

# No More Whack-a-Mole:

## How to Find and Prevent Entire Classes of Security Vulnerabilities

Presented by Sam Lanning - GitHub



# About Me



- Developer Advocate for GitHub
  - ◆ (formerly Semmle, acquired by GitHub)
  - ◆ (formerly core developer for LGTM.com)
- Passionate about Open Source, Security, Privacy, Cryptography, Vulnerability Research, Code Quality & Lighting.
- Twitter: **@samlanning**    GitHub: **@s0**



# A story of many bugs (CVE-2017-8046)

7 September 2017

Mo privately discloses vulnerability and exploit in Spring Framework

22 September 2017

Mo checks patch, sees it's incomplete sends updated exploit to Pivotal

27 September 2017

Mo checks patch, sees it's *still* incomplete sends updated exploit to Pivotal



21 September 2017

Pivotal publish a patch, and make an announcement.

26 September 2017

Pivotal sends Mo details of second attempt at fix

25 October 2017

Pivotal publishes a complete refactor of relevant code to hopefully prevent further occurrences.

<https://blog.semmle.com/spring-data-rest-CVE-2017-8046-ql/>



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# A story of many bugs 2

**27 April 2016**

S2-032 / CVE-2016-3081

RCE in Apache Struts 2 via OGNL

Nike Zheng

**20 June 2016**

S2-037 / CVE-2016-4438

RCE in Apache Struts 2 via OGNL

Chao Jack, Shinsaku Nomura

**22 September 2017**

S2-046 / CVE-2017-5638

RCE in Apache Struts 2 via OGNL

Chris Frohoff, Nike Zheng, Alvaro Munoz

**12 May 2016**

S2-033 / CVE-2016-3087

RCE in Apache Struts 2 via OGNL

Alvaro Munoz

**19 March 2017**

S2-045 / CVE-2017-5638

RCE in Apache Struts 2 via OGNL

Nike Zheng

**24 September 2018**

S2-057 / CVE-2018-11776

RCE in Apache Struts 2 via OGNL

Man Yue Mo

See Also: CVE-2012-0391, CVE-2012-0392, CVE-2012-0394, CVE-2013-1965, CVE-2013-1966, CVE-2013-2115, CVE-2013-2134, CVE-2013-2135, CVE-2016-0785, CVE-2016-3090



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# **Solution:**

**When a new mistake is discovered, try and find similar mistakes across your code base**

# Variant Analysis?

“After doing this [\[root cause analysis\]](#), our next step is **variant analysis**: finding and investigating any variants of the vulnerability. It’s important that we find all such variants and patch them simultaneously, otherwise we bear the risk of these being exploited in the wild.”

*- Steven Hunter, MSRC Vulnerabilities & Mitigations team*

<https://blogs.technet.microsoft.com/srd/2018/08/16/vulnerability-hunting-with-semmler-ql-part-1/>



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.gitignore  
.htaccess  
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.phpstorm.meta.php  
.prod.env  
123.php  
\_ide\_helper.php  
artisan  
composer.json  
composer.lock  
gulpfile.js  
part

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3 SPR = Product::select('id', 'image', 'mirror')->whereIn('cat_id', [156,162])->where('color_id', 13);  
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6 $bar = new ProgressBar($this->output, SPR->count());  
7 $bar->setFormat('%d%% [=====]<----->')->setBarWidth(50)->start();  
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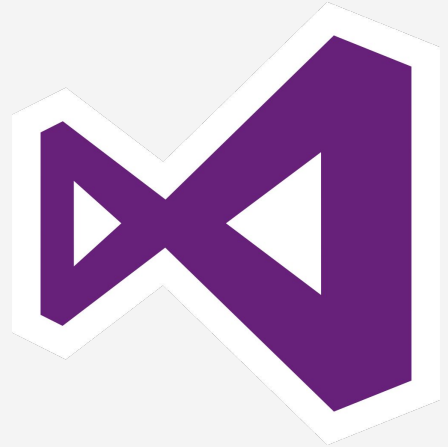
# Code Navigation / IDE



**sourcegraph**



**eclipse**



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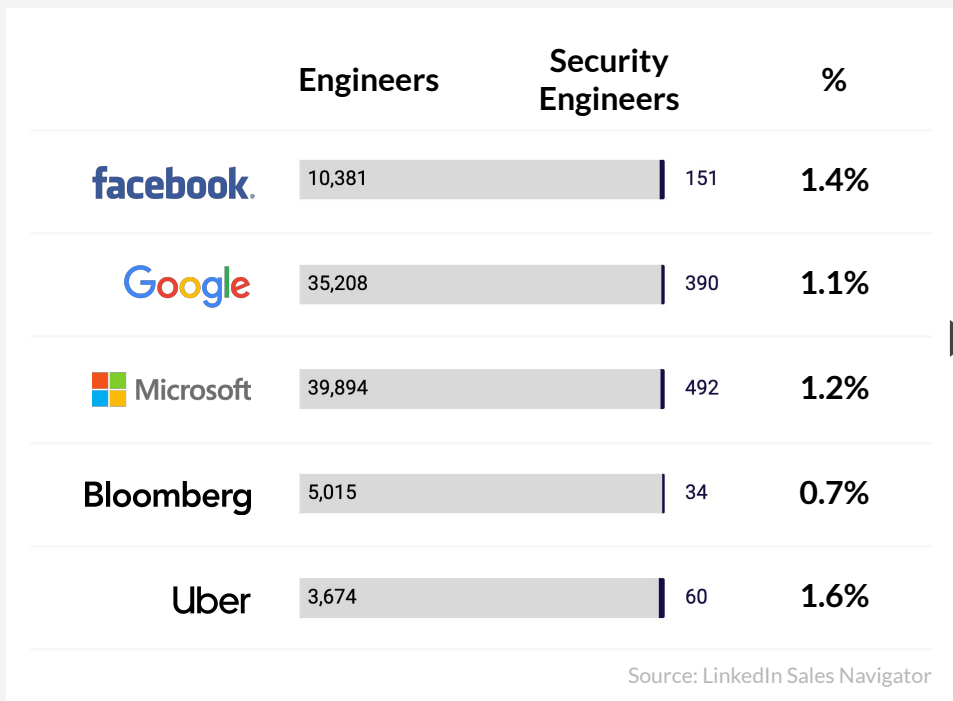


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# Never enough security researchers



Even hi-tech leaders,  
can't find enough talent

The security skills gap is  
only expected to grow



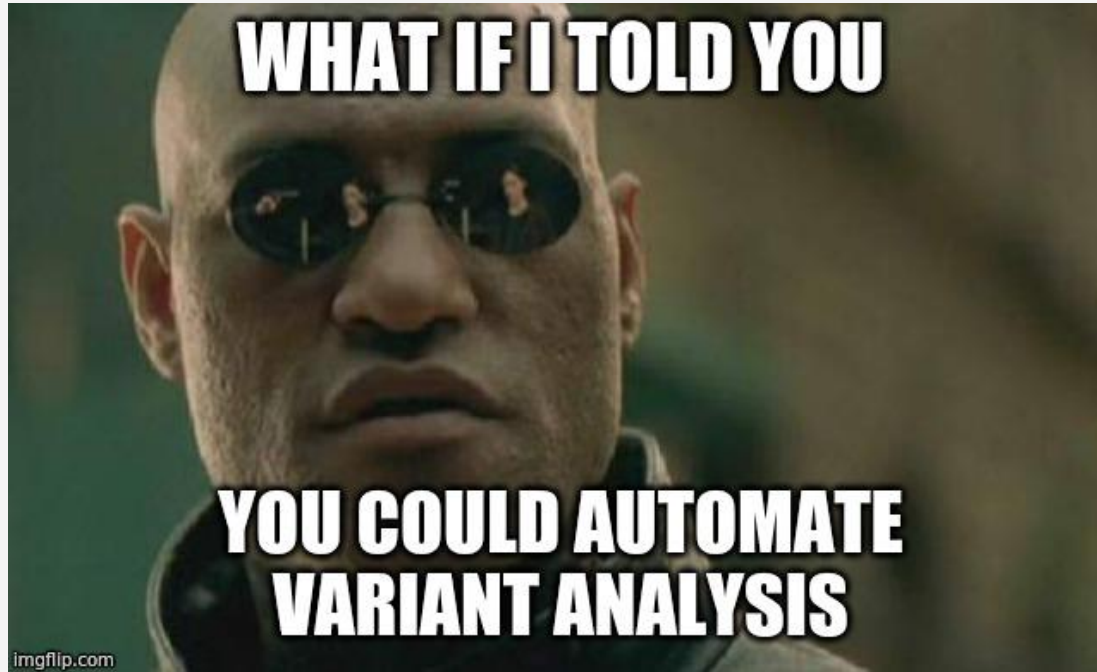
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# Automating Variant Analysis



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# Automating Variant Analysis



Harbormaster completed remote builds in B2850: Diff 5207.

Jul 13 2018, 5:30 PM



reviewbot added a subscriber: reviewbot.

Jul 13 2018, 5:50 PM

Code analysis found 17 defects in this patch:

- 10 defects found by clang-tidy
- 7 defects found by mozlint

You can run this analysis locally with:

- `./mach static-analysis check path/to/file.cpp` (C/C++)
- `./mach lint path/to/file` (JS/Python)

If you see a problem in this automated review, please report it here: <https://bit.ly/2tb8Qk3>



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# An Example: Chakra

```
HRESULT SomeClass::vulnerableFunction(Var* args, UINT argCount, Var* retVal)
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    // get second argument -
    // from Chakra, obtain an integer value
    int someValue;
    hr = Jscript::VarToInt(args[2], &someValue);

    // perform some operation on the array acquired previously
    doSomething(pBuffer, bufferSize);
}
```

C++

<https://blogs.technet.microsoft.com/srd/2018/08/16/vulnerability-hunting-with-semmler-ql-part-1/>



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C++

<https://blogs.technet.microsoft.com/srd/2018/08/16/vulnerability-hunting-with-semmler-ql-part-1/>



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# An Example: Chakra

```
var buf = new ArrayBuffer(length);
var arr = new Uint8Array(buf);

var param = {}
param.valueOf = function() {
  neuter(buf); // neuter `buf` by e.g. posting it to a web worker
  gc();        // trigger garbage collection
  return 0;
};

vulnerableFunction(arr, param);
```

JavaScript

<https://blogs.technet.microsoft.com/srd/2018/08/16/vulnerability-hunting-with-semmler-ql-part-1/>



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<https://blogs.technet.microsoft.com/srd/2018/08/16/vulnerability-hunting-with-semmler-ql-part-1/>



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# An Example: Chakra

```
from Variable v, TypedArrayBufferPointer def, FunctionCall call, VariableAccess use
where
  // variable is defined at "def", and used at "use"
  v.getAnAccess() = def and v.getAnAccess() = use
  // "call" may eventually call a function that calls back into JS code
  and exists(Function g | g.hasName("MethodCallToPrimitive") and call.getTarget().calls+(g))
  // "call" happens after "def"
  and def.getASuccessor+() = call
  // "use" happens after "call"
  and call.getASuccessor+() = use
select def, call, use
```

Query

\*slightly modified query from:

<https://blogs.technet.microsoft.com/srd/2018/08/16/vulnerability-hunting-with-semmler-ql-part-1/>




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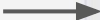
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    doSomething(pBuffer, bufferSize);
}
```

def

use

C++

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call

C++

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```

1st

def

2nd

call

C++

<https://blogs.technet.microsoft.com/srd/2018/08/16/vulnerability-hunting-with-semmler-ql-part-1/>



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1st  
call  
2nd use

C++

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  // "call" may eventually call a function that calls back into JS code
  and exists(Function g | g.hasName("MethodCallToPrimitive") and call.getTarget().calls+(g))
  // "call" happens after "def"
  and def.getASuccessor+() = call
  // "use" happens after "call"
  and call.getASuccessor+() = use
select def, call, use
```

Query

\*slightly modified query from:

<https://blogs.technet.microsoft.com/srd/2018/08/16/vulnerability-hunting-with-semmler-ql-part-1/>



@samlanning



@s0



# Beyond your own code

- Make your (general-purpose) queries/checks open source!
- Use external queries/checks!



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@s0



# ZipSlip



<https://snyk.io/research/zip-slip-vulnerability>



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# ZipSlip

Metadata	Name (path)	Data
<metadata>	lib/foo	<7731911f...
<metadata>	lib/bar	<236dbe48...
<metadata>	usr/foo	<e80b70d2...
<metadata>	usr/foo/bar	<63f30ae0...

<https://snyk.io/research/zip-slip-vulnerability>



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# ZipSlip

../../../../.bashrc

../../../../../../../../../../../../etc/crontab

<https://snyk.io/research/zip-slip-vulnerability>



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# ZipSlip

```
Enumeration<ZipEntry> entries = zip.getEntries()
while (entries.hasMoreElements()) {
    ZipEntry e = entries.nextElement();
    File f = new File(destinationDir, e.getName());
    InputStream input = zip.getInputStream(e);
    IOUtils.copy(input, write(f));
}
```

Java

<https://snyk.io/research/zip-slip-vulnerability>



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# ZipSlip

```
Enumeration<ZipEntry> entries = zip.getEntries()
while (entries.hasMoreElements()) {
    ZipEntry e = entries.nextElement();
    → File f = new File(destinationDir, e.getName());
    InputStream input = zip.getInputStream(e);
    IOUtils.copy(input, write(f));
}
```

Java

<https://snyk.io/research/zip-slip-vulnerability>



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# ZipSlip

```
Enumeration<ZipEntry> entries = zip.getEntries()
while (entries.hasMoreElements()) {
    ZipEntry e = entries.nextElement();
    File f = new File(destinationDir, e.getName());
    → if (!f.toPath().normalize().startsWith(destinationDir.toPath()))
        throw new IOException("Bad zip entry");
    InputStream input = zip.getInputStream(e);
    IOUtils.copy(input, write(f));
}
```

Java

<https://snyk.io/research/zip-slip-vulnerability>



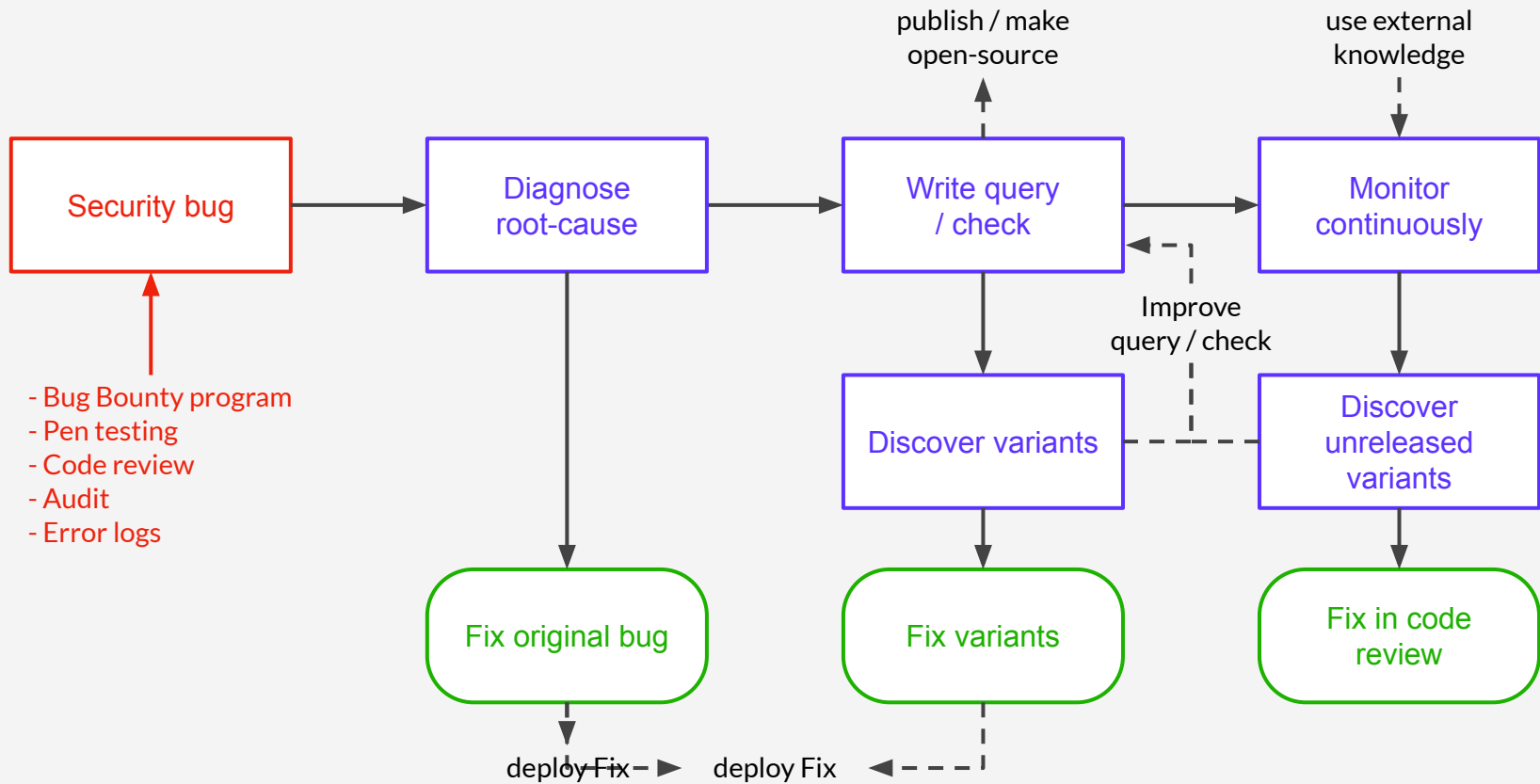
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**No vulnerability response  
process?**

**Independent security  
researcher / consultant?**

# Get Started

- Writing / Maintaining Software?
  - ◆ Look at which tools other teams are using
  - ◆ Try out a selection, choose what works for you
- Security Researcher?
  - ◆ Experiment writing checks / queries with different technologies, see what works for you
  - ◆ Blog posts from researchers finding variants



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# Recap

- You should do variant analysis (if creating software)
- Better yet, you should do *automated* variant analysis
- Checks should be run *continuously*, not once-off!
- *Use* and *contribute* to open-source queries / checks
- Can use variant analysis to supercharge research
- VA *compliments* (not replaces) other security practices



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**Thank You**

**Questions?**



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