Directembedding

Concealing the Deep Embedding of DSLs

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Overview

Motivation

Mission statement

Enable wider adoption of embedded DSLs

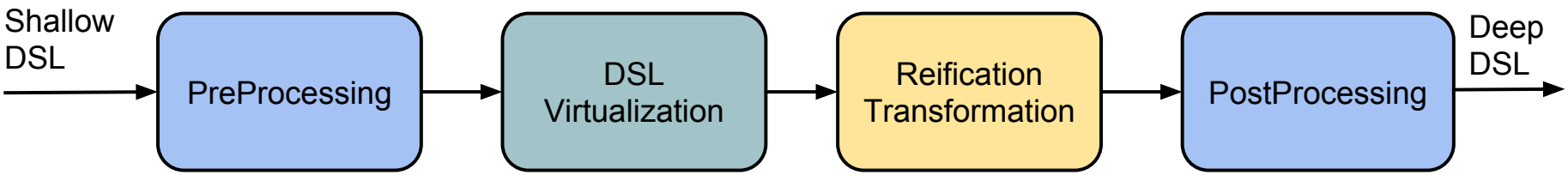
The Struggle

Deeply embedded vs. Shallowly embedded

	Author	User
Deep		
Shallow		

Overview

Pipeline


Shallow
DSL
PreProcessing
DSL
Virtualization
Reification
Transformation
PostProcessing
Deep
DSL

Language Virtualization

Override standard language features

```
if (cond) 1 else 2 => __ifThenElse(cond, 1, 2)
x == y             => infix_==(x, y)
var x = "str"      => __newVar("str")
while (cond) body  => __while(cond, body)
// etc.
```

Type overriding

Override behavior predefined and third-party types

```
class MyInt {
  @reifyAs(IntPlus)
  def +(x: Int): Int = ???
}
// Shallow
dsl {
  val x = 1
  x + 2
}
// Deep
IntPlus(x, lift(1))
```

Improved error messages

```
// Shallow
dsl {
  val s = "foobar"
  s.charAt(1)
}
// Compiler error
[error] method charAt on class String is not
    supported in example.dsl:
  s.charAt(1)
    ^
```

Configuration
@reifyAs

```
// Inside Query trait.
@reifyAs(Take)
def take(i: Long): Query[T, C] = ???
// Shallow query.
query {
  Query.take(1)
}
// Deep query.
Take(Query, lift(1))
```

Configuration
@reifyAsInvoked

```
// Inside Query trait.
@reifyAsInvoked
def take(i: Long): Query[T, C] = ???
// Shallow query.
query {
  Query.take(1)
}
// Deep query.
lift(Query).take(lift(1))
```

Configuration
@passThrough

```
// Inside Query trait.
@passThrough
def take(i: Long): Query[T, C]
def missingAnnotation(): Int = 1
// Shallow query.
query {
  Query.take(missingAnnotation())
}
// Deep query.
lift(Query).take(missingAnnotation())
```

Overview

Problem statement

Problem statement

Develop an awesome embedded query language in Scala

Lifted embedding
aka Slick

- Currently supported API in Slick 3.0

The good parts

1. Uses standard Scala
2. Feature rich

The bad parts

1. Lifted embedding table requires boilerplate
2. Cryptic error messages

Problem 1

Lifted embedding table requires boilerplate

```
case class User(id: Int, name: String)

// Lifted embedding table
class Users(tag: Tag)
  extends Table[User](tag, "User") {

  def id: Rep[Int] = column[Int]("id")
  def name: Rep[String] = column[String]("name")

  def * = ProvenShape.proveShapeOf((id, name) <>
      ((User.apply _).tupled, User.unapply))
}
```

Problem 2
Cryptic error messages

```
[Error] User.scala:25: No matching Shape found.
Slick does not know how to map the given types.
Possible causes: T in Table[T] does not
match your * projection.  Or you use an
unsupported type in a Query (e.g. scala List).
  Required level: slick.lifted.FlatShapeLevel
     Source type:
(slick.lifted.Rep[Int], slick.lifted.Rep[String],
    slick.lifted.Rep[Int])
   Unpacked type: (Int, String)
     Packed type: Any
def * = ProvenShape.proveShapeOf(
(id, name, id) <> ((User.apply _).tupled,User.unapply)
                  ^
```

Direct embedding
Deprecated in Slick 3.0

The good parts

1. No more boilerplate
2. Comprehensible error messages

The bad parts

1. Queries can fail at runtime
2. Difficult to develop and maintain

Benefit 1
No more boilerplate

```
@Table("USER")
case class User(
  @PrimaryKey @Column("ID")
  id: Int,
  @Column("NAME")
  name: String
)
```

Problem 1
Queries can fail at runtime

```
// Compiles!
Query[User].map(_.id.toDouble)
// But runtime error...
```

Shadow embedding
Powered by Yin-Yang

- Master project of Amir Shaikhha, August 2013

The good parts

1. User-friendly API
2. Comprehensive and comprehensible error messages
3. Great performance

The not so good parts

1. Challenging for the DSL author

Shadow embedding
Powered by Yin-Yang

- Master project of Amir Shaikhha, August 2013

The good parts

1. User-friendly API
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3. Great performance

The not so good parts

1. Challenging for the DSL author

We are almost there!

Problem
Auto generated SlickCake

```
trait YYSlickCakeTuples {
  type Tuple2[T1,T2] = YYTuple2[T1,T2]
  implicit def yyRepTuple2ToYYTuple[T1,T2](x:
     CakeRep[scala.Tuple2[T1,T2]]): Tuple2[T1,T2]
       = x.asInstanceOf[Tuple2[T1,T2]]
  // 1300 more LOC for up to Tuple22...
}
trait YYSlickCake with YYSlickCakeTuples {
    implicit def yyColumnOptionToYYOption[T](x:
       YYColumn[scala.Option[T]]): YYOption[T]
                = YYOption.fromYYColumn(x)
  // ...
}
```

Problem

3 layers of Query

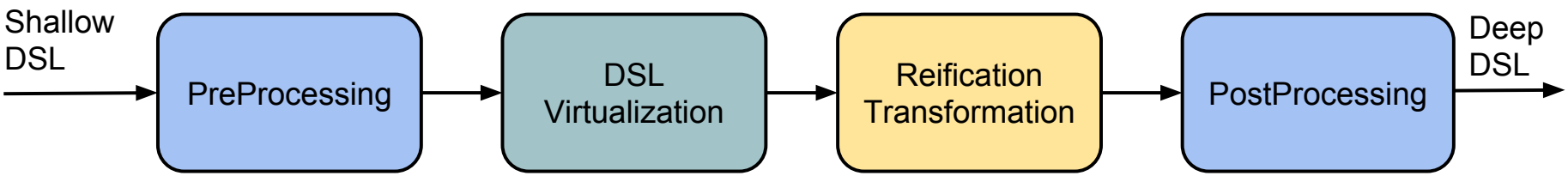
```
trait Query[T] // Shallow
  def map[S](projection: T => S): Query[S]
trait YYQuery[T] // Shadow
  def map[S](projection: YYRep[T] => YYRep[S]):
      YYQuery[S]
       = YYQuery.fromQuery(
         query.map(underlyingProjection(projection))
         (YYShape.ident[S]))
trait Query[E, T] // Lifted
  def map[F, G, T](f: E => F)(implicit shape:
      Shape[F, T, G]): Query[G, T]
```

Directembedding

From shallow to deep in one step

slick-direct v2

Pipeline reminder



Shallow configuration
Simplified example

```
trait Query[T, C[_]]
  @reifyAsInvoked
  def filter(f: T => Boolean): Query[T, C]

@reifyAs(SlickReification.column _)
def column[T, C](e: T, name: String,
                 tt: TypedType[C]): C
@reifyAs(SlickReification.slick_=== _)
def infix_==(a: Int, b: Int): Boolean = ???

object SlickPredef
  @passThrough
  def implicitly[T]: T
```

Deep configuration
Simplified example

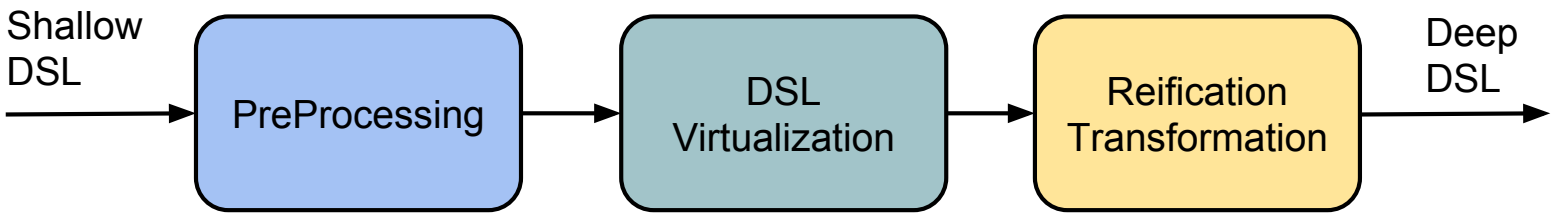
```
object SlickReification {
  def slick_===[T](lhs: lifted.Rep[T], rhs:
     lifted.Rep[T]): Rep[Option[Boolean]] = {
    columnExtensionMethods(lhs) === rhs
  }
  def column[T, C](e: AnyRef,
       field: Rep[String],
       tt: TypedType[C]): Rep[C]
  // 20 more LOC
}
```

Directembedding transformation

Pipeline

Shallow query

```
query {
  Query[User].filter(_.name == "Olafur")
}
```

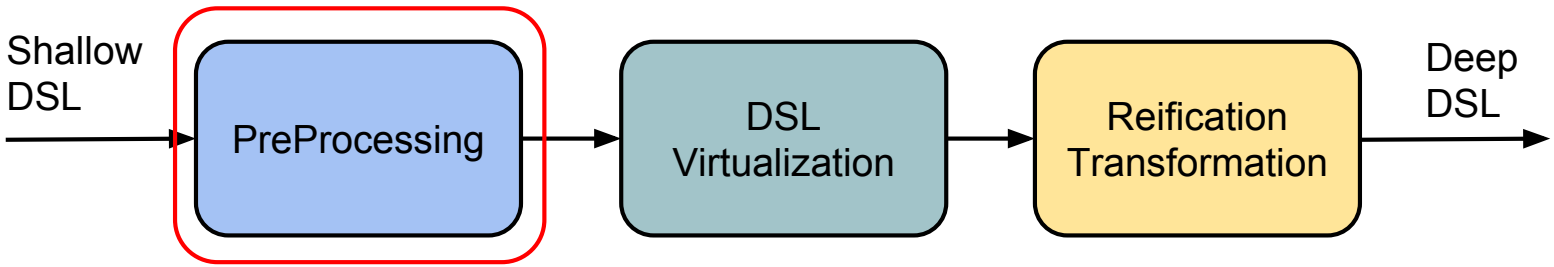


Directembedding transformation

Pipeline

PreProcessing

```
class UserTable extends Table[User] { /* ... */ }
UserTable.filter { u =>
  column(u, "name", implicitly[TypedType[String]])
    == "Olafur"
}
```

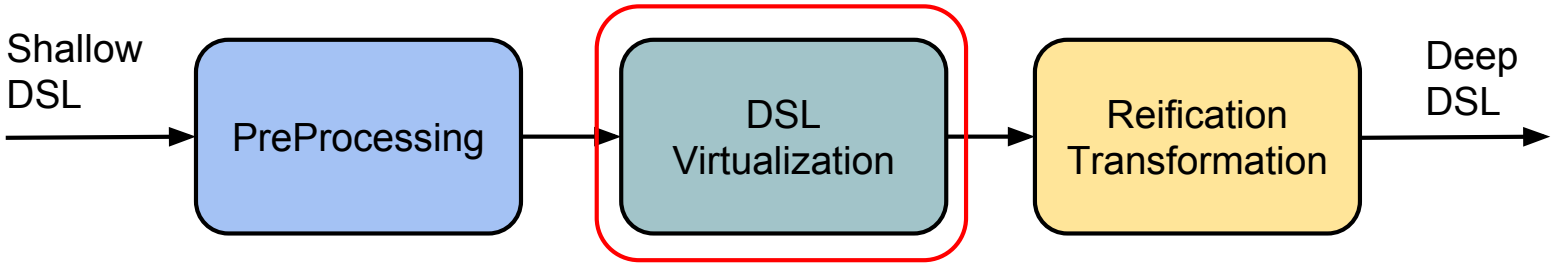


Directembedding transformation

Pipeline

DSL Virtualization

```
import DslConfig._
class UserTable extends Table[User] { /* ... */ }
UserTable.filter { u => infix_==(
    shallowColumn(u, "name",
      implicitly[TypedType[String]]),
    "Olafur"
  )
}
```

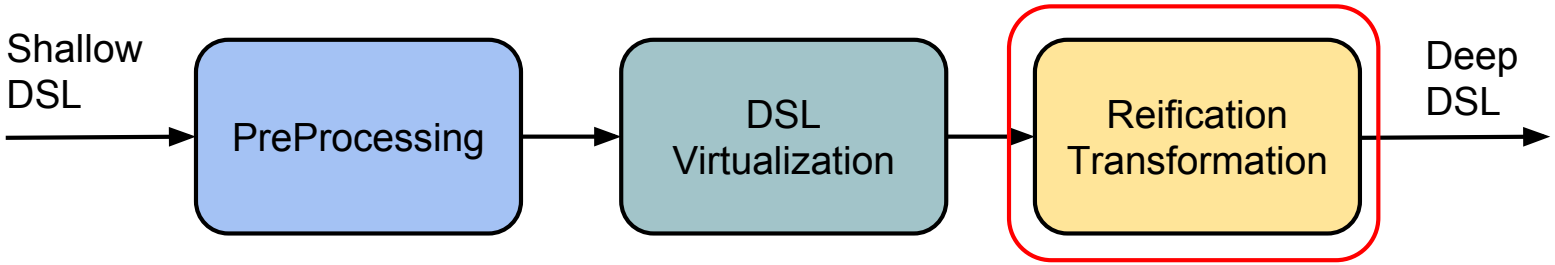


Directembedding transformation

Pipeline

Reification Transformation

```
import DslConfig._
class UserTable extends Table[User] { /* ... */ }
lift(UserTable).filter { u => slick_===(
    deepColumn(u, lift("name"),
      implicitly[TypedType[String]]),
    lift("Olafur")
  )
}
```



It works!

FilterSpec

```
"filter" should "work with string equality" in {
  equalQueries(
    query {
      directUsers.filter(_.name == "Olafur")
    }.result,
    liftedUsers.filter(_.name === "Olafur").result
  )
} // Success
```

Overview

Conclusion

Directembedding

- Language virtualization
- Type overriding
- More reification options
- Improved configuration

Slick-direct v2

- Under 300 LOC, developed in less than 2 weeks
- Queries supported: select *, join, filter, map, flatMap, take, (custom column types)

Future work

- More case studies
- Improve slick-direct

The End

Thank you!