Rethinking Scala Macros

Work in progress, not available yet

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Outline

- What is Palladium?
- Planned features
- Planned deliverables
- Final words

What is Palladium?

Project Palladium

- Successor of Project Kepler
- Goal of Project Kepler: bring macros to Scala
- Goal of Project Palladium: make macros in Scala easy to use

Scala macros: the good parts

- Enable cool use cases that were previously impossible/impractical
- Have a significant community of research and production users
- A lot of popular libraries in Scala ecosystem use macros

Scala macros: the bad parts

- Using macros is easy, developing macros is hard
- This contributes to the public image of metaprogramming
- Useful, but hacky and obscure

I'm very envious of Racket macros, because it's very extensible. But I don't know how to do it for Haskell. TH is the nearest, but it's nowhere near.

—Simon Peyton Jones

Palladium goal #1: Being straightforward

```
coll.map(x => x + 1)
```

```
{
  def fn(x: Int) = x + 1
  val buf = Coll.newBuilder[T]
  var i = 0
  while (i < coll.length) buf += fn(coll(i))
  buf.result
}
```

- A canonical example that illustrates current problems with macros
- Currently possible, but prohibitively complex to get right
- To goal of Palladium is to make such macros writeable on autopilot

Palladium goal #2: Being portable

The trick is to make this work with:

- Scala compilers other than `scalac`
- Integrated development environments
- Incremental compilation
- Interactive documentation
- Runtime reflection

Summary

Palladium will make macros straightforward and portable

Planned features

Our running example

```
coll.map(x => x + 1)
```

```
{
  def fn(x: Int) = x + 1
  val buf = Coll.newBuilder[T]
  var i = 0
  while (i < coll.length) buf += fn(coll(i))
  buf.result
}
```

- Let's take another look at Paul's declosurify
- Possible but ridiculously hard at the moment
- How can Palladium help?

Disclaimer

- What follows is just a sketch, nothing's implemented yet
- We might or might not be able to figure out everything
- But all in all, the plan seems reasonable enough
- After we have results, we'll see how/when this can be part of Scala

Feature #1: Simple definitions

```
import scala.reflect._
import scala.language.macros

implicit class Mapper[Coll[_], A](coll: Coll[A]) {
  macro map[B](fn: A => B): Coll[B] = {
    val q"(..$ps) => $body" = fn
    val newBuilder = t"Coll".companion.method("newBuilder")
    q"""
      def fn(..$ps) = $body
      val buf = $newBuilder[$A]
      var i = 0
      while (i < coll.length) buf += fn(coll(i))
      buf.result
    """
  }
}
```

- No longer necessary to split macro defs and macro impls
- No longer necessary to write tiresome c.Expr and c.WeakTypeTag

Feature #2: Simple reflection

```
import scala.reflect._
import scala.language.macros

implicit class Mapper[Coll[_], A](coll: Coll[A]) {
  macro map[B](fn: A => B): Coll[B] = {
    val q"(..$ps) => $body" = fn
    val newBuilder = t"Coll".companion.method("newBuilder")
    q"""
      def fn(..$ps) = $body
      val buf = $newBuilder[$A]
      var i = 0
      while (i < coll.length) buf += fn(coll(i))
      buf.result
    """
  }
}
```

- Explicit macro context will be gone, along with path dependencies
- Redesigned reflection API that makes introspection and codegen easy

Feature #3: Simple trees

```
import scala.reflect._
import scala.language.macros

implicit class Mapper[Coll[_], A](coll: Coll[A]) {
  macro map[B](fn: A => B): Coll[B] = {
    val q"(..$ps) => $body" = fn
    val newBuilder = t"Coll".companion.method("newBuilder")
    q"""
      def fn(..$ps) = $body
      val buf = $newBuilder[$A]
      var i = 0
      while (i < coll.length) buf += fn(coll(i))
      buf.result
    """
  }
}
```

- No more manual construction/deconstruction, reification, exprs
- Trees won't carry types or symbols, but will be typecheckable

Feature #4: Simple types

```
import scala.reflect._
import scala.language.macros

implicit class Mapper[Coll[_], A](coll: Coll[A]) {
  macro map[B](fn: A => B): Coll[B] = {
    val q"(..$ps) => $body" = fn
    val newBuilder = t"Coll".companion.method("newBuilder")
    q"""
      def fn(..$ps) = $body
      val buf = $newBuilder[$A]
      var i = 0
      while (i < coll.length) buf += fn(coll(i))
      buf.result
    """
  }
}
```

- Convenient notation to construct and deconstruct types
- No more tags, no more case `TypeRef(...)`, no more `appliedType`

Feature #5: Simple symbols

```
import scala.reflect._
import scala.language.macros

implicit class Mapper[Coll[_], A](coll: Coll[A]) {
  macro map[B](fn: A => B): Coll[B] = {
    val q"(..$ps) => $body" = fn
    val newBuilder = t"Coll".companion.method("newBuilder")
    q"""
      def fn(..$ps) = $body
      val buf = $newBuilder[$A]
      var i = 0
      while (i < coll.length) buf += fn(coll(i))
      buf.result
    """
  }
}
```

- Symbols as we know them should be gone for good
- Introspection serviced by `Members`, bindings handled by hygiene

Feature #6: Inline expansion

- We can treat macro applications as folded regions of code
- When you press [+], a given macro application expands
- When you press [-], a given macro expansion collapses back

Feature #7: Expansion error highlighting

- Inline expansion will provide long-awaited interactivity
- For one, errors in macro expansions are going to make sense
- Have an error? Click [+] and see what exactly causes it!

Feature #8: Expansion error troubleshooting

- Quasiquotes can be smart, capturing locations they originate from
- That would enable tracking culprits of errors in generated code
- One could even imagine interactive fixes to codegen errors

Feature #9: Inline debugging

- The concept of interactive expansion is also applicable to debugging
- Once a macro is expanded, you will be able to set breakpoints in expanded code

Feature #10: Incremental compilation

SBT will correctly handle macro expansions:

- No more whole project recompilations on a tiny change in a macro
- Changes to macro arguments will recompile expansions
- Changes to macro bodies and their helpers will recompile expansions
- Changes to types introspected by macros will recompile expansions

Summary

- Simple macro definitions
- Simple reflection API
- Interactive expansion
- Inline debugging
- Incremental compilation

Planned deliverables

M1

- Aims to deliver a demoable prototype of the Palladium macro system
- That works nicely with the existing ecosystem of tools
- And is reasonably compatible with existing popular macros
- By ScalaDays 2014 (16-18 June)

Component #1: New reflection API

- Reflection Core, a redesigned compile-time/runtime reflection library
- Interface shared between Scala, Dotty, Eclipse, Intellij, SBT, etc
- Specced and developed independently of implementors

Component #2: Hygienic quasiquotes

- Smart quasiquoting facility that respects hygiene and ref transparency
- Very much relies on getting trees right
- Denys will elaborate on that at Scala Days

Component #3: AST interpretation

- Macros will run in an interpreter, ensuring portability and compatibility
- NB! Here we only need to interpret typed ASTs, relying on the fact that our host is going to provide a typechecking facility
- Having an AST interpreter is also useful beyond macro expansion
- For example, it will give us a fast and minimalistic REPL!

Component #4: AST persistence

- In order to interpret macros, we need to store their ASTs
- And not only their ASTs, but also ASTs of their dependencies
- Ramping this up, how about we store ASTs for everything?!
- AST persistence is also useful beyond macro expansion

Components #3+4: Runtime expansion

- AST interpretation and AST persistence work very well together
- Interpreted ASTs => we don't need the compiler to run macros
- Persistent ASTs => we don't need the compiler to setup environment
- As a result, we will be able to expand macros at runtime!!

Component #5: Tooling infrastructure (SBT)

- At the moment, SBT doesn't know almost anything about macros
- A) If macro body changes, we've got to recompile, but we don't
- B) If macro data changes, we've got to recompile, but we don't
- With ASTs and interpretation traces, we can do so much better!

Component #5: Tooling infrastructure (IDE)

- Not much can be done if macros are just arbitrary functions
- However with interpretation we can easily control expansions
- The model of [+]/[-] buttons for macro applications
- Both for interactive editing and debugging

Summary

- Straightforward reflection API decoupled from compiler internals
- Hygienic quasiquotes which are essential for tree manipulations
- AST interpreter
- AST persistence
- Tooling infrastructure: incremental compilation and IDEs

Final words

Status

- Palladium was kicked off just two weeks ago
- Most of the team is from EPFL with several external contributors
- It is a research platform for new metaprogramming technologies
- Targetting Scala and Dotty

Feedback

- Your feedback and contributions are very much welcome
- Mailing list: palladium-dev @ groups.google.com
- Design documents: Palladium Shared @ docs.google.com

Summary

- Palladium will make macros straightforward and portable
- New reflection + AST interpretation + AST persistence + tooling
- Welcome to the future of Scala macros!