How We Built Tools That Scale to Millions of Lines of Code

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About me

- Founder of Scala macros, Scalameta and Rsc
- Member of the Scala Improvement Process committee
- PhD from Martin Odersky's lab at EPFL (2011-2016)
- Tech lead of the Advanced Scala Tools team at Twitter (2017-present)

Credits

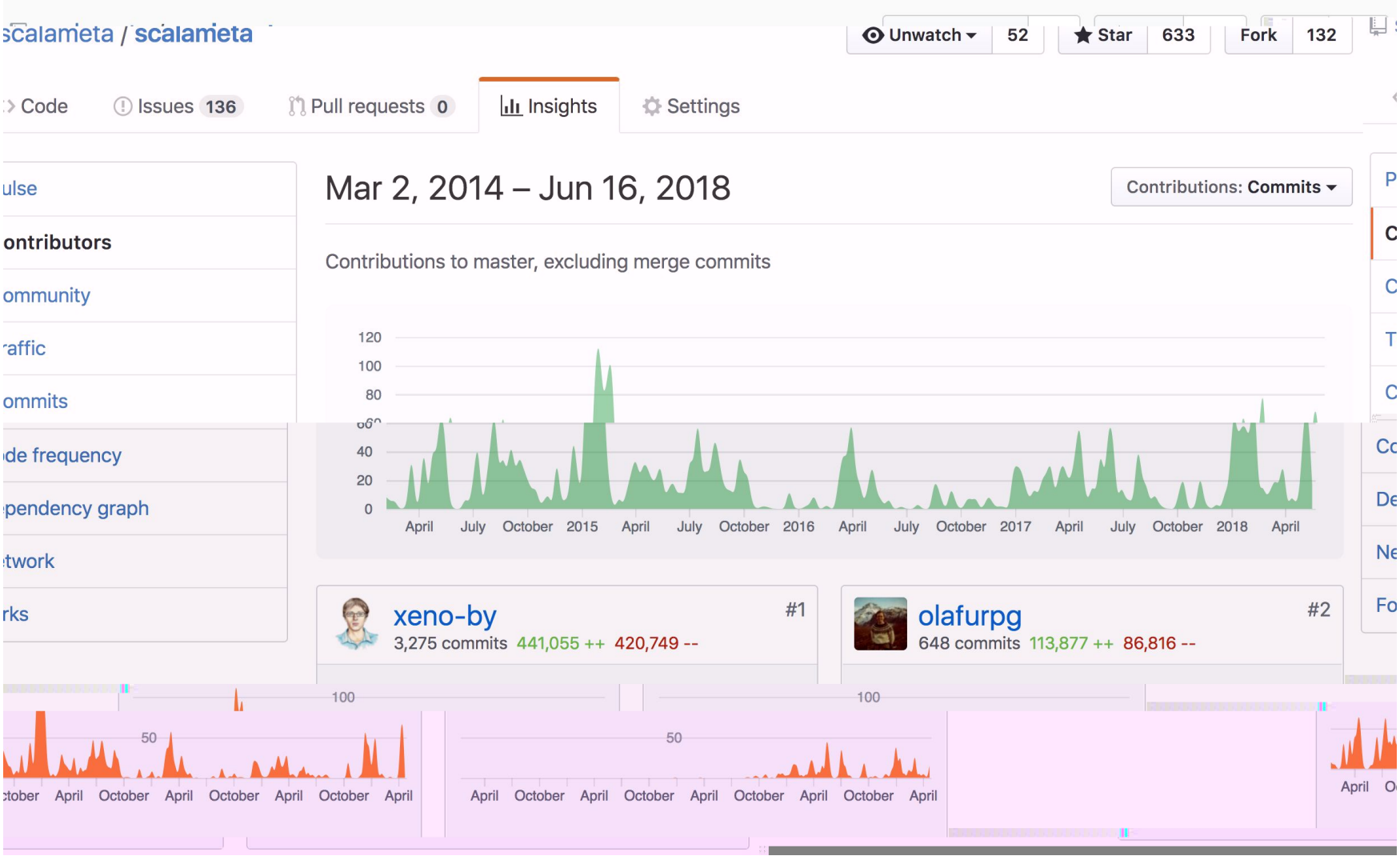
Core contributors

Advanced Scala Tools team at Twitter:

- Eugene Burmako
- Shane Delmore
- Uma Srinivasan

Early adopters

- Build team
- Continuous Integration team
- Code Review team
- Core Data Libraries team
- Core Systems Libraries team
- Other folks at Twitter


scalameta / scalameta
Unwatch 52
Star 633
Fork 132
Code
Issues 136
Pull requests 0
Insights
Settings
ulse
ontributors
ommunity
raffic
ommits
de frequency
pendency graph
twork
rks
Mar 2, 2014 – Jun 16, 2018
Contributions: Commits
Contributions to master, excluding merge commits
120
100
80
40
20
0
April
July
October
2015
2016
2017
2018
xeno-by
#1
3,275 commits 441,055 ++ 420,749 --
olafurpg
#2
648 commits 113,877 ++ 86,816 --
100
50

Problem statement

Huge codebase (ca. 2017)

- ~2^25 lines of human-written code
- ~2^16 targets

Need for semantic tooling (ca. 2017)

- Not enough to treat programs like text
- Need to understand semantics:
  - What does this identifier resolve to?
  - What are all the usages of this definition?
  - What is the type of this expression?
  - Etc etc.

Prioritized user asks (ca. 2017)

- Code browsing
- Code review
- Code evolution

State of semantic tooling (ca. 2017)

- Code browsing = IDEs, but IDEs couldn't load entire Twitter source
- Code review = Phabricator, which didn’t have Scala integration
- Code evolution = scala-refactoring, which didn’t have a maintainer
- Also, several proprietary solutions with varied Scala support

Advanced Scala Tools team

- Founded in June 2017
- Mission: “Raise the bar on what is possible for an effective Scala development environment both at Twitter and in the Scala community”
- Roadmap: improve code browsing, code review and code evolution in the Twitter development workflow

Existing semantic APIs

Existing semantic APIs (ca. 2017)

- Scala compiler internals
- Scala.reflect (thin wrapper over compiler internals)
- ScalaSignatures (serialization format for compiler internals)

Blocker #1: Learning curve

- Compiler internals span dozens of modules and thousands of methods
- Complicated data model and arcane preconditions for the APIs
- I did a PhD in Scalac internals, but still can’t make sense of all that

Blocker #2: Scarce documentation

- Scala requires an extensive semantic API
- This requires lots and lots of documentation
- Even for scala.reflect, the documentation is significantly lagging behind

Blocker #3: Compiler instance

- Compiler internals require a compiler instance
- This means poor performance even for simple operations like “Go to definition” or “Find all usages”
- Tools that use Scala compiler internals either roll their own indexer or accept the limitations

Future semantic APIs

Future semantic APIs (ca. 2020)

- Scala.reflect is based on Scala compiler internals, so it was discarded
- Meet Tasty - serialization format for Dotty compiler internals
- Used in Dotty IDE and the upcoming Dotty macro system

library/src/scala/tasty/Tasty.scala

```
abstract class Tasty {
  ...

  // DefDef
  type DefDef <: Definition
  implicit def defDefClassTag: ClassTag[DefDef]
  val DefDef: DefDefExtractor

  ...
}
```

library/src/scala/tasty/Universe.scala

```
trait Universe {
  val tasty: Tasty
  implicit val context: tasty.Context
}

object Universe {
  implicit def compilationUniverse: Universe = throw new
Exception("Not in inline macro.")
}
```

compiler/.../CompilationUniverse.scala

```
import dotty.tools.dotc.core.Contexts.Context

class CompilationUniverse(val context: Context) extends
scala.tasty.Universe {
  val tasty: TastyImpl.type = TastyImpl
}
```

Summary

- In its current form, Tasty looks very similar to scala.reflect, but reimplemented for Dotty
- Still based on compiler internals
- Still underdocumented
- **Still requires a compiler instance**

Rolling our own semantic APIs

Scalameta (ca. 2018)

- More than 10 projects
- More than 10000 commits
- More than 200 contributors
- Funded by Twitter and Scala Center

SemanticDB

- Data model for semantic information about programs
- Focused on what tool writers need from the compiler...
- ...not on what is convenient to expose in the compiler
- Collaboration between Eugene Burmako (a compiler writer) and Ólafur Páll Geirsson (a tool writer)

Interchange format

```
message TextDocument {
  Schema schema = 1;
  string uri = 2;
  string text = 3;
  Language language = 10;
  repeated SymbolInformation symbols = 5;
  repeated SymbolOccurrence occurrences = 6;
  repeated Diagnostic diagnostics = 7;
  repeated Synthetic synthetics = 8;
}
```

Example

```
object Test {
  def main(args: Array[String]): Unit = {
    println("hello world")
  }
}
```

Workflow

```
$ scalac -Xplugin:our/plugin.jar Test.scala
// Alternatively: metac Test.scala

$ find .
./META-INF
./META-INF/Test.scala.semanticdb
./Test.scala
```

Payload

```
$ xxd META-INF/semanticdb/Test.scala.semanticdb
00000000: 0ae4 0408 0312 0a54 6573 742e 7363 616c  .......Test.scal
00000010: 611a 596f 626a 6563 7420 5465 7374 207b  a.Yobject Test {
00000020: 0a20 2064 6566 206d 6169 6e28 6172 6773  .  def main(args
00000030: 3a20 4172 7261 795b 5374 7269 6e67 5d29  : Array[String])
00000040: 3a20 556e 6974 203d 207b 0a20 2020 2070  : Unit = {.    p
00000050: 7269 6e74 6c6e 2822 6865 6c6c 6f20 776f  rintln("hello wo
00000060: 726c 6422 290a 2020 7d0a 7d0a 2a5b 0a1a  rld").  }.}.*[..
00000070: 5f65 6d70 7479 5f2e 5465 7374 2e6d 6169  _empty_.Test.mai
00000080: 6e28 292e 2861 7267 7329 1808 2a04 6172  n().(args)..*.ar
...
```

Payload

```
$ metap .

Summary:
Schema => SemanticDB v3
Uri => Test.scala
Text => non-empty
Language => Scala
Symbols => 3 entries
Occurrences => 7 entries
```

Symbols

```
_empty_.Test. => final object Test extends AnyRef { +1 decls }
_empty_.Test.main(). => method main(args: Array[String]): Unit
_empty_.Test.main().(args) => param args: Array[String]
```

Occurrences

```
[0:7..0:11): Test <= _empty_.Test.
[1:6..1:10): main <= _empty_.Test.main().
[1:11..1:15): args <= _empty_.Test.main().(args)
[1:17..1:22): Array => scala.Array#
[1:23..1:29): String => scala.Predef.String#
[1:33..1:37): Unit => scala.Unit#
[2:4..2:11): println => scala.Predef.println(+1).
```

To learn more

- Check out “SemanticDB for Scala developer tools” by Ólafur Páll Geirsson (ScalaSphere 2018)
- Detailed examples of SemanticDB payloads
- Introduction to CLI utilities to work with SemanticDB
- Overview of existing tools based on SemanticDB

Rolling our own semantic tools

Opensource tools

- Metadoc (code browsing)
- Metals (code browsing and interactive development)
- Scalafix (code linting and refactoring)

Developed by Ólafur Páll Geirsson and a community of opensource contributors based on Scalameta

Company-wide semantic index

- SemanticDB doesn’t require a compiler instance
- Therefore can be made extremely fast even on huge codebases
- SQLite indexes take ~500Mb per 1Mloc and provide ~10ms query times
- Using different storage technology at Twitter, with similar characteristics

Company-wide language server

- Experimental LSP implementation backed by the semantic index
- Implements textDocument/definition and textDocument/references

Code browsing

- Experimental Intellij IDEA plugin with custom “Go to definition” and “Find references” powered by the company-wide language server
- Finally, an IDE that can handle the entire Twitter source

Code review

- Upstream improvements to DiffusionExternalSymbolsSource to take source positions into account
- Experimental implementation of a symbol source powered by the company-wide language server

Code evolution

- Upstream Scalafix, closely following cutting edge milestone builds
- Distributed Scalafix to run code rewrites across the entire Twitter source
- To learn more, check out “Scalafix @ Twitter scale” by Uma Srinivasan (Typelevel Summit Boston 2018)

Summary

Summary

- Advanced Scala Tools team was founded to improve code browsing, code review and code evolution in the Twitter development workflow
- We use SemanticDB - an opensource interchange format for semantic information developed by Eugene Burmako and Ólafur Páll Geirsson
- We have implemented experimental improvements to multiple areas of interest, integrating opensource and closed-source solutions

We are hiring!

- Are you interested in compilers and developer tools?
- Are you ready to get your hands dirty to make things happen?
- Drop Eugene Burmako an email: eburmako@twitter.com