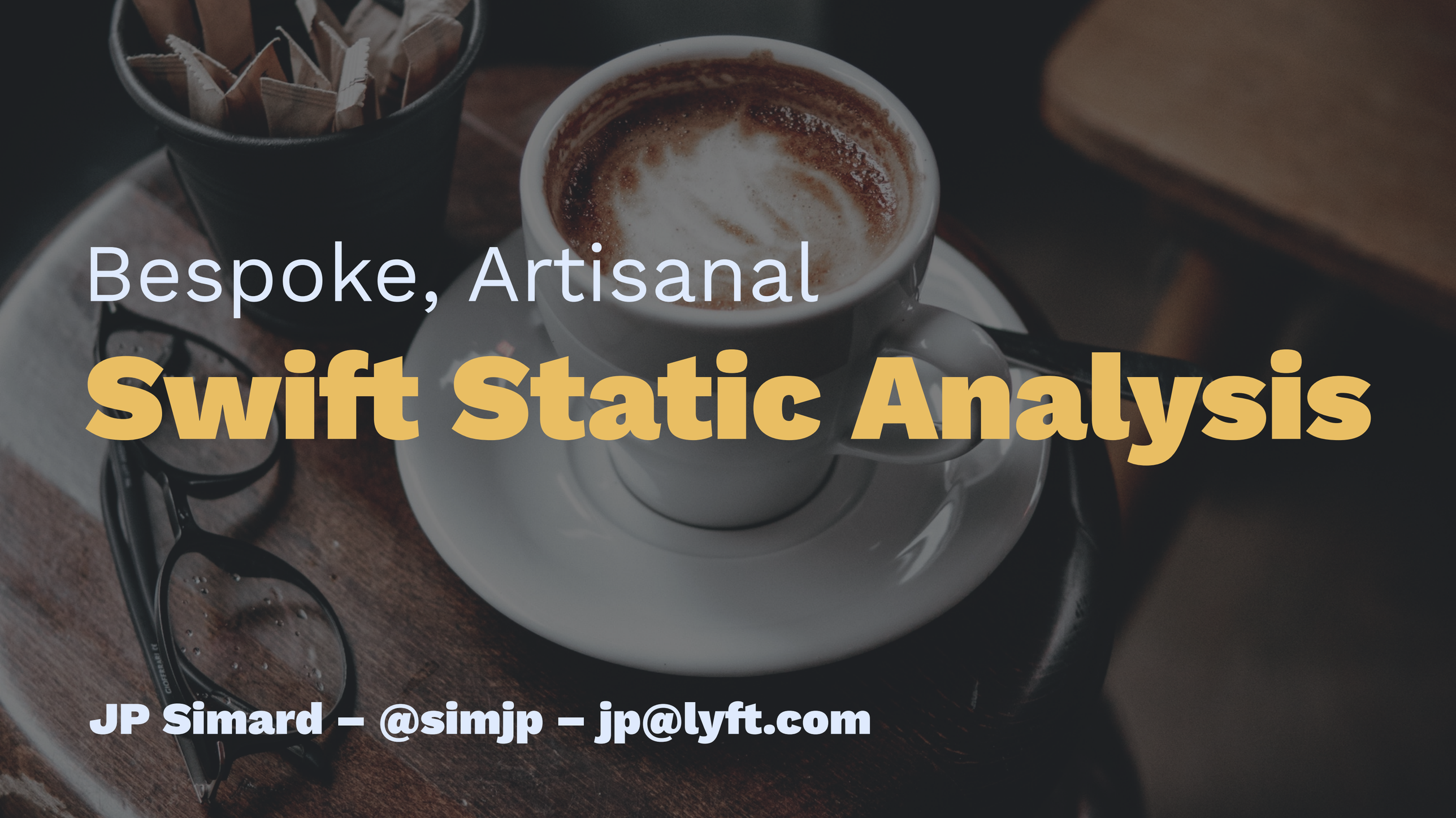

Bespoke, Artisanal

# Swift Static Analysis

**JP Simard – @simjp – jp@lyft.com**

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@johnregehr

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periodic reminder that afaik there's only one good freely available introduction to static analysis and this is it: cs.au.dk/~amoeller/spa/…

3:03 PM - 4 Sep 2018

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# Static Program Analysis

Anders Møller and Michael I. Schwartzbach

September 5, 2018

# Static analysis

**Static program analysis** is the art of reasoning about the **behavior** of computer programs **without actually running them**.

**Anders Møller and Michael I. Schwartzbach**

**https://cs.au.dk/~amoeller/spa/spa.pdf**

# How hard can it be?

# How hard can it be?

— Interprocedural Control Flow Graphs
— Lattice Theory
— Monotonicity
— Constant Propagation Analysis
— Very Busy Expressions
— Transfer Functions
— Closure Analysis for the λ-calculus
— 😳, 🤔, 🙃, 🚶‍♂️ 🚶‍♂️ 🚶‍♂️ 🚶‍♂️ 🚶‍♂️

# Objective-C

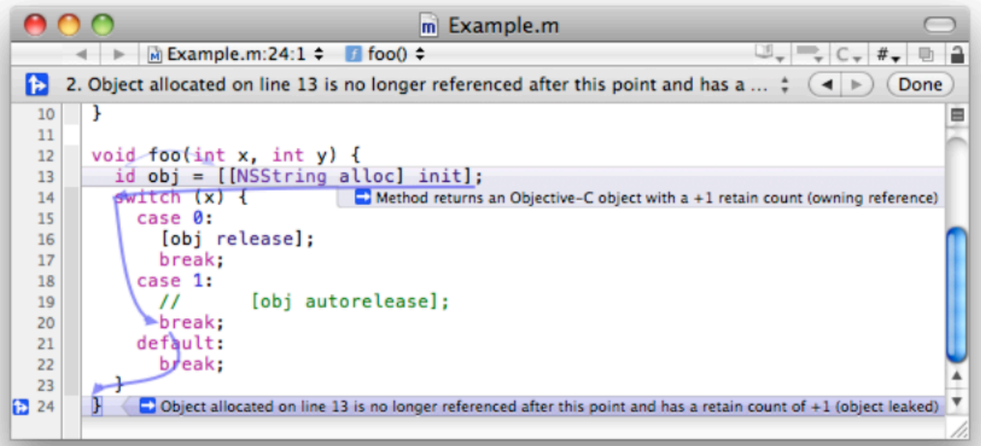
About | Filing Bugs | User Manual | Development | Mailing Lists

# Clang Static Analyzer

The Clang Static Analyzer is a source code analysis tool that finds bugs in C, C++, and Objective-C programs.

Currently it can be run either as a standalone tool or within Xcode. The standalone tool is invoked from the command line, and is intended to be run in tandem with a build of a codebase.

The analyzer is 100% open source and is part of the Clang project. Like the rest of Clang, the analyzer is implemented as a C++ library that can be used by other tools and applications.

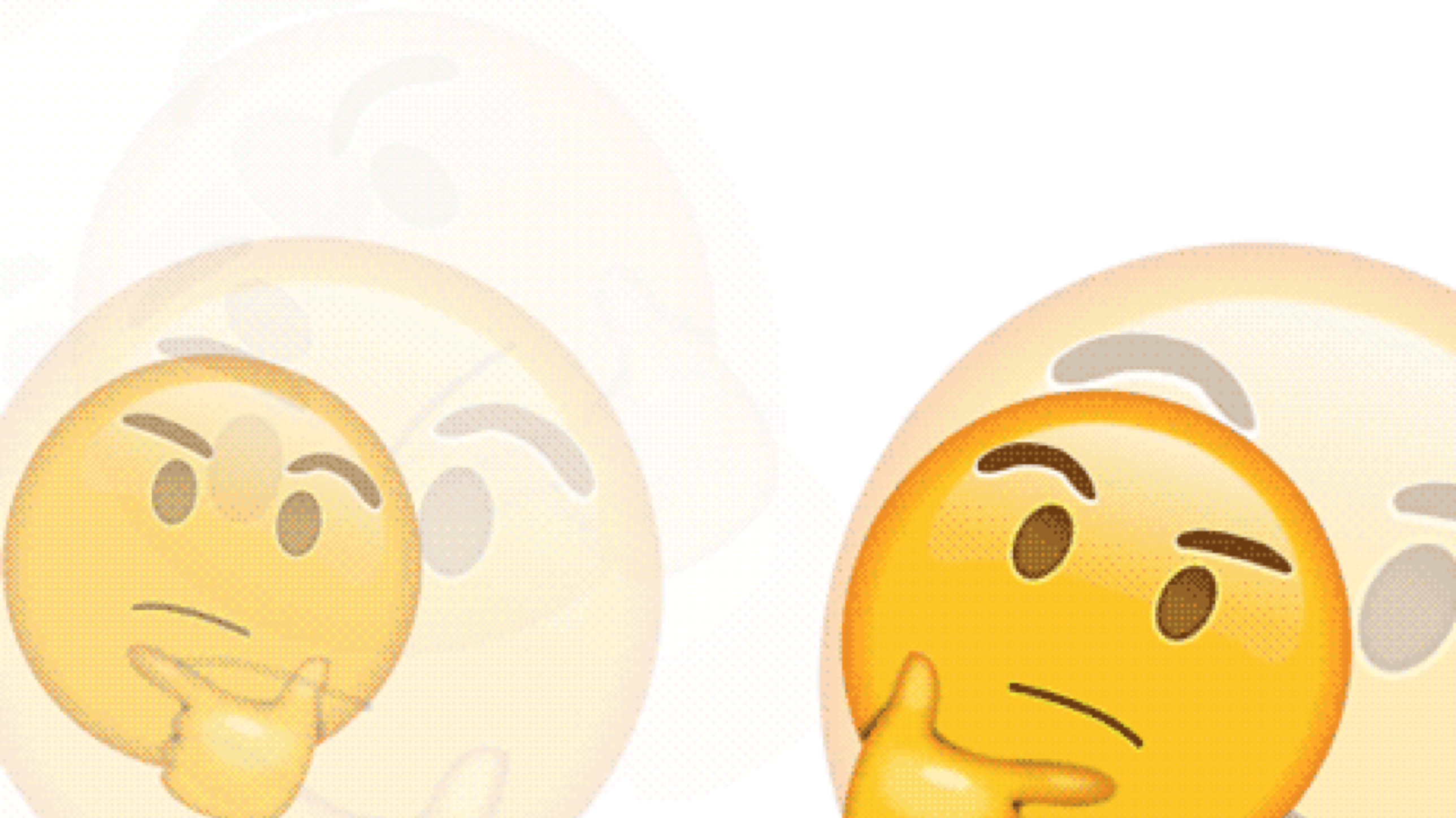



As its name implies, the **Clang Static Analyzer** is built on top of **Clang** and **LLVM**.

https://clang-analyzer.llvm.org

# What would a Swift static analyzer look like?

— Similar to how the Clang Static Analyzer is built on Clang & LLVM
— Built alongside the Swift compiler & LLVM
— Require deep knowledge of the compiler internal architecture
— Written in C++
— Require advanced static analysis concepts like CFG's



## Can we build Swift static analysis that is:

1. **Simple** to extend?
2. **Fast** to build?
3. **Easy** to run?
4. Doesn't require deep knowledge of C++ or the Swift compiler internals?


Bespoke, Artisanal
Swift Static Analysis

# What are the ingredients?

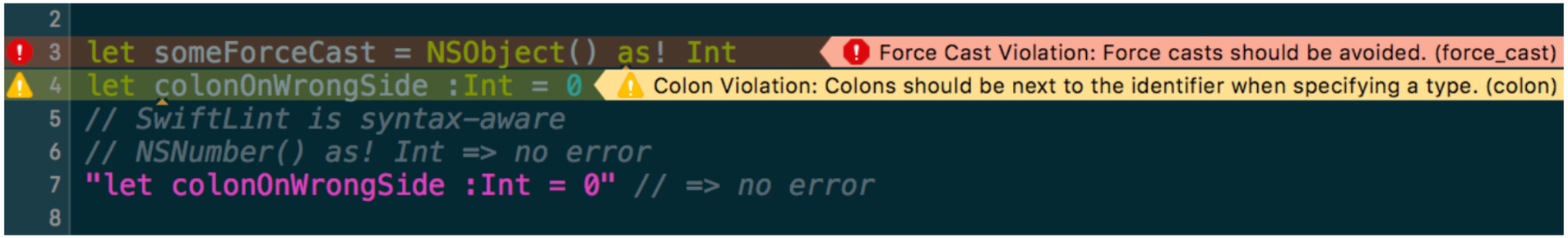
1. A way to **run over source files**
2. A way to **perform an action** on the source
3. A way to **get detailed information** about the source
4. A way to **extract interesting results** from that information
5. A way to **report these results** to the user
6. A way to **act on these results** whenever possible

# SwiftLint

A tool to enforce Swift style and conventions, loosely based on GitHub's Swift Style Guide.

SwiftLint hooks into Clang and SourceKit to use the AST representation of your source files for more accurate results.

build error | codecov 90%



# SwiftLint Already Provides

1. A way to **run over source files**
2. A way to **perform an action** on the source
3. A way to **get detailed information** about the source
4. A way to **extract interesting results** from that information
5. A way to **report these results** to the user
6. A way to **act on these results** whenever possible

All that's left is to find out how to

get detailed information
and
extract interesting results

Easy!

# SourceKit

https://github.com/apple/swift/tree/master/tools/SourceKit

Interesting requests:

— Editor Open
— Index*
— Cursor Info*

* Requires compiler arguments

# Editor open

```
// main.swift
struct A {
  func b() {}
}
```

```
{
  "key.substructure" : [
    {
      "key.kind" : "source.lang.swift.decl.struct",
      "key.offset" : 0,
      "key.nameoffset" : 7,
      "key.namelength" : 1,
      "key.bodyoffset" : 10,
      "key.bodylength" : 13,
      "key.length" : 24,
      "key.substructure" : [
        {
          "key.kind" : "source.lang.swift.decl.function.method.instance",
          "key.offset" : 11,
          "key.nameoffset" : 16,
          "key.namelength" : 3,
          "key.bodyoffset" : 21,
          "key.bodylength" : 0,
          "key.length" : 11,
          "key.substructure" : [

          ],
          "key.name" : "b()"
        }
      ],
      "key.name" : "A"
    }
  ],
  "key.offset" : 0,
  "key.diagnostic_stage" : "source.diagnostic.stage.swift.parse",
  "key.length" : 24
}
```

# Index

```
// main.swift
struct A {
  func b() {}
}
```

```
[
  {
    "key.column" : 8,
    "key.entities" : [
      {
        "key.column" : 10,
        "key.kind" : "source.lang.swift.decl.function.method.instance",
        "key.line" : 2,
        "key.name" : "b()",
        "key.usr" : "s:4main1AV1byyF"
      }
    ],
    "key.kind" : "source.lang.swift.decl.struct",
    "key.line" : 1,
    "key.name" : "A",
    "key.usr" : "s:4main1AV"
  }
]
```

# Cursor Info

```
// main.swift
struct A {
  func b() {}
}
```

```
{
  "key.accessibility" : "source.lang.swift.accessibility.internal",
  "key.annotated_decl" : "<Declaration>func b()<\/Declaration>",
  "key.filepath" : "\/path\/to\/main.swift",
  "key.fully_annotated_decl" : "<...see below...>",
  "key.kind" : "source.lang.swift.decl.function.method.instance",
  "key.length" : 3,
  "key.name" : "b()",
  "key.offset" : 32,
  "key.typename" : "(A) -> () -> ()",
  "key.typeusr" : "_T0yycD",
  "key.usr" : "s:4main1AV1byyF"
}
```

```
<decl.function.method.instance>
  <syntaxtype.keyword>func</syntaxtype.keyword> <decl.name>b</decl.name>()
</decl.function.method.instance>
```

# How can we derive interesting results from this information?

# Finding Dead Code ☠️

```
struct Fika {
  func eat() {}
}

struct Bagel {
  func eat() {} // <- never used
}

let fika = Fika()
fika.eat()
print(Bagel())
```

# Finding Dead Code ☠️☠️

```
let allCursorInfo = file.allCursorInfo(compilerArguments: compilerArguments)
let declaredUSRs = findDeclaredUSRs(allCursorInfo: allCursorInfo)
// s:4main4FikaV, s:4main4FikaV3eatyyF, s:4main5BagelV, s:4main5BagelV3eatyyF,
// s:4main4fikaAA4FikaVvp
let referencedUSRs = findReferencedUSRs(allCursorInfo: allCursorInfo)
// s:4main4FikaV, s:4main4fikaAA4FikaVvp, s:4main4FikaV3eatyyF,
// s:s5printyypd_SS9separatorSS10terminatortF, s:4main5BagelV
let unusedDeclarations = declaredUSRs.filter {
    !referencedUSRs.contains($0.usr)
}
// s:4main5BagelV3eatyyF
```

# Watch out!

Not all code that isn't directly accessed is unused!

```
enum WeekDay: String {
    // All these are used but not directly accessed
    case monday, tuesday, wednesday, thursday, friday
}

extension String {
    var isWeekday: Bool {
        return WeekDay(rawValue: self) != nil
    }
}
```

# Dead code traps

Turns out, there's a lot of valid Swift code that's never directly accessed.

1. Enum cases
2. Dynamic code: `@IBOutlet`, `@IBAction`, `@objc`
3. Protocol conformance code

# Unused Imports ⬇️

```
import Dispatch // <- never used
struct A {
    static func dispatchMain() {}
}
A.dispatchMain()

// Would use `Dispatch` module:
//
// dispatchMain()
// or
// Dispatch.dispatchMain()
```

# Unused Imports ⬇️⬇️

1. Find all imported modules

```
import Dispatch
//     ^ cursor info request

{
  "key.is_system" : true,
  "key.kind" : "source.lang.swift.ref.module",
  "key.modulename" : "Dispatch",
  "key.name" : "Dispatch"
}
```

# Unused Imports ⬇️⬇️

## 2. Find all referenced modules

```
dispatchMain()
//^ cursor info request
```

```
{
  "key.annotated_decl" : "<Declaration>func dispatchMain()...<\/Declaration>",
  "key.doc.full_as_xml" : "<Function>...<\/Function>",
  "key.filepath" : "...\/usr\/include\/Dispatch\/queue.h",
  "key.fully_annotated_decl" : "<decl.function.free>...<\/decl.function.free>",
  "key.is_system" : true,
  "key.kind" : "source.lang.swift.ref.function.free",
  "key.length" : 13,
  "key.modulename" : "Dispatch",
  "key.name" : "dispatchMain()",
  "key.offset" : 35595,
  "key.typename" : "() -> Never",
  "key.typeusr" : "_T0s5NeverOycD",
  "key.usr" : "c:@F@dispatch_main"
}
```

# Unused Import Traps

— Doesn't yet support operators
— Doesn't yet support transitive dependencies

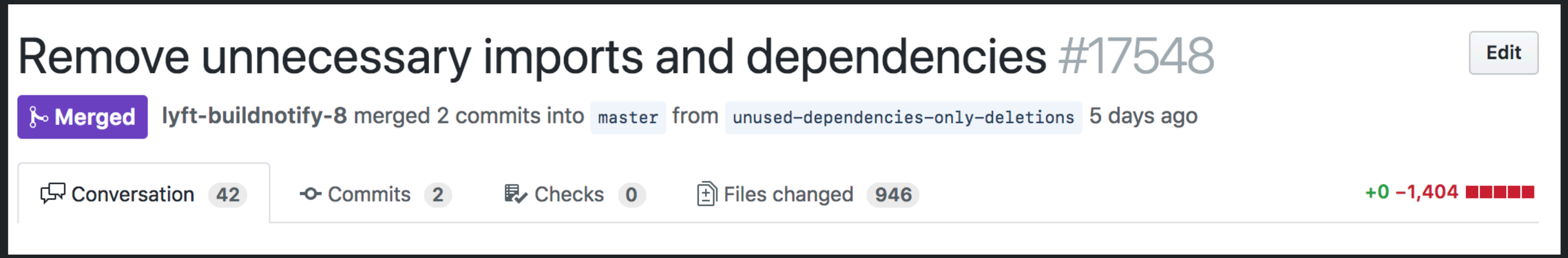
# Demo

## Configure

```
# .swiftlint.yml
included:
  - Source
analyzer_rules:
  - explicit_self
  - unused_import
  - unused_private_declaration
```

## Run

```
$ swiftlint analyze
    --autocorrect
    --compiler-log-path xcodebuild.log
```




— Lyft's driver & passenger apps are built from over 4,000 Swift files

— 1,358 imports removed

— 70 direct dependencies removed

# Rule Ideas

— Inefficient code patterns
(e.g. `filter(...).first` instead of `first(where:)`)
— Conversion of iteration to functional code
— Enforcing code architecture or style policies
— Avoiding or encouraging certain function calls or types
— Linting: explicit/implicit `self`, superfluous type annotations, etc.

# Final Thoughts

— 🧙‍♂️ You don't need to be a **compiler wizard** to build Swift tools.

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— Tools are **just apps**.

— Xcode may be closed source, but **most of the building blocks** you need for custom Swift tooling is **open source**.

# Final Thoughts

— 🧙 You don't need to be a **compiler wizard** to build Swift tools.

— Tools are **just apps**.

— Xcode may be closed source, but **most of the building blocks** you need for custom Swift tooling is **open source**.

— Other language communities **build all their own tools**. The Swift community should do the same! ✊

# Thank You!

**JP Simard — @simjp — jp@lyft.com**