Reflection in Pharo: Beyond Smalltak

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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

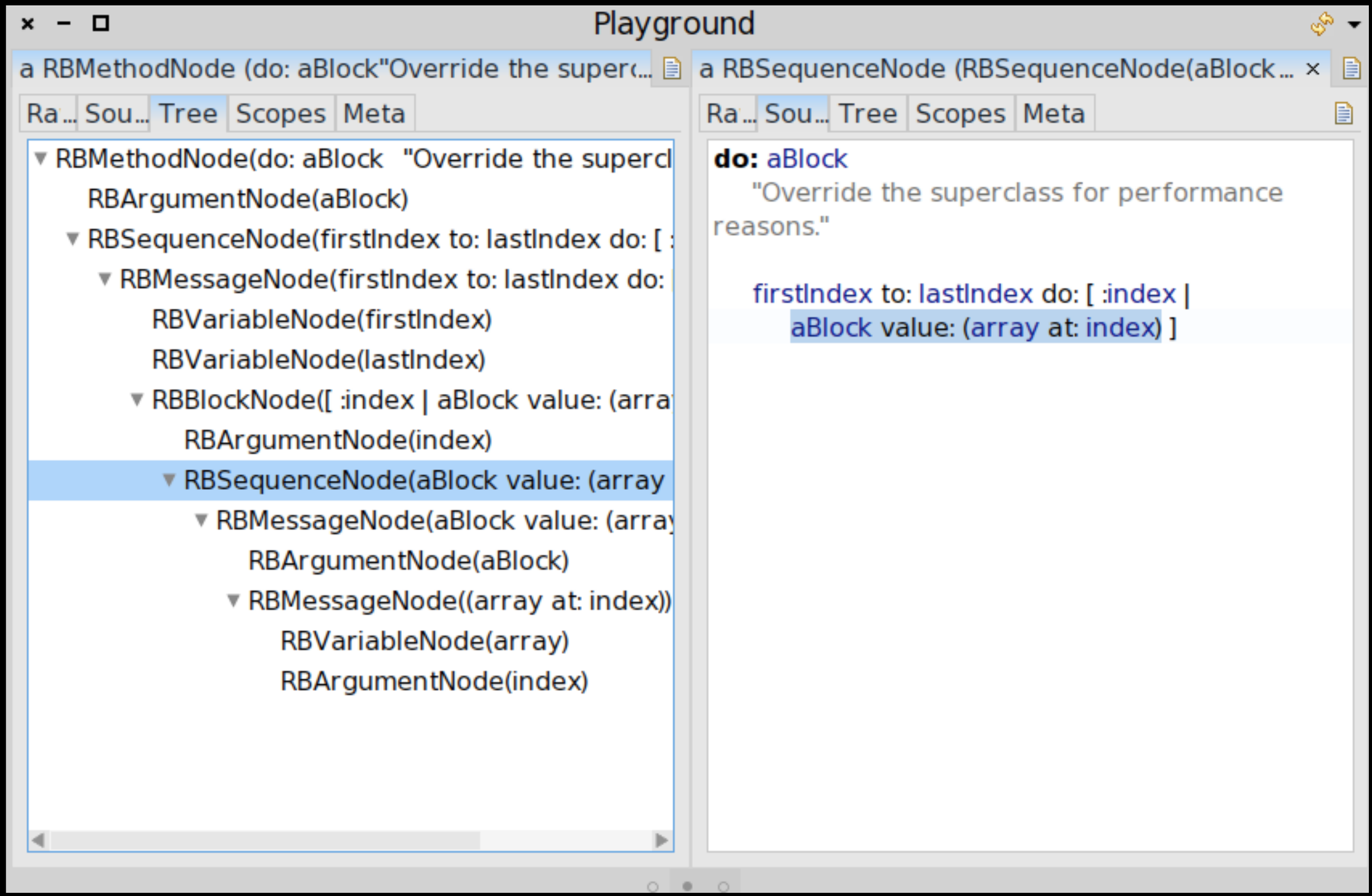
DEMO

(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


Playground
a RBMethodNode (do: aBlock"Override the super...
a RBSequenceNode (RBSequenceNode(aBlock...
Ra... Sou... Tree Scopes Meta
Ra... Sou... Tree Scopes Meta
RBMethodNode(do: aBlock "Override the superc
RBArgumentNode(aBlock)
RBSequenceNode(firstIndex to: lastIndex do: [
RBMessageNode(firstIndex to: lastIndex do:
RBVariableNode(firstIndex)
RBVariableNode(lastIndex)
RBBlockNode([:index | aBlock value: (arra
RBArgumentNode(index)
RBSequenceNode(aBlock value: (array
RBMessageNode(aBlock value: (array
RBArgumentNode(aBlock)
RBMessageNode((array at: index))
RBVariableNode(array)
RBArgumentNode(index)
do: aBlock
"Override the superclass for performance reasons."
firstIndex to: lastIndex do: [:index |
aBlock value: (array at: index)]

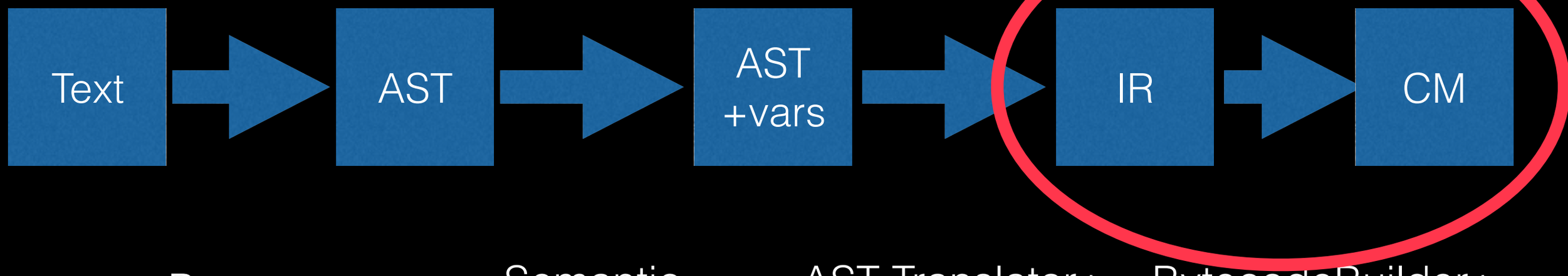
Opal Compiler

- Uses RB AST
- Based on Visitors

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

Too complicated

Too low level

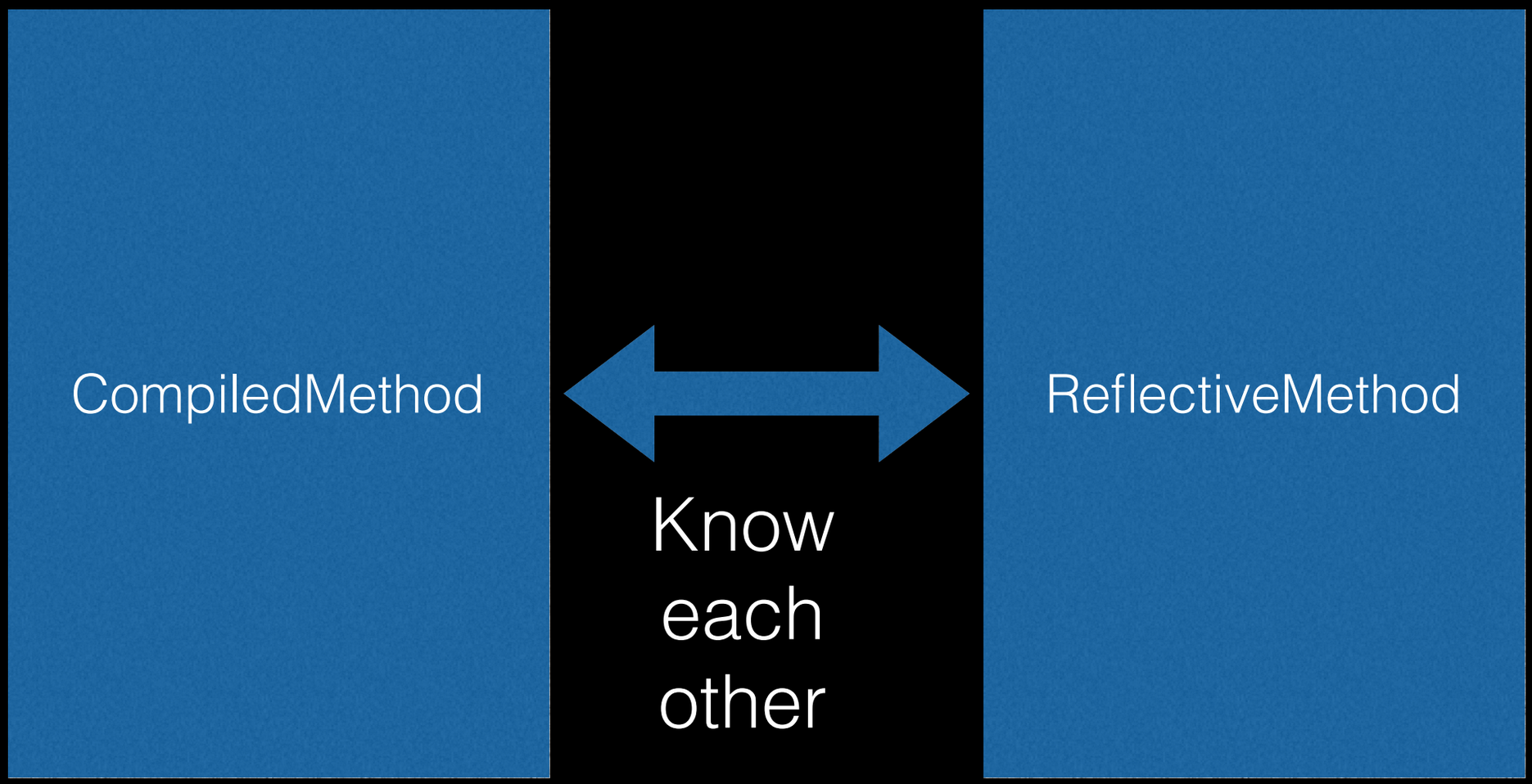
Can we do better?

AST Meta Annotation

- We have an AST with properties
- We have Opal with Pluggable API

Can’t we use that?

Basis: the Evil Twin



Bytecode

AST

Basis: the Evil Twin

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

AST

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

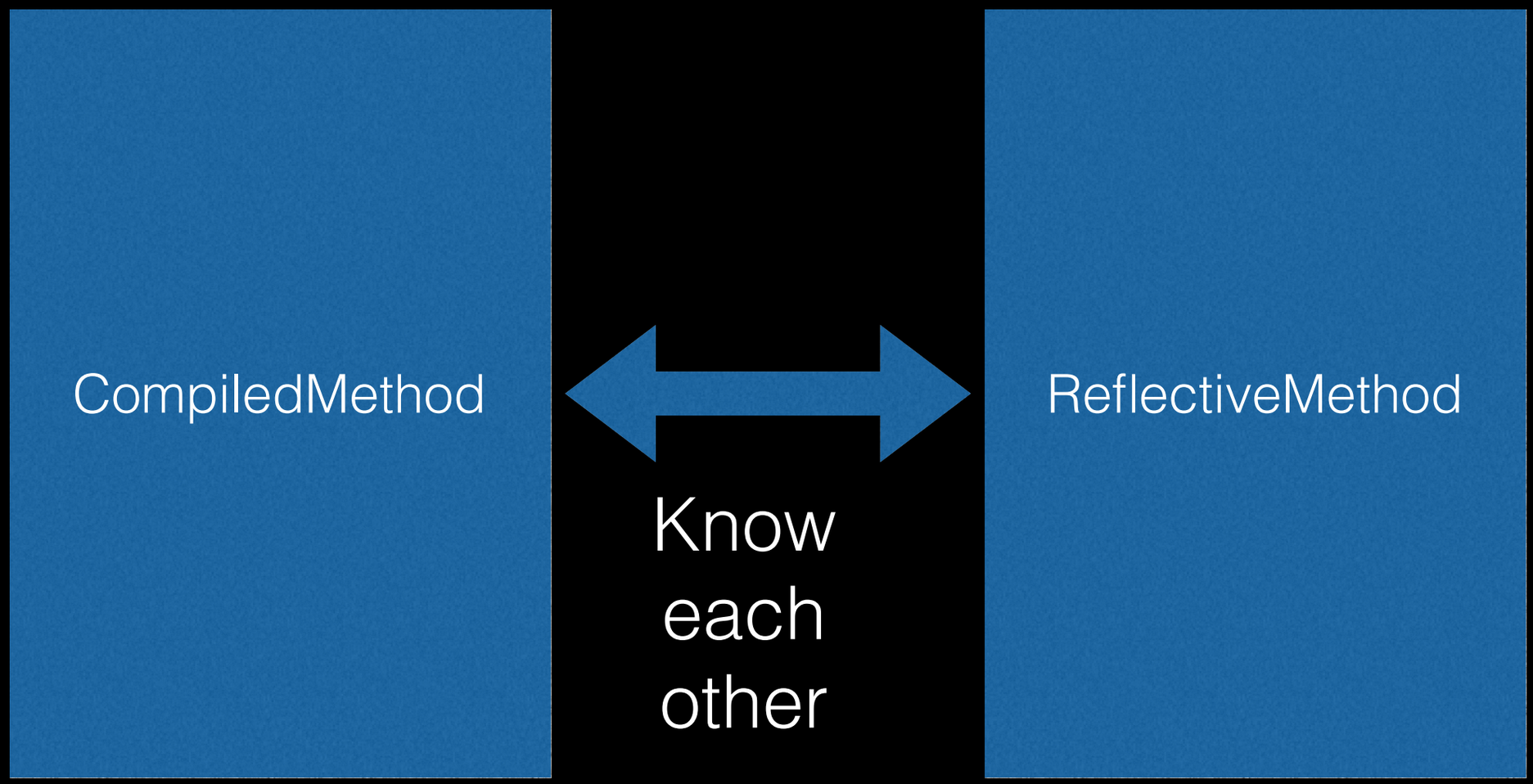
DEMO: Simple Link

```
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



Bytecode

AST

Link: metaobject

The object to send a message to

```
link := MetaLink new
        metaObject: [self halt]
```

Link: selector

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 sublass “LiteralVariable”
- Sublasses GlobalVariable, ClassVariable
- Enhance API

Globals/ClassVariables

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)

Class Template

```
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 ?