making your JavaScript debuggable

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http://pmuellr.github.io/slides/2015/11-debuggable-javascript
http://pmuellr.github.io/slides/2015/11-debuggable-javascript/slides.pdf
http://pmuellr.github.io/slides/ (all of Patrick's slides)

code reading

> *I'm doing 90% maintenance and 10% development, is this normal?*

Stack Overflow

> *In 2001, more than 50% of the global software population is engaged in modifying existing applications rather than writing new applications.*

Capers Jones

you will write a little code

you will read a lot of code

optimize for readability

pyramid of doom

```
fs.readdir(".", function(err, files){
  files.forEach(function(file) {
    fs.stat(file, function(err, stats){
      if (!stats.isFile()) return
      fs.readFile(file, "utf8", function(err, data){
        console.log(file, data.length)
      })
    })
  })
})
```

pyramid of doom fixed - I

```
fs.readdir(".", cbReadDir)
function cbReadDir(err, files) {
  files.forEach(eachFile)
}
function eachFile(file) {
  fs.stat(file, (err, stats) => cbStatFile(err, stats,
}
function cbStatFile(err, stats, file) {
  if (!stats.isFile()) return
  fs.readFile(file, "utf8", (err, data) => cbReadFile(e
}
function cbReadFile(err, data, file) {
  console.log(file, data.length)
}
```

pyramid of doom fixed - 2

```
fs.readdir(".", cbReadDir)
function cbReadDir(err, files) {
  files.forEach(eachFile)
}
function eachFile(file) {
  fs.stat(file, cbStatFile)
  function cbStatFile(err, stats) {
    if (!stats.isFile()) return
    fs.readFile(file, "utf8", cbReadFile)
  }
  function cbReadFile(err, data) {
    console.log(file, data.length)
  }
}
```

pyramid of doom - unnamed functions!

```
fs.readdir(".", function(err, files){
  files.forEach(function(file) {
    throw new Error("huh?")
  })
})



// Error: huh?
//    at path/to/script.js:6:11
//    at Array.forEach (native)
//    at path/to/script.js:5:9
//    at FSReqWrap.oncomplete (fs.js:82:15)
```

pyramid of doom - unnamed functions fixed!

```
fs.readdir(".", cbReadDir)
function cbReadDir(err, files) {
  files.forEach(eachFile)
}
function eachFile(file) {
  throw new Error("huh?")
}

// Error: huh?
//    at eachFile (path/to/script.js:9:9)
//    at Array.forEach (native)
//    at cbReadDir (path/to/script.js:6:9)
//    at FSReqWrap.oncomplete (fs.js:82:15)
```

pyramid of doom - see also

- async - npm - Caolan McMahon
- Promises - Axel Rauschmayer

linting and code style - standard

```
$ node_modules/.bin/standard

standard: Use JavaScript Standard Style
      (https://github.com/feross/standard)
  path/to/bole.js:1:22: Strings must use singlequote.
  path/to/bole.js:3:18: Strings must use singlequote.
  ...

(it never ends)
```

> *No decisions to make. No .eslintrc, .jshintrc, or .jscsrc files to manage. It just works.*

other things

- keep functions shorter than a "page"; v8 will "inline" short functions!
- one-line arrow functions - no return or braces needed!

```
[ 1, 4, 9 ].map(x => Math.sqrt(x)) // [ 1, 2, 3 ]
```

- lots of great general ideas in Code Complete

logging

> *The most effective debugging tool is still careful thought, coupled with judiciously placed print statements.*

Brian W. Kernighan

console.log()

```
console.log(__filename + ": foo")
// prints: /path/to/script.js: foo

console.log("foo", "bar")
// prints: foo bar

console.log({x:1, y:2})
// prints: { x: 1, y: 2 }

console.log("a-%s-b %j", 1, {x:1})
// prints: a-1-b {"x":1}

console.log(process)
// prints: { title: 'node', ...many lines... }
```

console.time()

```
console.time("foo")
doStuff()
console.timeEnd("foo")

function doStuff() {
    // takes a long time
}

// prints: foo: 1121ms
```

console.trace()

```
function a() { b() }
function b() { c() }
function c() { console.trace("foo") }

a()

// Trace: foo
//     at c (<program>:3:24)
//     at b (<program>:2:16)
//     at a (<program>:1:78)
//     at ...
```

console.table()???

```
// dream code!

const people = [
  {firstName: 'George', lastName: 'Bush'},
  {firstName: 'Barack', lastName: 'Obama'},
]

console.table(people)

// index  firstName  lastName
// -----  ---------  --------
//     0  George     Bush
//     1  Barack     Obama
```

logging that stays in your code

npm debug

```
const debugA = require("debug")("thing-A")
const debugB = require("debug")("thing-B")

function a() { debugA("thrashing") }
function b() { debugB("churning") }

setInterval(a, 500); setInterval(b, 333)
```

```
$ DEBUG=* node debug.js
thing-B churning +0ms
thing-A thrashing +0ms
thing-B churning +339ms
thing-A thrashing +501ms
...
```

npm winston

```
const winston = require("winston")

const transports = winston.transports

winston.remove(transports.Console)
winston.add(transports.Console, { level: "warn" })
winston.add(transports.File, { filename: "x.log" })

winston.info("info message")
winston.warn("warning message")
winston.error("error message")

// prints:
// warn: warning message
// error: error message
```

npm bunyan

```
const bunyan = require("bunyan")

const log = bunyan.createLogger({name: "myapp"})
log.level("info")

log.info("hi")

// prints
// {"name":"myapp", "hostname":"my-hostname",
//   "pid":49675, "level":30, "msg":"hi",
//   "time":"2015-10-27T03:49:14.759Z", "v":0}

// du -h bunyan - 2.5M
```

npm bole

```
const bole = require("bole")

const log = bole("myapp")
bole.output({ level: "info", stream: process.stdout })

log.info("hi")

// prints
// {"time":"2015-10-27T03:56:45.762Z",
//  "hostname":"my-hostname", "pid":53014,
//  "level":"info", "name":"myapp", "message":"hi"}

// du -h bole - 144K
```

npm hooker

```
function preCall(name) {
    const args = [].slice.call(arguments,1)
    log("->", name, args)
}
function postCall(result, name) {
    log("<-", name, result)
}
hooker.hook(Math, Object.getOwnPropertyNames(Math), {
  passName: true,
  pre:  preCall,
  post: postCall
})

Math.max(5, 6, 7)
Math.sqrt(2)
```

npm hooker

prints:

```
-> Math.max: [5,6,7]
<- Math.max: 7
-> Math.sqrt: [2]
<- Math.sqrt: 1.4142135623730951
```

also provides

- filtering arguments
- overriding results

error handling

builtin process events

```
process.on("exit", code =>
    console.log("exiting with code: " + code))
process.on("uncaughtException", err =>
    console.log("uncaught exception: " + err.stack))

function a() { throw new Error("die die die") }

a()

// prints:
//
// uncaught exception: Error: die die die
//     at a (.../script.js:9:22)
//     at Object.<anonymous> (.../script.js:11:1)
//     ... more stack trace lines
// exiting with code: 0
```

Error.prepareStackTrace() - before

```
try { a() } catch(err) { console.log(err.stack) }
function a() { b() }
function b() { c() }
function c() { throw new Error("foo blatz") }

// Error: foo blatz
//     at c (.../script.js:5:22)
//     at b (.../script.js:4:16)
//     at a (.../script.js:3:16)
//     at Object.<anonymous> (.../script.js:2:7)
//     at Module._compile (module.js:456:26)
//     ...
```

Error.prepareStackTrace() - after

```
Error.prepareStackTrace = function(err, stackTrace) {
  ...
}

try { a() } catch(err) { console.log(err.stack) }
function a() { b() }
function b() { c() }
function c() { throw new Error("foo blatz") }

// Error: foo blatz
//     script.js  13 - c()
//     script.js  12 - b()
//     script.js  11 - a()
```

Error.prepareStackTrace = ...

```
function v8PrepareStackTrace(error, callSites) {
  for (let callSite of callSites) {
    const funcName = callSite.getFunctionName()
    const file     = callSite.getFileName()
    const line     = callSite.getLineNumber()
    ...
  }
  return outputString
}
```

reference: javascript_stack_trace_api.md

npm longjohn - before

```
a()

function a() { setTimeout(b, 100) }
function b() { setTimeout(c, 100) }
function c() { throw new Error("foo") }

// Error: foo
//     at c [as _onTimeout] (/path/to/script.js:6:22)
//     at Timer.listOnTimeout [as ontimeout] (timers.js
```

npm longjohn - after

```
if (process.env.NODE_ENV !== 'production')
  require('longjohn')

a()
function a() { setTimeout(b, 100) }
function b() { setTimeout(c, 100) }
function c() { throw new Error("foo") }
// Error: foo
//     at [object Object].c (path/to/script.js:6:22)
//     at Timer.listOnTimeout (timers.js:92:15)
// ---------------------------------------------
//     at [object Object].b (path/to/script.js:5:16)
//     at Timer.listOnTimeout (timers.js:92:15)
// ---------------------------------------------
//     at a (path/to/script.js:4:16)
//     at Object.<anonymous> (path/to/script.js:2:1)
//     ...
```

actual debugging

builtin module repl

```
var repl = require("repl")

function a(i) {
    var context = repl.start("repl> ").context
    context.pi  = 3.14
    context.arg = i
}

a(3)

// repl> pi
// 3.14
// repl> arg
// 3
// repl>
```

builtin debugger

```
function a() {
    debugger
    var x = 1
    var y = 2
    console.log(x + " + " + y + " = " + (x+y))
}

setTimeout(a, 1000)
```

builtin debugger

```
> node debug debugger.js
< debugger listening on port 5858
connecting... ok
...
debug> watch("x")
debug> cont
break in debugger.js:2
Watchers:
  0: x = undefined

  1 function a() {
  2     debugger
  3     var x = 1
  4     var y = 2
debug> next
```

```
...
debug> next
break in debugger.js:4
Watchers:
  0: x = 1

  2     debugger
  3     var x = 1
  4     var y = 2
  5     console.log(x + " + " ..
  6 }
debug> cont
< 1 + 2 = 3
program terminated
debug>
```

npm `node-inspector`

- Chrome Dev Tools user interface
  - breakpoints
  - stepping
  - watches
- but for debugging node

IDEs with debugging support

- IntelliJ IDEA
- Visual Studio Code

cpu profiles / heap snapshots

- V8 provides a built-in sampling cpu profiler
    - see time spent in expensive functions
    - shows stack for those functions
- V8 provides a built-in heap snapshot facility
    - dumps a representation of **ALL** JS objects

cpu profiles / heap snapshots

- npm `v8-profiler`
- StrongLoop
- N|Solid

These tools generate files that can be loaded in Chrome Dev Tools. StrongLoop and N|Solid also provide their own viewers.

cpu profiles - pro tips

- **NAME YOUR FUNCTIONS**
- **always set `NODE_ENV` to `"production"`** (environment variable)
- use **`node --no-use-inlining`** if your functions are getting inlined
- more info at Google's Chrome DevTools site

heap snapshots - pro tips

- data is organized by class name
- if classes won't work, inject "tags" (named class instances) into objects you want to track
- take two snapshots, then "Comparison view" to see object counts diffs between the two
- more info at Google's Chrome DevTools site

heap snapshots - tagging things

```
class RequestTag {}
class ResponseTag {}
...
function requestHandler(req, res) {
  req.__hstag = new RequestTag
  res.__hstag = new ResponseTag
  ...
}
```

Now you can search the snapshot for **`"tag"`** to see all tagged objects.

demo - memory leak

- server that leaks **`request`** objects - demos/snapshot-untagged.js
- same server, but tags **`request`** and **`response`** objects - demos/snapshot-tagged.js
- run both, take heap snapshots, and you can see from the 'tagged' version exactly what's leaking, since **`requests`** are instances of **`IncomingMessage`**

demo - cpu profiling

- program with a number of small functions - demos/profile-inline.js
- run with no special flags - most of the functions will be inlined, and no longer visible in stack traces
- run with **`--no-use-inlining`** - none of the functions will be inlined, and all will be visible in stack traces

want to help build more debugging tools?

moar debugging tools!

- lots of low hanging fruit
  - what do other languages support?
  - what did Smalltalk and LISP do 30 years ago?
- lots of data from existing v8 debugging tools
- also needed - better typesetting of code

Node.js Tracing Work Group

- one of the many Node.js Working Groups
- working on low-level, real-time tracing APIs and tools
- come join us at a hangout; meeting minutes at github.com/nodejs/tracing-wg

cpu profiles

- tree of function invocation records
- for each function
  - functions called, available as **`children`**
  - number of "ticks" spent executing code

Highlight expensive functions/lines in your editor?

Find which module is uses the most CPU?

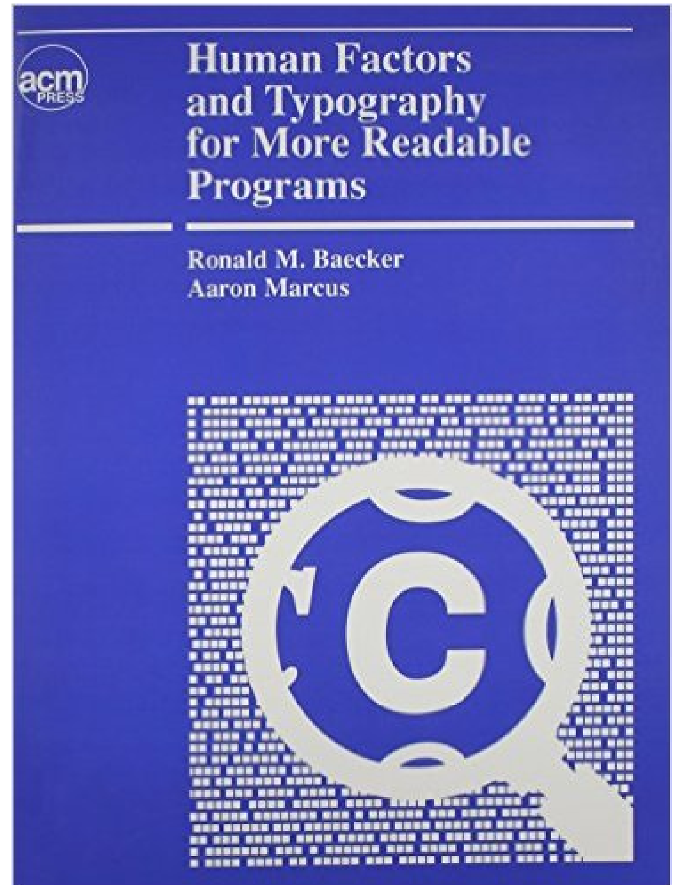
heap snapshots

- **tons** of data; even a small snaphot is megabytes in size
- start with **`npm snapshot-utils`**
- example: displaying all "variables" in a shapshot

Human Factors and Typography for More Readable Programs

- 1990
- Ronald M. Baecker, Aaron Marcus

ISBN 0201107457



Encode phone number as a vector of digits, without punctuation. Returns number of digits in phone number or FALSE to indicate failure.

static bool
getpn(str)

```
char                                   *str;
int                                    i = 0;

while (*str != '\0')
    if (i >= PNMAX)
        return FALSE;
```

Set pn to the digits ignoring spaces and dashes

```
    if (*str != ' ' && *str != '-')
        if ('0' <= *str && *str <= '9')
            pn[i++] = *str – '0';
        else
            return FALSE;
```

Fig. 1. A program presentation example from Baecker/Marcus [1, pg. 61]

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