Reflection in Pharo5

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Everything is an Object

Everything?

Classes, yes.

Methods, yes

But Code?

Code is a String!

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

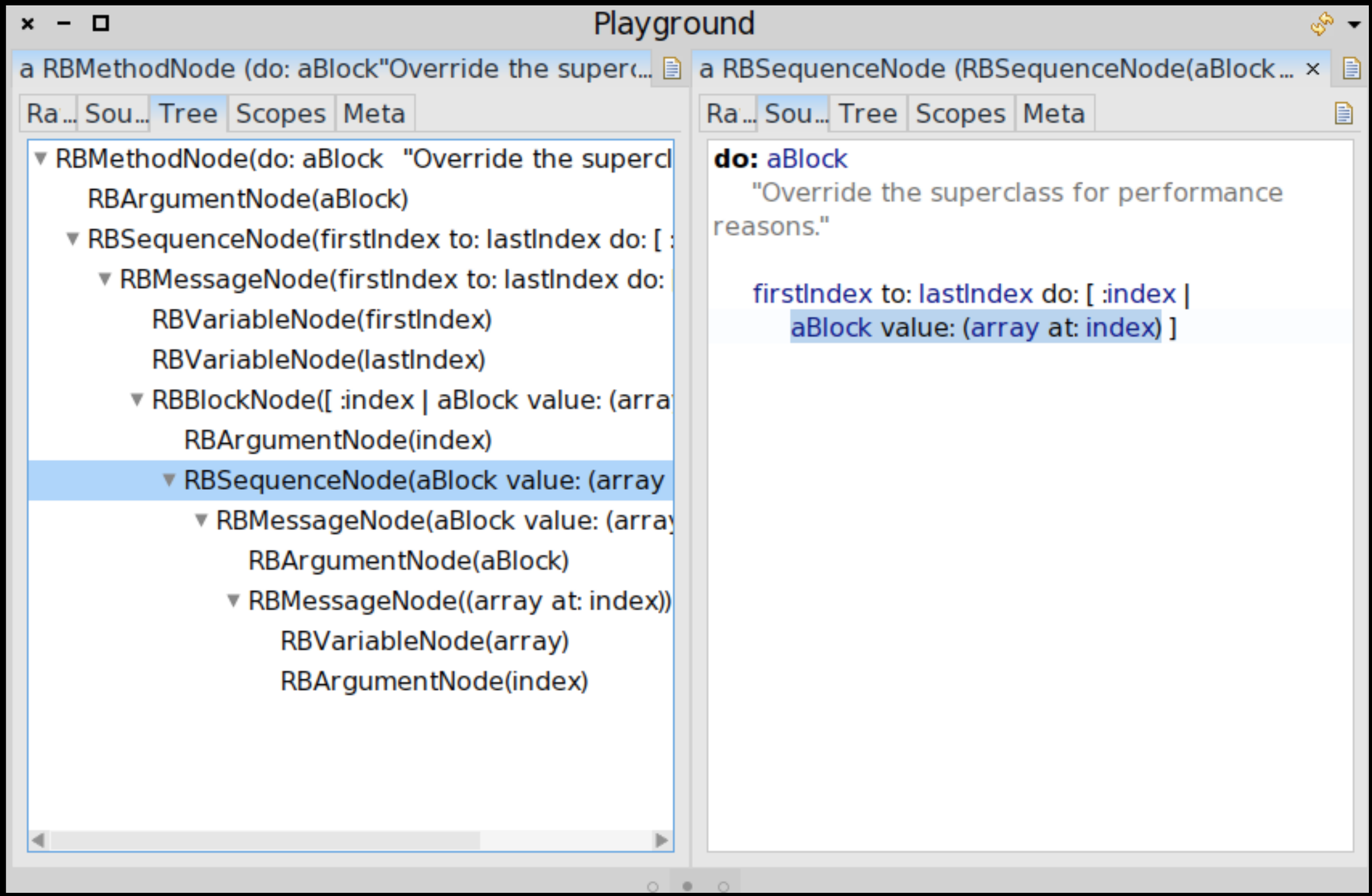
DEMO

(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)]

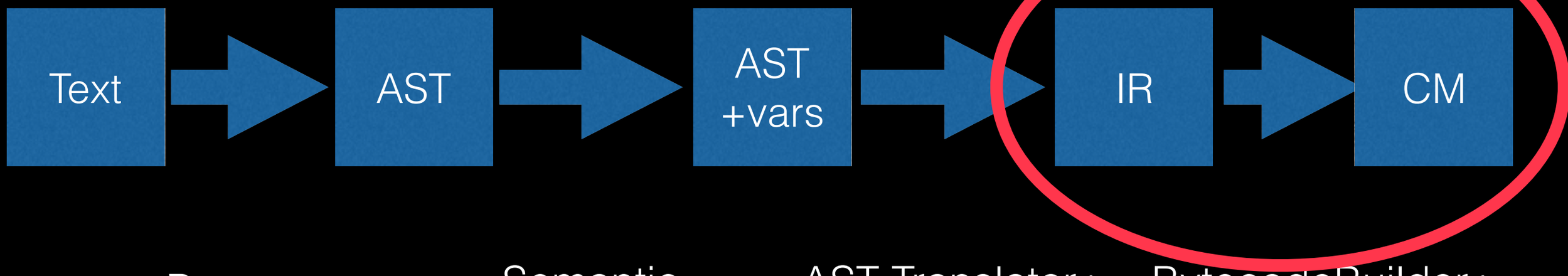
Opal Compiler

- 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

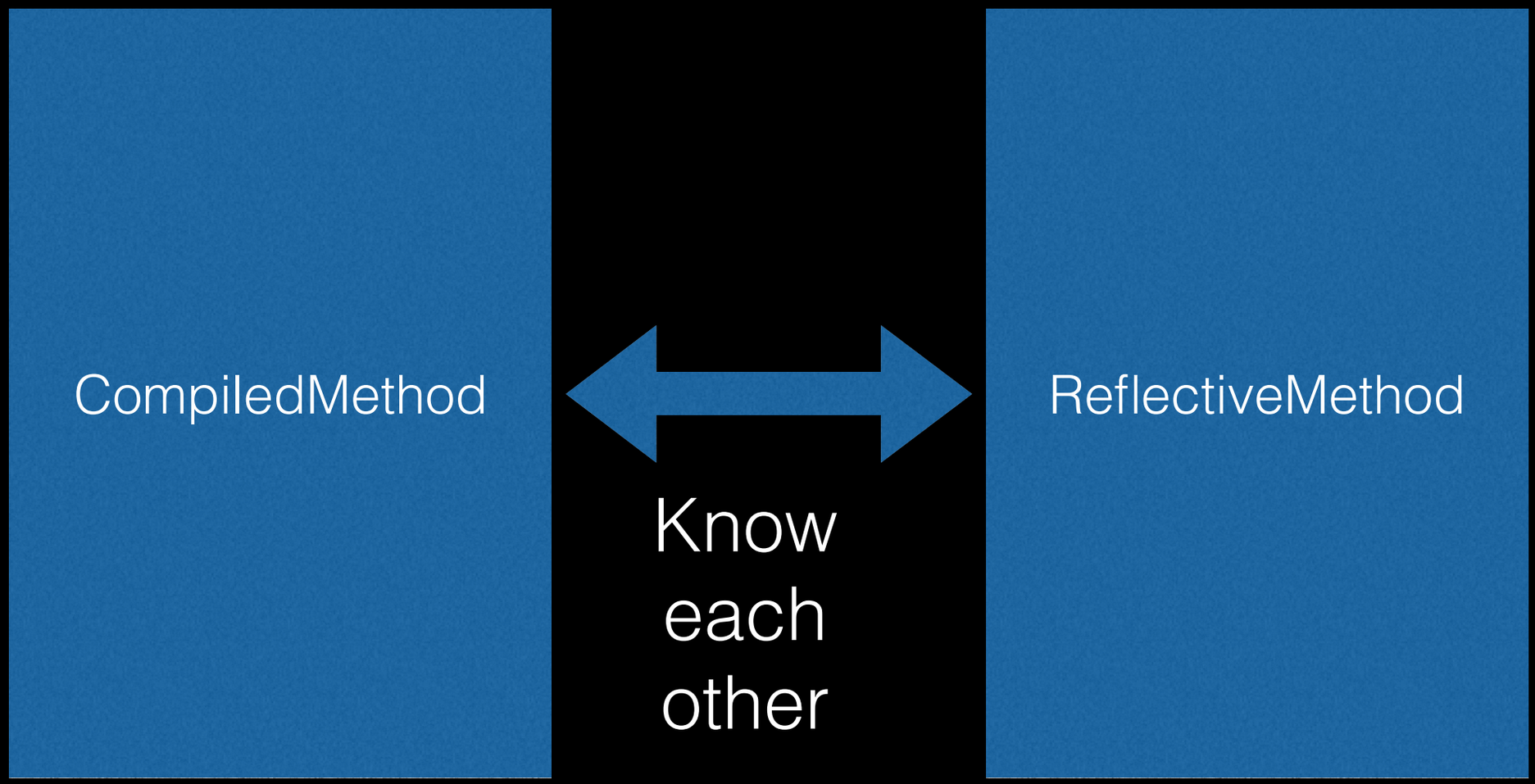
Can we do better?

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

```
recompileAST
    ast compilationContext
        semanticAnalyzerClass: RFSemanticAnalyzer;
        astTranslatorClass: RFASTTranslator.
    ast doSemanticAnalysis. "force semantic analysis"
    compiledMethod := ast generate: compiledMethod trailer.
    compiledMethod reflectiveMethod: self.
```

Annotations?

MetaLink

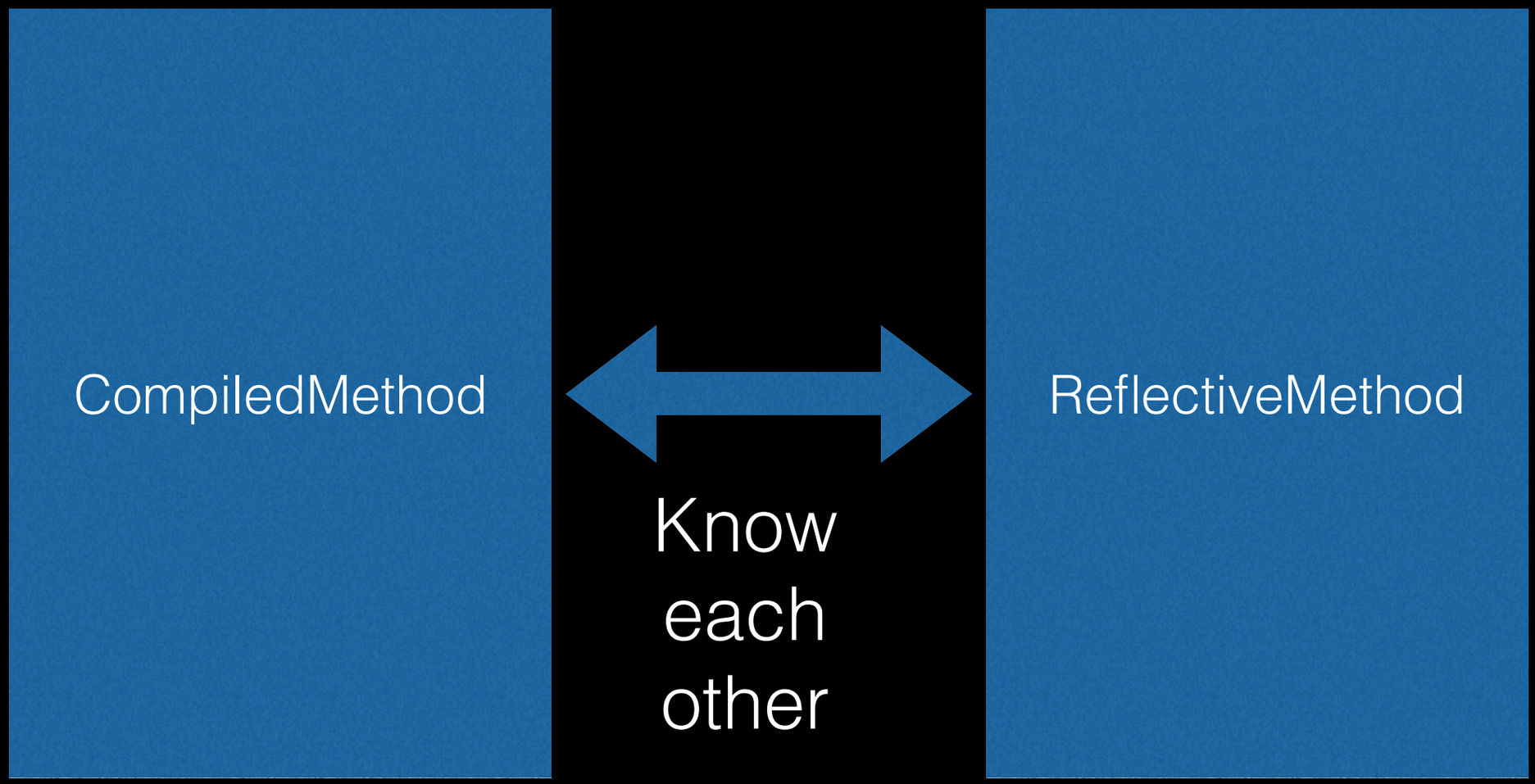
DEMO: Simple Link

```
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].
```

Variables

- Helper methods

Point assignmentNodes

- But: can’t we annotate variables directly?

Friday: Slots+Globals

RoadMap

- Pharo4: Opal is default
- Pharo5
  - Remove old Compiler/AST
  - Reflectivity: First finished version
- Pharo6: Object specific links

Users

- Tools of ObjectProfile are being ported
- BreakPoints Pharo5
- Coverage Kernel by Pavel
- ....

Thanks!

- Work of many people…
- Too many to list here. (And I would forget for sure someone)

Questions ?