.error(err);
  // tell naught to stop sending us connections & start up a replacement
  process.send('offline');
  process.exit(1);
});

server.listen(80, function () {
  // tell naught we're ready for traffic
  if (process.send) process.send('online');
});
```

**6. Accept when it's
time to pack up shop,
clean up, shut down**

When we catch a "fatal" error, we want to:

- Quit accepting new connections
- Start reporting whatever we're gonna report
- Tell proc manager we're gonna die so it starts replacement
- Wait for any existing requests, sockets, etc to be dealt with
- Close any open resources, connections, etc
- Shut down

We want to report that stack trace!

```
function reportError(err, cb) {  
    // send the stack trace somewhere, then call cb()  
}  
  
process.on('uncaughtException', function (err) {  
    process.send('offline');  
    reportError(err, function (sendErr) {  
        // once error has been reported, let's shut down  
        process.exit(1);  
    });  
});
```

Maybe get a text message:

```
var myPhone = "..."  
function reportError(err, cb) {  
  console.error(err);  
  twilio.sendTextMessage(myPhone, err.message, cb);  
}
```

Also useful to report operational errors

```
db.query('SELECT ...', function (err, results) {  
  if (err) {  
    return reportError(err);  
  }  
  doSomething(results);  
});
```

**But then the database
goes down...**

Alternatively, use Sentry

The raven npm package is our Node SDK:

```
var Raven = require('raven');  
Raven.config('<my-sentry-key>');  
  
function reportError(err, cb) {  
  console.error(err);  
  Raven.captureException(err, cb);  
}
```

Graceful shutdown

```
server = http.createServer(...);
function shutdownGracefully(err, cb) {
  // quit accepting connection, clean up any other resources
  server.close(function () {
    // can also wait for all connections: server._connections
    reportError(err, cb)
  });
}

process.on('uncaughtException', function (err) {
  process.send('offline');
  shutdownGracefully(function () {
    process.exit(1);
  });
});
```

- Wait for any existing requests, sockets, etc to be dealt with
- Close any open resources, connections, etc

Big Combined Example

```
server = http.createServer(...);

function reportError(err, cb) {
  console.error(err);
  Raven.captureException(err, cb);
}

function shutdownGracefully(err, cb) {
  // quit accepting connection, clean up any other resources
  server.close(function () {
    // can also wait for all connections: server._connections
    reportError(err, cb)
  });
}

process.on('uncaughtException', function (err) {
  process.send('offline');
  shutdownGracefully(function () {
    process.exit(1);
  });
});

server.listen(80, function () {
  if (process.send) process.send('online');
});
```

What NOT to do with a global catch-all:

- Just log the error and carry on
- Keep the process running indefinitely
- Try to recover in any way: it's too late!
- Try to centralize handling of operational errors into one place

Other global error mechanisms

- `process.on('uncaughtException')`
- `process.on('unhandledRejection')`
- Domains - but application code shouldn't need them

Recap: overall gameplan

1. Always know when errors happen: don't ignore!
2. Handle what you can, avoid what you can't
3. Know and use different mechanisms for effective handling
4. Have a global catch-all for the errors you couldn't handle
5. Use a process manager so shutting down is no big deal
6. Accept when it's time to pack up shop, clean up, shut down

Related things I didn't go into

- Run-to-completion semantics & the event loop
- V8 stacktrace API
- The "callback contract"
- Async/Await
- Domains (and `async_hooks`)
- Cluster module & process managers

Some related links

- <https://sentry.io/for/node/>
- <https://www.joyent.com/node-js/production/design/errors>
- <https://nodejs.org/api/errors.html>

Where are the slides?

- Slides available at [GitHub.com/LewisJEllis/node-error-talk](https://github.com/LewisJEllis/node-error-talk)
- I'm Lewis J Ellis: @lewisjellis on [Twitter](https://twitter.com/lewisjellis) and [GitHub](https://github.com/LewisJEllis)

Thank you!

**May your Node applications run
happily ever after**