Scala.meta semantic API

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What is scala.meta?
scala.meta is a cutting edge research
scala.meta is officially endorsed (EPFL)
Building code analysis tools at Twitter

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Long term user and advocate, medium term Scala build engineer. Helping to make it as pleasant to build Scala as it is to write it.

Friday (21st Apr.) 13:20
At Twitter, we’re working with millions of lines of Scala code, and that makes intelligent developer tools especially important. Multiple aspects of our development workflow, including code browsing, code review and code evolution, can be significantly improved if we go beyond just grep and ctags. In this talk, we will present our vision and hands-on experience with a next-generation code analysis toolkit based on the newly introduced scala.meta semantic API.
Refactoring with scalafix and scala.meta

Move fast and automatically refactor things. That's my dream at least. Scalafix is a new tool to create "rewrites" that refactor Scala code. Rewrites are composed of "patches", which is a small algebra of operations that can be assembled to run as a single refactoring step. The long-term goal of scalafix is to help automate the migration of Scala 2.x features to Dotty. In this talk, we'll learn how scalafix is implemented on top of scala.meta and how to write custom rewrites for ad-hoc library and application migrations. We'll also compare scalafix with the current landscape of Scala tooling.
scala.meta is an active project

User documentation
Head over to the user docs to learn more about the project and its roadmap.

Tutorial
If you'd like to find out how to use scala.meta, see this tutorial.

Team
The current maintainers (people who can merge pull requests) are:

- Eugene Burmako - @xeno-by
- Denys Shabalin - @desh
- Mikhail Mutcianko - @mutcianm
- Ólafur Páll Geirsson - @olafurpg
- David Dudson - @DavidDudson

An up-to-date list of contributors is available here: https://github.com/scala/meta/scala.meta/graphs/contributors.
Scala.meta API
Syntactic API

scala> import scala.meta._
import scala.meta._

scala> "println(List(1, 2, 3))".parse[Term].get
res0: scala.meta.Term = println(List(1, 2, 3))

scala> res0.structure
res1: String = Term.Apply(
    Term.Name("println"),
    Seq(Term.Apply(
        Term.Name("List"),
        Seq(Lit(1), Lit(2), Lit(3)))))

scala> res0.tokens
res2: scala.meta.tokens.Tokens = Tokens(, println, (, List, (, 1, ,, , 2, ,, , 3, ), ), )
Semantic API

- What does a name resolve to?
- What type does an expression have?
- What does an expression desugar to?
Semantic API

- What does a name resolve to?
- What type does an expression have?
- What does an expression desugar to?

println(List(1, 2, 3))

- println resolves to scala.Predef.println
- List resolves to scala.List
Semantic API

- What does a name resolve to?
- **What type does an expression have?**
- What does an expression desugar to?

```scala
println(List(1, 2, 3))
```

- `println` has type `(Any)Unit`
- `List` has type `List.type`
- 1, 2 and 3 have type `Int`
- `List(1, 2, 3)` has type `List`
- `println(List(1, 2, 3))` has type `Unit`
Semantic API

- What does a name resolve to?
- What type does an expression have?
- What does an expression desugar to?

println(List(1, 2, 3))

- List(...) desugars to List.apply(...)
- List.apply(...) desugars to List.apply[Int](...)

Our research shows that...

- These three questions can be easily answered using compiler internals
- Answering them robustly and portably is very hard
- Comprehensive solutions most likely require person-years to implement
- ...and maintain
Rethinking our strategy

- Incrementally ship semantic APIs in bite-sized portions
- Implementation simplicity trumps comprehensiveness
- Portability is still a fundamental goal of the project
In this talk

```
scala> q"println(List(1, 2, 3))"
res0: scala.meta.Term = println(List(1, 2, 3))

scala> res0.structure
res1: String = Term.Apply(Term.Name("println"),
   Seq(Term.Apply(Term.Name("List"),
                  Seq(Lit(1), Lit(2), Lit(3)))))
```
Semantic databases
Semantic databases

![File structure](image)

- **semanticdb** (06/02/17 23:28) 4.9 MB
- **streams** (06/02/17 23:29)
- **thrift_external** (06/02/17 23:29)
- **.history** (06/02/17 23:31) 1.2 KB
- **BUILD** (16/12/16 06:36) 244 bytes
- **GROUPS** (16/12/16 06:36) 11 bytes
- **OWNERS** (23/12/16 13:33) 55 bytes
$ ls
Library.scala

$ cat Library.scala
object Library {
    def main(args: Array[String]): Unit = {
        println(List(1, 2, 3))
    }
}
Semantic databases

$ scalac -Xplugin:.../scalahost.jar -Yrangepos Library.scala

$ ls
Library$.class
Library.class
Library.scala
semanticdb
Semantic databases

$ cat semanticdb
file:/Users/xeno_by/Projects/Meta1x/sandbox/Library.scala
[7..14): Library => _empty_.Library.
[23..27): main => _empty_.Library.main([Ljava/lang/String;)V.
[28..32): args => _empty_.Library.main([Ljava/lang/String;)V.(args)
[34..39): Array => _root_.scala.Array#
[40..46): String => _root_.scala.Prefdef.String#
[50..54): Unit => _root_.scala.Unit#
[63..70): println => _root_.scala.Prefdef.println(Ljava/lang/Object;)V.
[71..75): List => _root_.scala.collection.immutable.List.apply(...
Discussion

Semantic databases are...

- Portable
- Persistent
- Distributable
Mirrors
package scala.meta
package semantic
package v1

trait Mirror {
  def dialect: Dialect
  def sources: Seq[Source]
  def database: Database
  def symbol(ref: Ref): Completed[Symbol]
}
import scala.meta._

object Test extends App {
  val classpath = "...
  val sourcepath = "...
  implicit val mirror = Mirror(classpath, sourcepath)

  println(mirror.database)

  mirror.sources.foreach { source =>
    source.collect { case name @ Term.Name("println") =>
      println(name.symbol)
    }
  }
}
Discussion

You can create a mirror from:

- An instance of `scala.tools.nsc.Global`
- A classpath and a sourcepath
- An SBT build

Check out https://github.com/scalameta/sbt-semantic-example for a complete example and an accompanying guide.
Implementation details
Challenges

- Attributed trees have platform-dependent representation
- Including undocumented type inference
- Including undocumented desugarings
Strategy #1 (2015)

- Take compiler ASTs
- Try to revert platform-dependent desugarings
- Convert compiler ASTs to platform-independent ASTs

Half a year of work by compiler experts, several thousand lines of code, heavy modifications of the typechecker, almost works.
Strategy #2 (2016)

- Take compiler attributed ASTs
- Take platform-independent unattributed ASTs
- Traverse them together
- Produce platform-independent attributed ASTs

Several months of work by compiler experts, several thousand lines of code, no modifications to the typechecker, barely works.
Strategy #3 (2017)

- Take compiler ASTs
- For every name, locate a corresponding AST
- For every located AST, obtain and persist its symbol
- No platform-independent ASTs involved!

A month of work by compiler experts, several hundred lines of code, moderate modifications to the typechecker, almost works.
Future work
Next-generation tools

- Def macros
- Automatic refactorings (scalafix)
- Intelligent code browsers
- Better code review tools
- ...


More semantic APIs

- `Symbol.tpe`, `Symbol.members` and friends
- `Type.=:=`, `Type.<:<` and friends
- Additional functionality, strictly on per-usecase basis

Check out [https://github.com/scalameta/scalameta/issues/604](https://github.com/scalameta/scalameta/issues/604) for the current roadmap and links to individual work items.
Richer semantic databases

- Support for types
- Maybe even desugarings
- Tool-specific information (e.g. unused imports for scalafix)
Summary
Summary

- Scala.meta 1.6.0 ships with v1 of the semantic API
- Currently, the semantic API only includes `Ref.symbol`
- But we plan to iteratively ship more and more functionality in 2017
- This work is based on semantic databases - a major innovation in itself
Call for contributions

We need help with testing our semantic database technology. See https://github.com/scalameta/sbt-semantic-example for details.

To learn more:

- Ping us on Gitter: https://gitter.im/scalameta/scalameta
- Find me at a discussion table tomorrow at 12:00
- Join the scala.meta hackathon tomorrow at 17:00
- Attend our Scala Days talks in Chicago and Copenhagen