

State of the Meta, Summer 2015

Eugene Burmako (@xeno_by)

École Polytechnique Fédérale de Lausanne
<http://scalameta.org/>

Presented on 09 June 2015

Last updated on 03 Oct 2015

Video available in [the ScalaDays collection](#)

scala.meta

Simple, robust and portable metaprogramming foundation for Scala

— github.com/scalameta

Main goal

- ▶ Support all kinds of frontend metaprogramming tasks
- ▶ Especially novel tooling
- ▶ But also def macros and macro annotations
- ▶ More on that today in the live demo!

Presentation outline

- ▶ Syntactic API
- ▶ Semantic API
- ▶ Live demo
- ▶ Roadmap

Credits

Big thanks to everyone who helped turning scala.meta into reality!

- ▶ Uladzimir Abramchuk
- ▶ Eric Beguet
- ▶ Igor Bogomolov
- ▶ Eugene Burmako
- ▶ Mathieu Demarne
- ▶ Martin Duhem
- ▶ Adrien Ghosn
- ▶ Vojin Jovanovic
- ▶ Guillaume Massé
- ▶ Mikhail Mutcianko
- ▶ Dmitry Naydanov
- ▶ Artem Nikiforov
- ▶ Vladimir Nikolaev
- ▶ Martin Odersky
- ▶ Oleksandr Olgashko
- ▶ Alexander Podkhalyuzin
- ▶ Jatin Puri
- ▶ Dmitry Petrashko
- ▶ Denys Shabalin

Part 1: Syntactic API

Getting started

```
$ scala
```

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

Design goals

- ▶ In `scala.meta`, we keep all syntactic information about the program
- ▶ Nothing is desugared (e.g. `for` loops or string interpolations)
- ▶ Nothing is thrown away (e.g. comments or formatting details)

Implementation vehicle

First-class tokens

Tokens

```
scala> "class C { def x = 2 }".tokens  
...
```

Tokens

```
scala> "class C { def x = 2 }".tokens
res1: scala.meta.tokens.Tokens = Tokens(BOF (0..0),
class (0..5), (5..6), C (6..7), (7..8), { (8..9), (9..10),
def (10..13), (13..14), x (14..15), (15..16), = (16..17),
(17..18), 2 (18..19), (19..20), } (20..21), EOF (21..21))
```

Tokens

```
scala> "class C { def x = 2 }".tokens
res1: scala.meta.tokens.Tokens = Tokens(BOF (0..0),
class (0..5), (5..6), C (6..7), (7..8), { (8..9), (9..10),
def (10..13), (13..14), x (14..15), (15..16), = (16..17),
(17..18), 2 (18..19), (19..20), } (20..21), EOF (21..21))
```

Tokens

```
scala> "class C { def x = 2 }".tokens
res1: scala.meta.tokens.Tokens = Tokens(BOF (0..0),
class (0..5), (5..6), C (6..7), (7..8), { (8..9), (9..10),
def (10..13), (13..14), x (14..15), (15..16), = (16..17),
(17..18), 2 (18..19), (19..20), } (20..21), EOF (21..21))
```

Tokens

```
scala> "class C { def x = 2 }".tokens  
res1: scala.meta.tokens.Tokens = Tokens(BOF (0..0),  
class (0..5), (5..6), C (6..7), (7..8), { (8..9), (9..10),  
def (10..13), (13..14), x (14..15), (15..16), = (16..17),  
(17..18), 2 (18..19), (19..20), } (20..21), EOF (21..21))
```

Tokens

```
scala> "class C { def x = 2 }".tokens  
res1: scala.meta.tokens.Tokens = Tokens(BOF (0..0),  
class (0..5), (5..6), C (6..7), (7..8), { (8..9), (9..10),  
def (10..13), (13..14), x (14..15), (15..16), = (16..17),  
(17..18), 2 (18..19), (19..20), } (20..21), EOF (21..21))
```

High-fidelity parsers

```
scala> "class C".parse[Stat]  
res2: scala.meta.Stat = class C
```

```
scala> "class C {}".parse[Stat]  
res3: scala.meta.Stat = class C {}
```


High-fidelity parsers

```
scala> "class C".parse[Stat]  
res2: scala.meta.Stat = class C
```

```
scala> "class C {}".parse[Stat]  
res3: scala.meta.Stat = class C {}
```

```
scala> res2.tokens  
res4: scala.meta.tokens.Tokens = Tokens(BOF (0..0),  
class (0..5), (5..6), C (6..7), EOF(7..7))
```

```
scala> res3.tokens  
res5: scala.meta.tokens.Tokens = Tokens(BOF (0..0),  
class (0..5), (5..6), C (6..7),  
(7..8), { (8..9), } (9..10), EOF (10..10))
```

Automatic and precise range positions

```
scala> "class C { def x = 2 }".parse[Stat]  
res6: scala.meta.Stat = class C { def x = 2 }
```

```
scala> val q"class C { $method }" = res6  
method: scala.meta.Stat = def x = 2
```

Automatic and precise range positions

```
scala> "class C { def x = 2 }".parse[Stat]  
res6: scala.meta.Stat = class C { def x = 2 }
```

```
scala> val q"class C { $method }" = res6  
method: scala.meta.Stat = def x = 2
```

```
scala> method.tokens  
res6: scala.meta.tokens.Tokens = Tokens(  
def (10..13), (13..14), x (14..15), (15..16),  
= (16..17), (17..18), 2 (18..19))
```

Hacky quasiquotes in scala.reflect

```
$ scala -Yquasiquote-debug
```

```
scala> import scala.reflect.runtime.universe._  
import scala.reflect.runtime.universe._
```

```
scala> val name = TypeName("C")  
name: reflect.runtime.universe.TypeName = C
```

```
scala> q"class $name"  
...
```

Hacky quasiquotes in scala.reflect

```
$ scala -Yquasiquote-debug
```

```
scala> import scala.reflect.runtime.universe._  
import scala.reflect.runtime.universe._
```

```
scala> val name = TypeName("C")  
name: reflect.runtime.universe.TypeName = C
```

```
scala> q"class $name"
```

```
...
```

```
code to parse:
```

```
class qq$a2912896$macro$1
```

```
parsed:
```

```
Block(List(), ClassDef(Modifiers(),
```

```
TypeName("qq$a2912896$macro$1"), List(), Template(...))
```

```
...
```

Principled quasiquotes in scala.meta

```
$ scala -Dquasiquote.debug
```

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

```
scala> val name = t"C"  
...  
name: scala.meta.Type.Name = C
```

```
scala> q"class $name"  
...
```

Principled quasiquotes in scala.meta

```
$ scala -Dquasiquote.debug
```

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

```
scala> val name = t"C"  
...  
name: scala.meta.Type.Name = C
```

```
scala> q"class $name"  
...  
Adhoc(List(BOF (0..0), class (0..5), (5..6),  
$name (0..5), EOF (0..0)))  
...
```

Derived technologies

First-class tokens enable:

- ▶ High-fidelity parsers
- ▶ Automatic and precise range positions
- ▶ Principled quasiquotes

Part 2: Semantic API

Getting started

```
$ scala
```

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

```
scala> implicit val c = Context(...)  
c: scala.meta.Context = ...
```

Getting started

```
$ scala
```

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

```
scala> implicit val c = Context(...)  
c: scala.meta.Context = ...
```

Contexts can come from:

- ▶ `scalahost`: based on `scalac` internals

Getting started

```
$ scala
```

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

```
scala> implicit val c = Context(...)  
c: scala.meta.Context = ...
```

Contexts can come from:

- ▶ `scalahost`: based on `scalac` internals
- ▶ `intellijhost`: implemented on top of IntelliJ

Getting started

```
$ scala
```

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

```
scala> implicit val c = Context(...)  
c: scala.meta.Context = ...
```

Contexts can come from:

- ▶ `scalahost`: based on `scalac` internals
- ▶ `intellijhost`: implemented on top of IntelliJ
- ▶ Anywhere else: anyone can implement a context

Design goals

- ▶ In `scala.meta`, we model everything just with its abstract syntax
- ▶ Types, members, names, modifiers: all represented with trees
- ▶ There's only one data structure, so there's only one way to do it

Implementation vehicle

First-class names

Bindings in scala.reflect

```
$ scala
```

```
scala> import scala.reflect.runtime.universe._  
import scala.reflect.runtime.universe._
```

```
scala> showRaw(q"class C { def x = 2; def y = x }")  
...
```


Bindings in scala.reflect

```
$ scala
```

```
scala> import scala.reflect.runtime.universe._  
import scala.reflect.runtime.universe._
```

```
scala> showRaw(q"class C { def x = 2; def y = x }")  
res1: String = ClassDef(  
  Modifiers(), TypeName("C"), List(),  
  Template(  
    List(Select(Ident(scala), TypeName("AnyRef"))),  
    noSelfType,  
    List(  
      DefDef(NoMods, termNames.CONSTRUCTOR, ...),  
      DefDef(NoMods, TermName("x"), ..., Literal(Constant(2))),  
      DefDef(NoMods, TermName("y"), ..., Ident(TermName("x")))))
```

Bindings in scala.reflect

```
$ scala
```

```
scala> import scala.reflect.runtime.universe._  
import scala.reflect.runtime.universe._
```

```
scala> showRaw(q"class C { def x = 2; def y = x }")  
res1: String = ClassDef(  
  Modifiers(), TypeName("C"), List(),  
  Template(  
    List(Select(Ident(scala), TypeName("AnyRef"))),  
    noSelfType,  
    List(  
      DefDef(NoMods, termNames.CONSTRUCTOR, ...),  
      DefDef(NoMods, TermName("x"), ..., Literal(Constant(2))),  
      DefDef(NoMods, TermName("y"), ..., Ident(TermName("x")))))
```

Bindings in scala.reflect

```
$ scala
```

```
scala> import scala.reflect.runtime.universe._  
import scala.reflect.runtime.universe._
```

```
scala> showRaw(q"class C { def x = 2; def y = x }")  
res1: String = ClassDef(  
  Modifiers(), "C", List(),  
  Template(  
    List(Select(Ident(scala), "AnyRef")),  
    noSelfType,  
    List(  
      DefDef(NoMods, termNames.CONSTRUCTOR, ...),  
      DefDef(NoMods, "x", ..., Literal(Constant(2))),  
      DefDef(NoMods, "y", ..., Ident("x")))))
```

Bindings in scala.reflect

```
$ scala
```

```
scala> import scala.reflect.runtime.universe._  
import scala.reflect.runtime.universe._
```

```
scala> showRaw(q"class C { def x = 2; def y = x }")  
res1: String = ClassDef(  
  Modifiers(), "C", List(),  
  Template(  
    List(Select(Ident(scala), "AnyRef")),  
    noSelfType,  
    List(  
      DefDef(NoMods, termNames.CONSTRUCTOR, ...),  
      DefDef(NoMods, "x", ..., Literal(Constant(2))),  
      DefDef(NoMods, "y", ..., Ident("x")))))
```

Bindings in scala.meta

```
$ scala
```

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

```
scala> q"class C { def x = 2; def y = x }".show[Structure]  
res1: String = Defn.Class(  
  Nil, Type.Name("C"), Nil,  
  Ctor.Primary(Nil, Ctor.Name("this"), Nil),  
  Template(  
    Nil, Nil,  
    Term.Param(Nil, Name.Anonymous(), None, None),  
    Some(List(  
      Defn.Def(Nil, Term.Name("x"), ..., Lit.Int(2)),  
      Defn.Def(Nil, Term.Name("y"), ..., Term.Name("x")))))
```

Key example

`List[Int]`

Key example

```
scala> t"List[Int]".show[Structure]  
res1: String =  
Type.Apply(Type.Name("List"), List(Type.Name("Int")))
```

```
scala> implicit val c = Context(...)  
c: scala.meta.Context = ...
```

Key example

```
scala> t"List[Int]".show[Structure]
res1: String =
Type.Apply(Type.Name("List"), List(Type.Name("Int")))
```

```
scala> implicit val c = Context(...)
c: scala.meta.Context = ...
```

```
scala> t"List[Int]".show[Semantics]
res3: String =
Type.Apply(Type.Name("List")[1], List(Type.Name("Int")[2]))
[1] {1}::scala.package#List
[2] {2}::scala#Int
...
```


Name resolution

```
scala> implicit val c = Context(...)
c: scala.meta.Context = ...
```

```
scala> q"scala.collection.immutable.List".defn
res2: scala.meta.Member.Term = object List extends
SeqFactory[List] with Serializable { ... }
```

```
scala> res2.name
res3: scala.meta.Term.Name = List
```

Other semantic APIs

```
scala> q"scala.collection.immutable.List".defs("apply")
res4: scala.meta.Member.Term =
override def apply[A](xs: A*): List[A] = ???
```

```
scala> q"scala.collection.immutable.List".supermembers
res5: Seq[scala.meta.Member.Term] =
List(abstract class SeqFactory...)
```

Derived technologies

First-class names enable:

- ▶ Unification of trees, types and symbols
- ▶ Referential transparency and hygiene (under development!)
- ▶ Simpler mental model of metaprogramming

Part 3: Live demo

Part 4: Roadmap

Where we've been before

- ▶ With `scala.meta`, we started from complete scratch

Lots of experimentation

- ▶ Safe by construction trees
- ▶ High-fidelity parsing
- ▶ Automatic and precise range positions
- ▶ Principled quasiquotes
- ▶ Unification of trees, symbols and types
- ▶ AST persistence
- ▶ AST interpretation
- ▶ Simple syntax and compilation for macros
- ▶ IDE support for macros
- ▶ SBT support for macros
- ▶ ...

Where we are now

- ▶ Tokens provide an elegant and powerful foundation for syntactic APIs
- ▶ Names enable a simple mental model for semantic APIs
- ▶ People are already successfully using these new concepts!

Where we will be soon

- ▶ Experimentation's temporarily on hold, we're now pushing for 0.1
- ▶ Main focus of 0.1 is making scala.meta trees publicly available
- ▶ <https://github.com/scalameta/scalameta/milestones/0.1>

Where we will be soon

- ▶ Experimentation's temporarily on hold, we're now pushing for 0.1
- ▶ Main focus of 0.1 is making scala.meta trees publicly available
- ▶ <https://github.com/scalameta/scalameta/milestones/0.1>

Contributor alert!

<https://github.com/scalameta/scalameta/issues>

Wrapping up

Summary

- ▶ scala.meta is a one-stop solution to frontend metaprogramming
- ▶ Our key innovations include first-class support for tokens and names
- ▶ We're now pushing for the 0.1 preview release
- ▶ Join us at <https://gitter.im/scalameta/scalameta>!