Reflection in Pharo: Beyond Smalltalk

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Everything is an Object
Classes
Methods
The Stack
Everything is an Object
Code?
AST: Abstract Syntax Tree
AST in Pharo5

• AST of the Refactoring browser
  • Transformation
  • Visitors
  • Annotations (properties)

• Deeper integrated:
  • Pretty Printing, Syntax Highlight, Suggestions
  • Compiler uses RB AST
AST in Pharo5

- Easy access
- #ast
- Demo: method and block
(OrderedCollection>>#do:) ast.

[ 1 + 2 ] sourceNode == thisContext method ast blockNodes first

- ASTCache: as twice, get the same answer (flushed on image save for now)
AST + Tools
Opal Compiler

- Uses RB AST
- Based on Visitors

### Diagram

- **Text** → **AST** → **AST + vars** → **IR** → **CM**

- **Parser** → **Semantic Analysis** → **AST Translator + IRBuilder** → **BytecodeBuilder + Encoder**
Opal: API

- All staged are Pluggable
  - e.g Semantic Analyzer or Code Generator can be changed.
- compiler options
Opal: Bytecode editing

- IR can be used to manipulate methods on a bytecode level

Diagram:

1. Text → Parser
2. AST → Semantic Analysis
3. AST + vars → AST Translator + IRBuilder
4. IR → BytecodeBuilder + Encoder
5. CM
Too complicated
Too low level
Can we do better?
AST Meta Annotation

• We have an AST with properties

• We have Opal with Pluggable API
Can’t we use that?
Basis: the Evil Twin

CompiledMethod

Know each other

ReflectiveMethod

Bytecode

AST
Basis: the Evil Twin

run: aSelector with: anArray in: aReceiver
self installCompiledMethod.
self recompileAST.
self installCompiledMethod.
^compiledMethod
  valueWithReceiver: aReceiver
  arguments: anArray
Demo: Morph

- Morph methods do: #createTwin
- Morph methods do: #invalidate
- inspect “Morph methods”
Putting it together

- Annotate the AST
- Create Twin if needed
- Invalidate method
- Next call: generate code changed by annotation
Annotations?
MetaLink
node := (ReflectivityExamples>>#exampleMethod) ast.
link := MetaLink
    new metaObject: (Object new);
selector: #halt.

node link: link.

ReflectivityExamples new exampleMethod
Meta Link

• When setting link:
  • create twin if needed
  • install reflective method

• On execution
  • generate code and execute, install CM
Twin Switch

CompiledMethod

ReflectiveMethod

Know each other

Bytecode

AST
Link: metaobject

The object to send a message to

link := MetaLink new
metaObject: [self halt]
The selector to send

link := MetaLink new
.....
selector: #value
Link: control

before, after, instead

link := MetaLink new

.....

control: #after
Link: control

after: #ensure: wrap

link := MetaLink new
.....
control: #after
Link: control

instead: last link wins
(for now no AOP around)

link := MetaLink new

.....

control: #instead
Link: condition

boolean or block

link := MetaLink new

.....

condition: [self someCheck]
Link: arguments

what to pass to the meta?
Reifications

• Every operation has data that it works on
• Send: #arguments, #receiver, #selector
• Assignment: #newValue, #name
• All: #node, #object, #context
Link: arguments

what to pass to the meta?

link := MetaLink new

.....

arguments: #(name newValue)
Reifications: condition

link := MetaLink new
    condition: [: object | object == 1];
Virtual meta

• Reifications can be the meta object

link := MetaLink new
    metaObject: #receiver;
    selector: #perform:withArguments:;
    arguments: #(selector arguments).
Statement Coverage

link := MetaLink new
    metaObject: #node;
    selector: #tagExecuted.

"set this link on all the AST nodes"
(ReflectivityExamples>>#exampleMethod) ast
    nodesDo: [:node | node link: link].
Users

- BreakPoints Pharo5
- Coverage Kernel
- ....
Everything is an Object
Everything is an object?

SmalltalkImage classVarNamed: #CompilerClass
  ==> returns value

Object binding class
  ==> Association
Why not an Object?
Globals/ClassVariables

- We are close: bindings are associations
- Add subclass “LiteralVariable”
- Subclasses GlobalVariable, ClassVariable
- Enhance API
Globals/Class Variables

SmalltalkImage classVariableNamed: #CompilerClass

Object binding class
Globals: Reflective API

global := SmalltalkImage classVariableNamed: #CompilerClass

global read
global write: someObject

+ helper methods + compatibility methods
Everything is an object?

- Point instanceVariables
- 5@3 instVarNamed: ‘x’
- 5@3 instVarNamed: ‘y’ put: 6
Why not an Object?
Slots

Point slots

(Point slotNamed: #x) read: (3@4)

(Point slotNamed: #x) write: 7 to: (3@4)
Variables+MetaLink

- Helper methods

  Point assignmentNodes

- But: can’t we annotate variables directly?
Variables + Links

- Object binding link: myMetaLink
- (Point slotNamed: #x) link: myMetaLink

(not yet in Pharo5)
Object subclass: #MyClass
slots: { #x => WeakSlot }
classVariables: { } 
category: 'Example'
Future

• Can’t we model bit patterns and bind them to named virtual slots?

• How to model Array-like layouts better?
Questions ?