Automatic refactorings for Scala programs

Taming multi-paradigm code

Ilya Sergey Dave Clarke Alexander Podkhalyuzin

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Outline

- Why implementing refactorings for Scala is challenging?
- What refactorings have we implemented for now?
- What kind of Scala-specific refactorings could be useful?

What are refactorings good for for

- Cleaning up code
- Changing internal code structure and design
- Improving understandability
- Providing better modularization

What are refactorings not used for

- Adding new functionality
- Fixing bugs
- Changing overall program behaviour

Case study: *extract method* refactoring in Java

```java
void printBanner() {
  String name = getName();
  final String banner = getBanner();

  //begin
  System.out.println("name: " + name);
  name = "Mr. " + name;
  System.out.println("banner " + banner);
  // end

  System.out.println(name);
}
```

```java
void printBanner() {
  String name = getName();
  final String banner = getBanner();
  name = changeName(banner, name);
  System.out.println(name);
}

 private String changeName(String banner,
                           String name) {
  System.out.println("name: " + name);
  name = "Mr. " + name;
  System.out.println("banner " + banner);
  return name;
}
```

Input and output local values
of the code fragment are captured

Catalog of useful refactorings in object-oriented frameworks

- Add Parameter
- Change Bidirectional Association to Unidirectional
- Change Reference to Value
- Change Unidirectional Association to Bidirectional
- Change Value to Reference
- Collapse Hierarchy
- Consolidate Conditional Expression
- Consolidate Duplicate Conditional Fragments
- Convert Dynamic to Static Construction
- Convert Static to Dynamic Construction
- Decompose Conditional
- Duplicate Observed Data
- Eliminate Inter-Entity Bean Communication
- Encapsulate Collection
- Encapsulate Downcast
- Encapsulate Field
- Extract Class
- Extract Interface
- Extract Method
- Extract Package
- Extract Subclass
- Extract Superclass
- Form Template Method
- Hide Delegate
- Hide Method
- Hide presentation tier-specific details from the business tier
- Inline Class
- Inline Method
- Inline Temp
- Introduce A Controller
- Introduce Assertion
- Remove Middle Man
- Remove Parameter
- Remove Setting Method
- Rename Method
- Replace Array with Object
- Introduce Business Delegate
- Introduce Explaining Variable
- Introduce Foreign Method
- Introduce Local Extension
- Merge Session Beans
- Move Business Logic to Session
- Move Class
- Move Field
- Move Method
- Parameterize Method
- Preserve Whole Object
- Pull Up Constructor Body
- Pull Up Field
- Pull Up Method
- Push Down Field
- Push Down Method
- Reduce Scope of Variable
- Refactor Architecture by Tiers
- Remove Assignments to Parameters
- Remove Control Flag
- Remove Double Negative
- Remove Middle Man
- Remove Parameter
- Remove Setting Method
- Replace Assignment with Initialization
- Replace Conditional with Polymorphism
- Replace Conditional with Visitor
- Replace Constructor with Factory Method
- Replace Data Value with Object
- Replace Delegation with Inheritance
- Replace Error Code with Exception
- Replace Exception with Test
- Replace Inheritance with Delegation
- Replace Iteration with Recursion
- Replace Magic Number with Symbolic Constant
- Replace Method with Method Object

Not all the refactorings should be automatized

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Now comes *Scala*

- Fusion of functional and object-oriented paradigms
- First-class and higher-order functions
- Dependent types / imports
- Custom implicit conversions
- Flexible scoping rules

Classical refactorings for Java must be reconsidered

Scala-specific refactorings

- Adapt Java programming style for Scala
- Abstract over structure of types
- Take advantage of Scala's functional programming features

Refactorings we have implemented so far

- Rename variable, method, class *etc*.
- Move class
- Safe delete class
- Optimize imports
- Introduce / inline variable
- Extract method

Optimize imports

- Goal: *Remove unused import statements*
- Challenge: *Implicit conversions demand additional checks*

Meaningful import of an implicit conversion function

```
class A
class B
object MyConversions {
  implicit def a2b(a: A): B = new B
}

def testB(b: B): Any = {/* some code */}

import MyConversions._

val a = testB(new A)
```

Cannot be removed!

In fact this is `a2b(new A)`

Demo

Optimize imports

Extract variable from an expression

- New coding style: *write-introduce*
- No more tedious preamble
  - `final Map<String, Object> map = new HashMap<...>();`
- Write an expression and introduce it as a variable: *the necessary type will be inferred*

Introduce variable by expression

- <u>Goal</u>: *Extract an expression to a new variable or parameter of a function*
- <u>Challenge:</u> *Infer the type of expression* **???**

Scala's type inference allows to omit explicit type declarations!

Is it always good?

Sometimes a type can provide essential information about an expression

Some unannotated code

```
trait Rule[-In, +Out, +A, +X] extends (In => Result[Out, A, X]) {
  val factory : Rules
  import factory._

  def as(name : String) = ruleWithName(name, this)

  def flatMap[Out2, B, X2 >: X](fa2ruleb : A => Out => Result[Out2, B, X2]) = mapResult {
      case Success(out, a) => fa2ruleb(a)(out)
      case Failure => Failure
      case err @ Error(_) => err
  }

  def map[B](fa2b : A => B) ? = flatMap { a => out => Success(out, fa2b(a)) }

  def >>[Out2, B, X2 >: X](fa2ruleb : A => Out => Result[Out2, B, X2]) ? = flatMap(fa2ruleb)

  def >->[Out2, B, X2 >: X](fa2resultb : A => Result[Out2, B, X2]) ? = flatMap { a => any => fa2resultb(a) }

  def >>?[Out2, B, X2 >: X](pf : PartialFunction[A, Rule[Out, Out2, B, X2]]) ? = filter(pf isDefinedAt _) flatMap pf

  def ~[Out2, B, X2 >: X](next : => Rule[Out, Out2, B, X2]) ? = for (a <- this; b <- next) yield new ~(a, b)

  def ~-[Out2, B, X2 >: X](next : => Rule[Out, Out2, B, X2]) ? = for (a <- this; b <- next) yield a

  def -~[Out2, B, X2 >: X](next : => Rule[Out, Out2, B, X2]) ? = for (a <- this; b <- next) yield b

  def ~++[Out2, B >: A, X2 >: X](next : => Rule[Out, Out2, Seq[B], X2]) ? = for (a <- this; b <- next) yield a :: b.toList

  /** Apply the result of this rule to the function returned by the next rule */
  def ~>[Out2, B, X2 >: X](next : => Rule[Out, Out2, A => B, X2]) ? = for (a <- this; fa2b <- next) yield fa2b(a)

  /** Apply the result of this rule to the function returned by the previous rule */
  def <~:[InPrev, B, X2 >: X](prev : => Rule[InPrev, In, A => B, X2]) ? = for (fa2b <- prev; a <- this) yield fa2b(a)

  def ~![Out2, B, X2 >: X](next : => Rule[Out, Out2, B, X2]) ? = for (a <- this; b <- next orError) yield new ~(a, b)

  def ~-![Out2, B, X2 >: X](next : => Rule[Out, Out2, B, X2]) ? = for (a <- this; b <- next orError) yield a

  def -~![Out2, B, X2 >: X](next : => Rule[Out, Out2, B, X2]) ? = for (a <- this; b <- next orError) yield b

  def -[In2 <: In](exclude : => Rule[In2, Any, Any, Any]) ? = !exclude -~ this

  def ^~^[B1, B2, B >: A <% B1 ~ B2, C](f : (B1, B2) => C) ? = map { a =>
    (a : B1 ~ B2) match { case b1 ~ b2 => f(b1, b2) }
  }
```

Demo

Introduce variable

Inline variable refactoring

- Goal: *Inline all occurrences of a variable*
- Challenge: *Computing reaching definitions of local variables to restrict the scope of refactoring*

Does definition reach a usage?

```scala
var a = 1
val cl = {
  println("Returning a closure");
  {(x: Int) => a = x}
}

foo(cl)

println(a)
```

The variable `a` cannot be inlined because it may be reassigned via closure `cl`

Finally, *extract method* in Scala

- Goal: *Extract a piece of code into a separate function*
- Challenges:
  - Scoping
  - Computing input and output variables of the code fragment

Demo

Extract method

Closure with state are evil!

```
def foo = {
  var a = 42

  val cl = (i: Int) => {
    a = a + i
  }

  doSomething(cl)
  print(a)
}
```

Closure `cl` changes the *local environment* of the method `foo`

Solution: introduce *environment* instance

```
class MyMethodEnv(var a: Int)

def myMethod1(env: MyMethodEnv) =
  (i: Int) => {
    env.a = env.a + i
  }

def foo = {
  val env = new MyMethodEnv(a = 42)
  val cl = myMethod1(env)
  doSomething(cl)
  println(env.a)
}
```

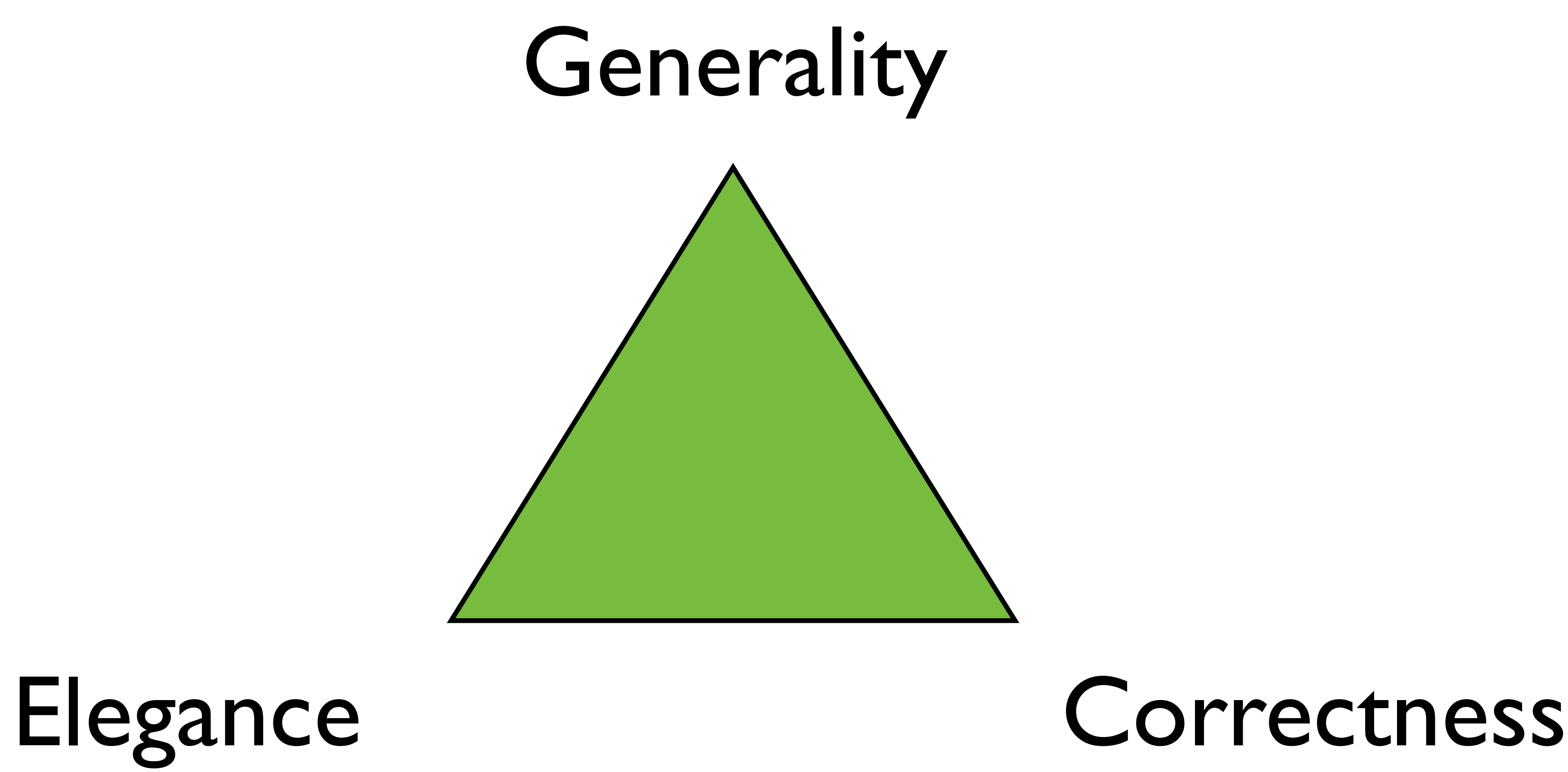
Abstracting context

- Closures change state
    - *Introduce environment object*
- Dependent types, inner classes or type aliases
    - *Introduce generics, presumably, of higher kind*
- Local implicit conversions
    - *Cannot be abstracted (at least, not elegantly)*

A correct refactoring sometimes makes code very messy...

How should the boundary between *useful* and *correct* refactoring be defined?

Refactoring implementation is a tradeoff



Future directions?

- Scripting language - *generality*
- Language of constraints - *correctness*
- Software metrics - *elegance*

Thanks for your attention

Questions?