RMod

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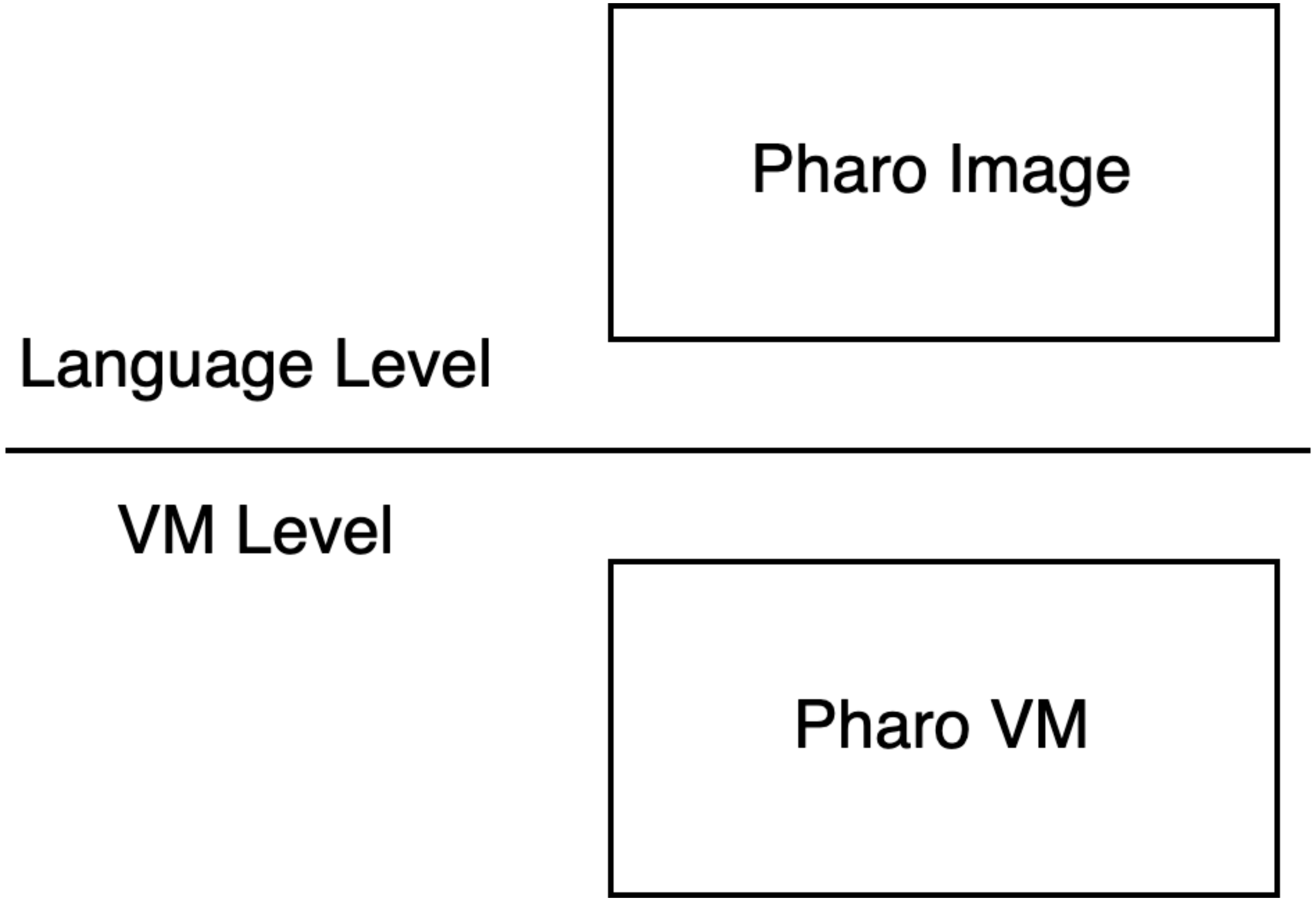
CRIStAL
Centre de Recherche en Informatique,
Signal et Automatique de Lille

Polyphemus
Ease Virtual Machine Level Tooling

Pierre Misse-Chanabier
Theo Rogliano

Who Does Not Love Tools ?

Tooling Levels



Pharo Image

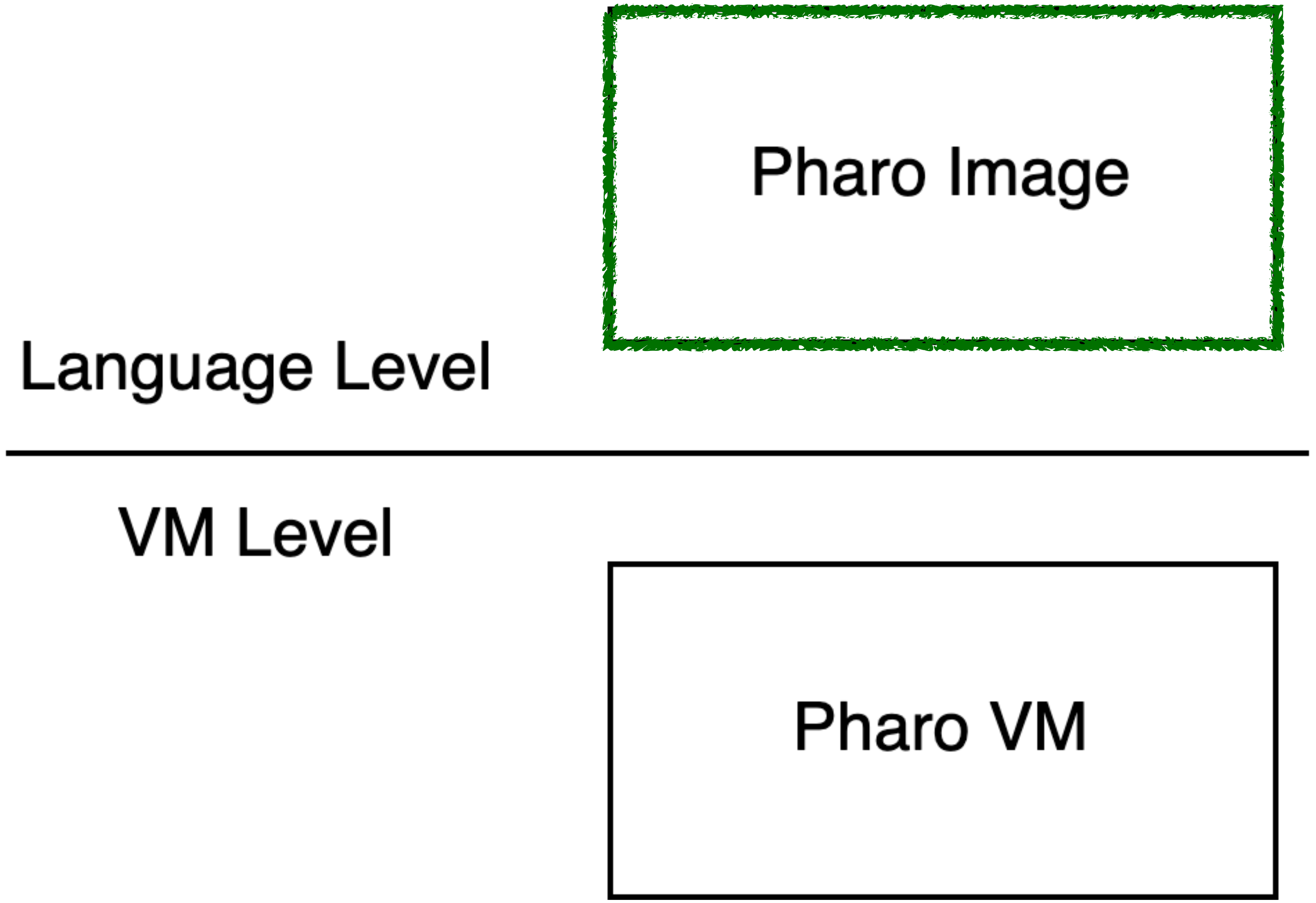
Language Level

VM Level

Pharo VM

Who Does Not Love Tools ?

Tools at the Language Level



Pharo Image

Language Level

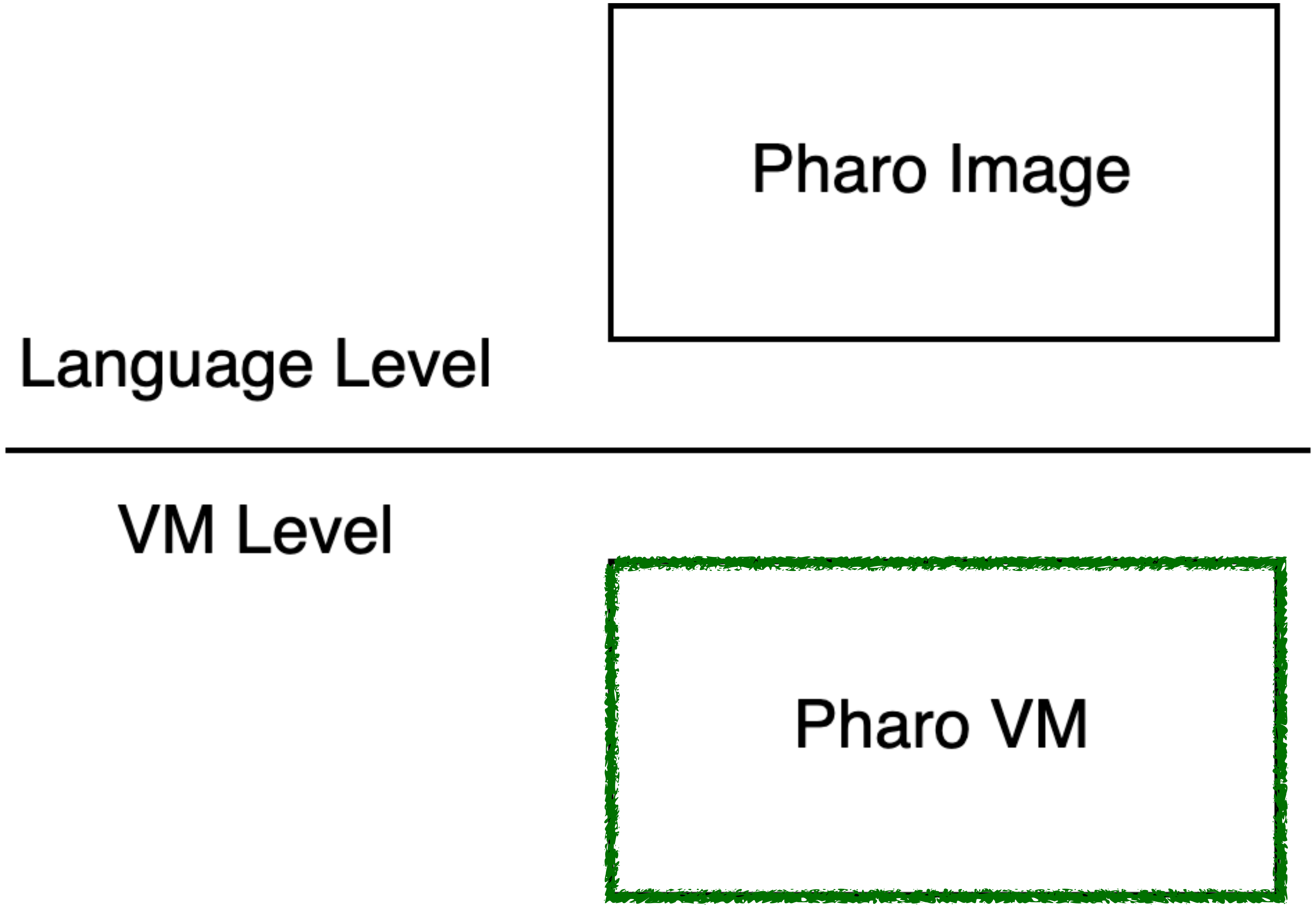
VM Level

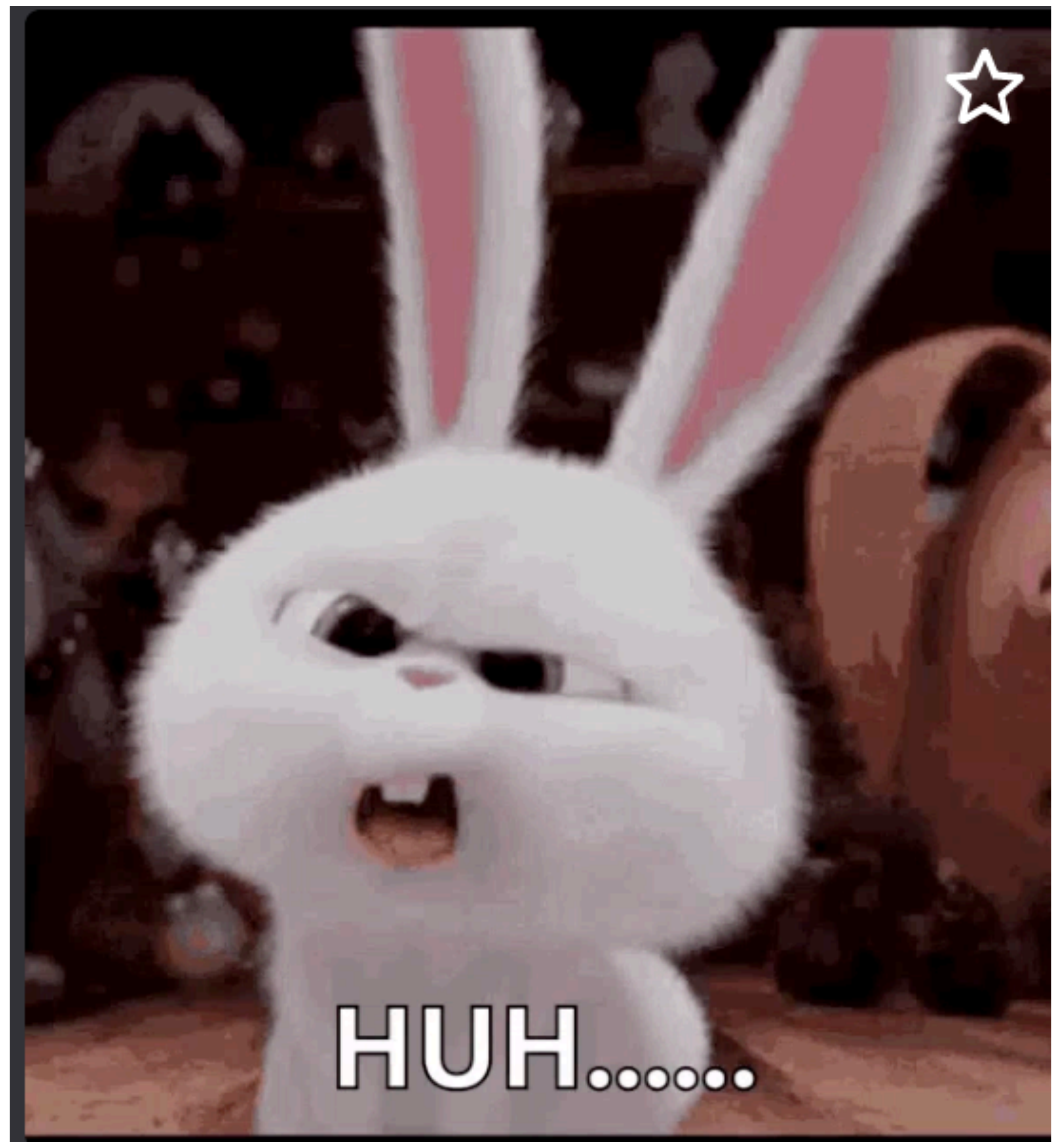
Pharo VM

NewTools, Moose, Roassal,
Calypso, SUnit, Iceberg, Refactoring, Epicea
… … …

Who Does Not Love Tools ?

Tools at the VM Level



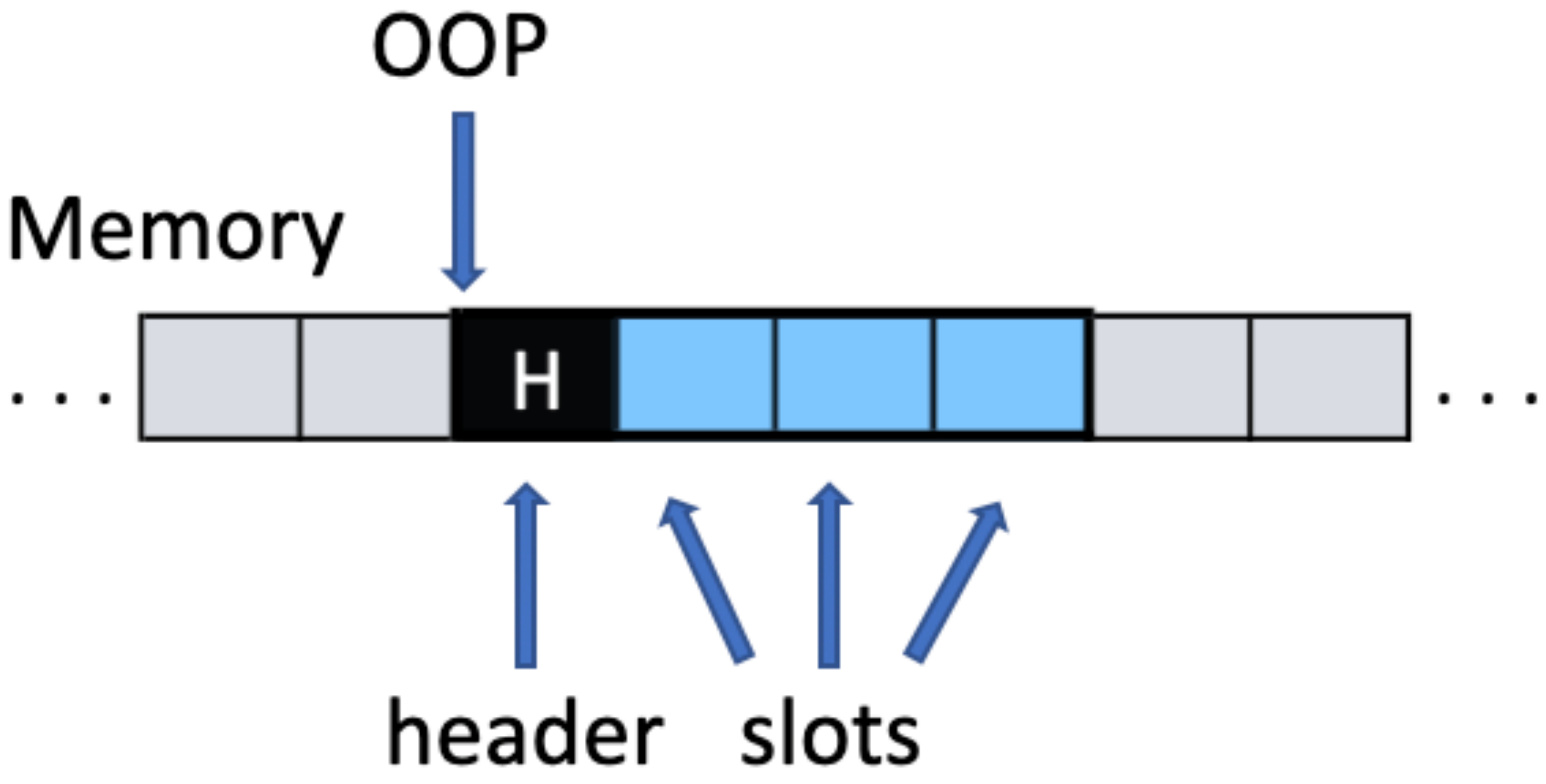


Bootstrap, VM machine code debugger
Others ?

Not many things a Pharo developer cares about !

Let’s Code VM Level Tools !

What’s an Ordinary Object Pointer (OOP)



Who Does Not Love Tools ?

Why Should we Care About VM Level Tools ?

```
Form >> #scaledByDisplayScaleFactor
        self halt.
        ^ self scaledToSize: self extent * self currentWorld displayScaleFactor.
```

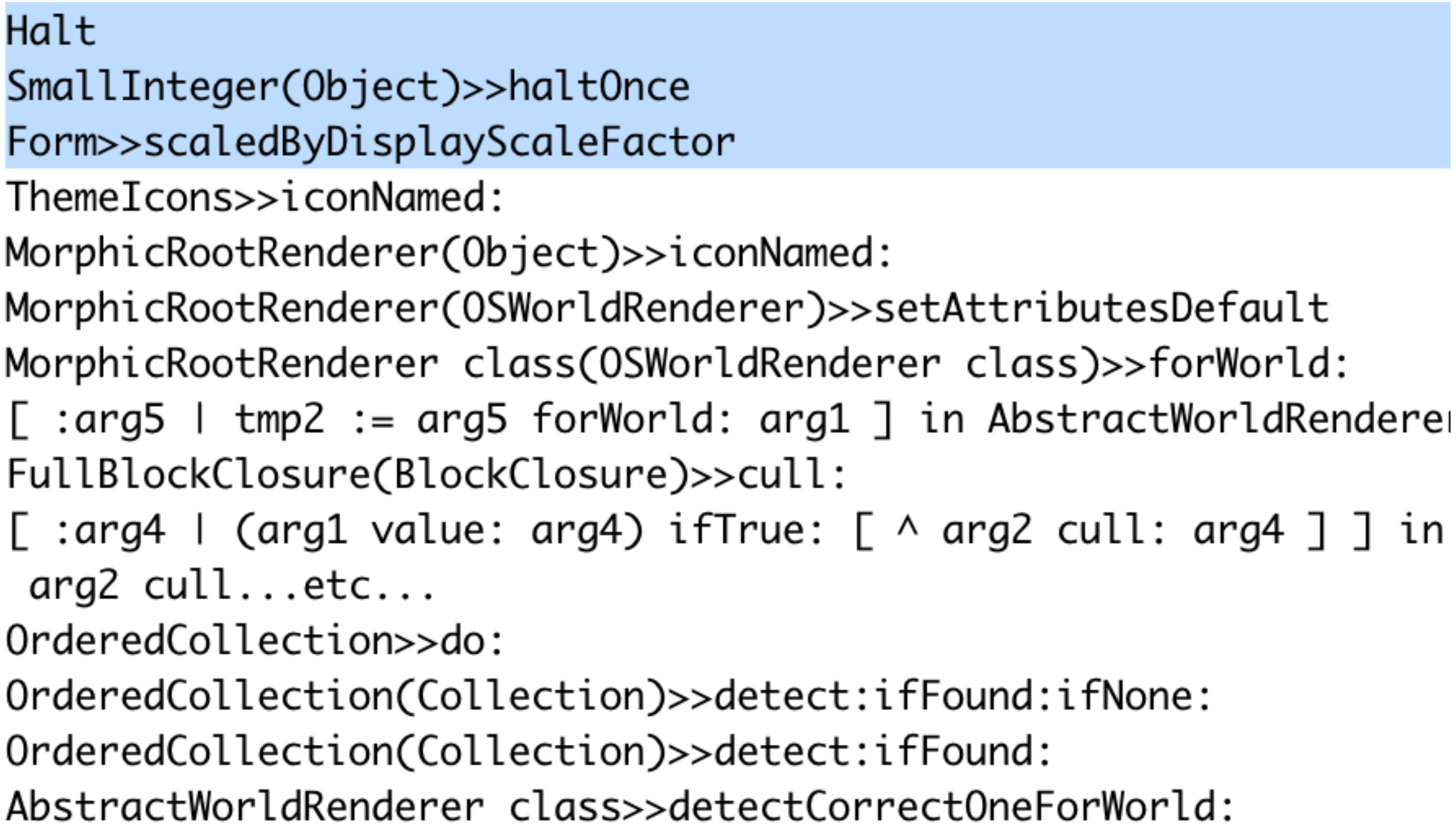
Who Does Not Love Tools ?

Don’t Close the Image !

```
Form >> #scaledByDisplayScaleFactor
    self halt.
    ^ self scaledToSize: self extent * self currentWorld displayScaleFactor.
```

Who Does Not Love Tools ?

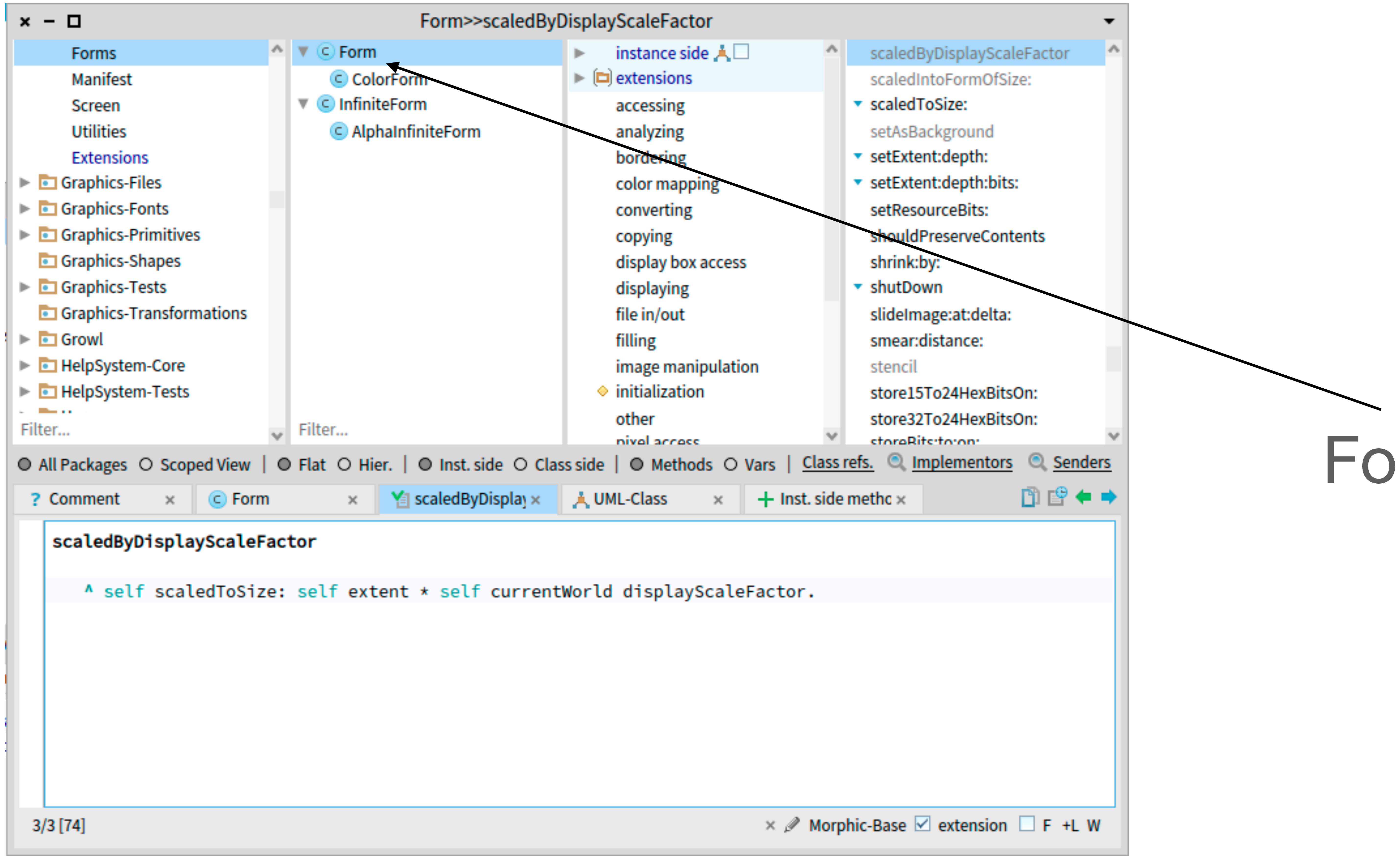
Too Late !



```
Halt
SmallInteger(Object)>>haltOnce
Form>>scaledByDisplayScaleFactor
ThemeIcons>>iconNamed:
MorphicRootRenderer(Object)>>iconNamed:
MorphicRootRenderer(OSWorldRenderer)>>setAttributesDefault
MorphicRootRenderer class(OSWorldRenderer class)>>forWorld:
[ :arg5 | tmp2 := arg5 forWorld: arg1 ] in AbstractWorldRendere
FullBlockClosure(BlockClosure)>>cull:
[ :arg4 | (arg1 value: arg4) ifTrue: [ ^ arg2 cull: arg4 ] ] in
 arg2 cull...etc...
OrderedCollection>>do:
OrderedCollection(Collection)>>detect:ifFound:ifNone:
OrderedCollection(Collection)>>detect:ifFound:
AbstractWorldRenderer class>>detectCorrectOneForWorld:
```

Let’s Code VM Level Tools !

Let’s Find the Class Form …



Form>>scaledByDisplayScaleFactor

Forms
Manifest
Screen
Utilities
Extensions
Graphics-Files
Graphics-Fonts
Graphics-Primitives
Graphics-Shapes
Graphics-Tests
Graphics-Transformations
Growl
HelpSystem-Core
HelpSystem-Tests
Filter...

Form
ColorForm
InfiniteForm
AlphaInfiniteForm
Filter...

instance side
extensions
accessing
analyzing
bordering
color mapping
converting
copying
display box access
displaying
file in/out
filling
image manipulation
initialization
other
pixel access

scaledByDisplayScaleFactor
scaledIntoFormOfSize:
scaledToSize:
setAsBackground
setExtent:depth:
setExtent:depth:bits:
setResourceBits:
shouldPreserveContents
shrink:by:
shutDown
slideImage:at:delta:
smear:distance:
stencil
store15To24HexBitsOn:
store32To24HexBitsOn:
storeBits:to:on:

● All Packages ○ Scoped View | ● Flat ○ Hier. | ● Inst. side ○ Class side | ● Methods ○ Vars | Class refs. Implementors Senders

? Comment × | Form × | scaledByDisplay × | UML-Class × | + Inst. side methc ×

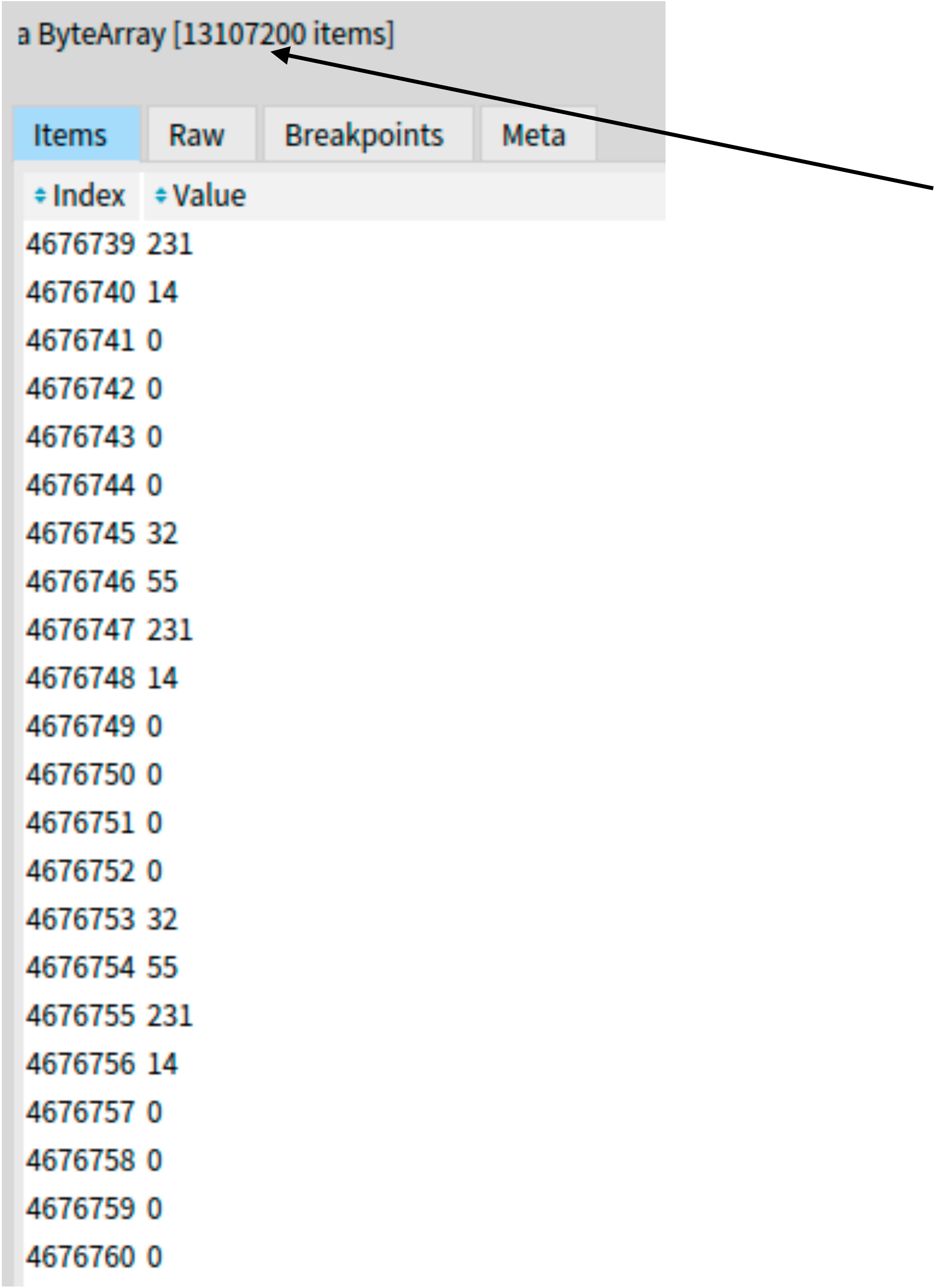
```
scaledByDisplayScaleFactor

	^ self scaledToSize: self extent * self currentWorld displayScaleFactor.
```

3/3 [74] × Morphic-Base ☑ extension □ F +L W

Found it !

Let’s Code VM Level Tools !

Let’s Find The Class Form … But at the VM Level …



a ByteArray [13107200 items]

Index	Value
4676739	231
4676740	14
4676741	0
4676742	0
4676743	0
4676744	0
4676745	32
4676746	55
4676747	231
4676748	14
4676749	0
4676750	0
4676751	0
4676752	0
4676753	32
4676754	55
4676755	231
4676756	14
4676757	0
4676758	0
4676759	0
4676760	0

13 107 200 items

Let’s Code VM Level Tools !

With the Help of the Simulator

```
findClassNamed: aClassName
    | classNameIndex classNameOop className |
    memory classTableEntriesDo: [ :aClassOop |
        aClassOop = memory nilOOP
            "ifTrue: [ not a class, nothing to do ]"
            ifFalse: [
                classNameIndex := memory classNameIndexForOop: aClassOop.
                classNameOop := memory fetchPointer: classNameIndex ofObject: aClassOop.
                className := memory convertStringOopToStringObject: classNameOop.
                className = aClassName ifTrue: [ ^ aClassOop ]]].
    ^ memory nilOOP
```

```
memory findClassNamed: Form >>> 406749864
```

Let’s Code VM Level Tools !

Knowledge Gaps

```
findClassNamed: aClassName
    | classNameIndex classNameOop className |
    memory classTableEntriesDo: [ :aClassOop |
        aClassOop = memory nilOOP
            "ifTrue: [ not a class, nothing to do ]"
            ifFalse: [
                classNameIndex := memory classNameIndexForOop: aClassOop.
                classNameOop := memory fetchPointer: classNameIndex ofObject: aClassOop.
                className := memory convertStringOopToStringObject: classNameOop.
                className = aClassName ifTrue: [ ^ aClassOop ]]].
    ^ memory nilOOP
```

VM level oop

Oop

Low level style

Common API

Let’s Code VM Level Tools !

Knowledge gaps recaps

Issues

- Ordinary Object Pointers (OOP)
- Common API
- VM level information

Polyphemus

Introducing LLOOPs

Language level OOPs

Issues

- Ordinary Object Pointers (OOP)
- Common API
- VM level information

Solutions

- Objects
- Specialized API & Polymorphism
- VM and Language level information

Polyphemus

Tooling the OOPs Using LLOOPs

- Object specific behavior
- Inspectors
- Memory visualisation
- Naming entities

- Depends on your imagination !

Polyphemus

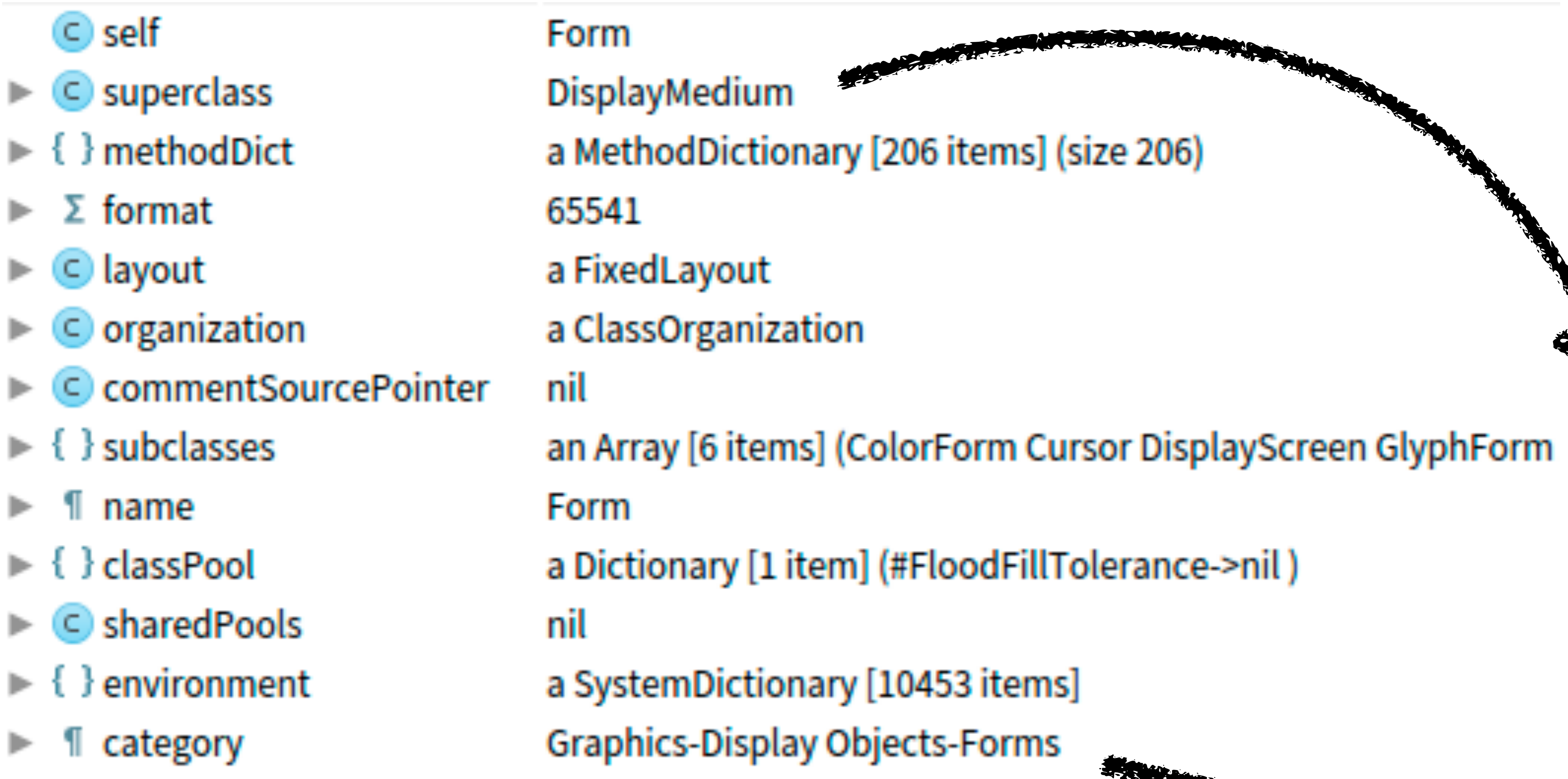
Object Specific Behavior

- aClass subclasses
- aClassTablePage indexInClassTable
- anIndexableObject numberOfSlots

Polyphemus

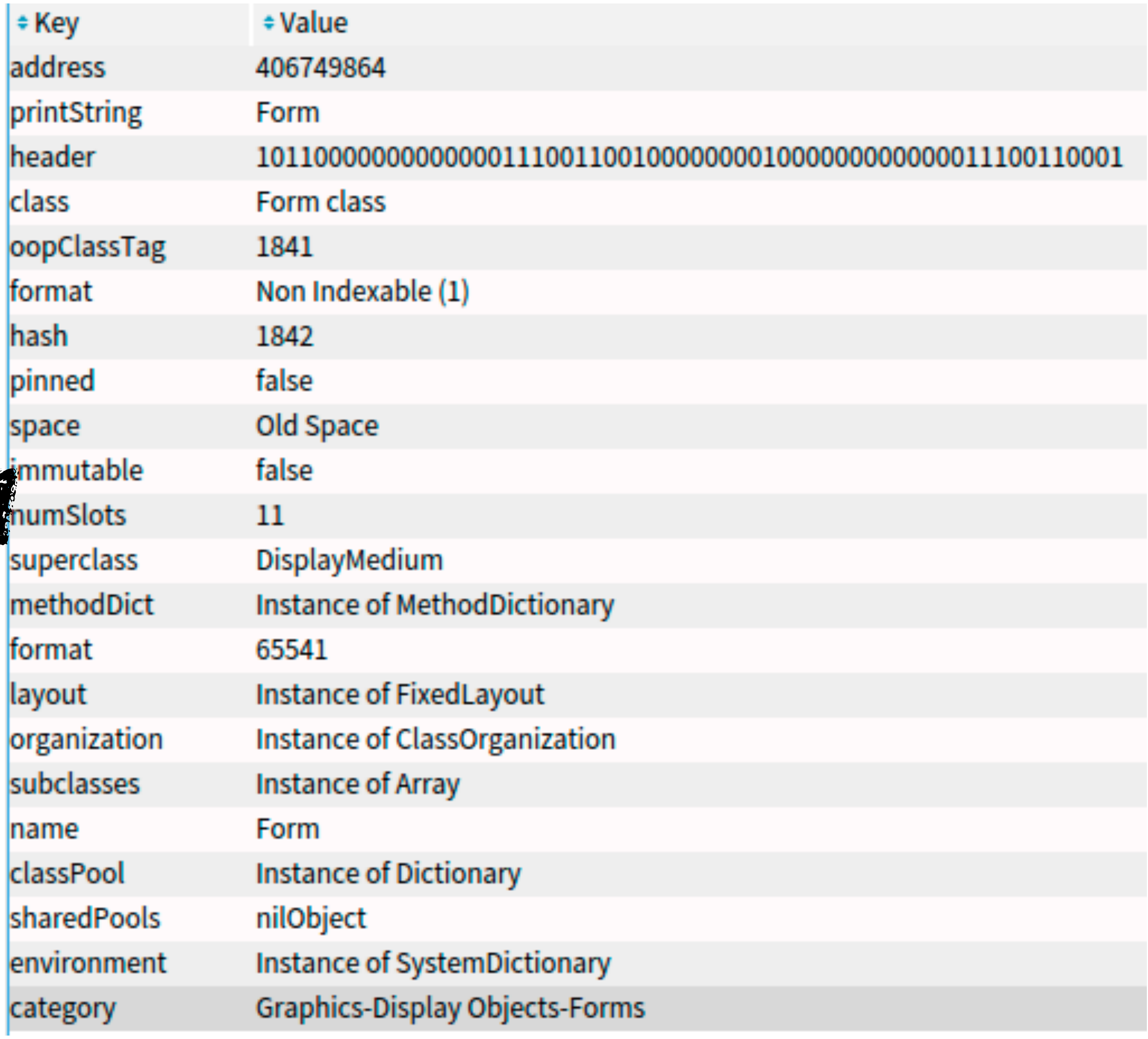
Inspectors

Pharo Object



self	Form
superclass	DisplayMedium
methodDict	a MethodDictionary [206 items] (size 206)
format	65541
layout	a FixedLayout
organization	a ClassOrganization
commentSourcePointer	nil
subclasses	an Array [6 items] (ColorForm Cursor DisplayScreen GlyphForm
name	Form
classPool	a Dictionary [1 item] (#FloodFillTolerance->nil)
sharedPools	nil
environment	a SystemDictionary [10453 items]
category	Graphics-Display Objects-Forms

LLOOP

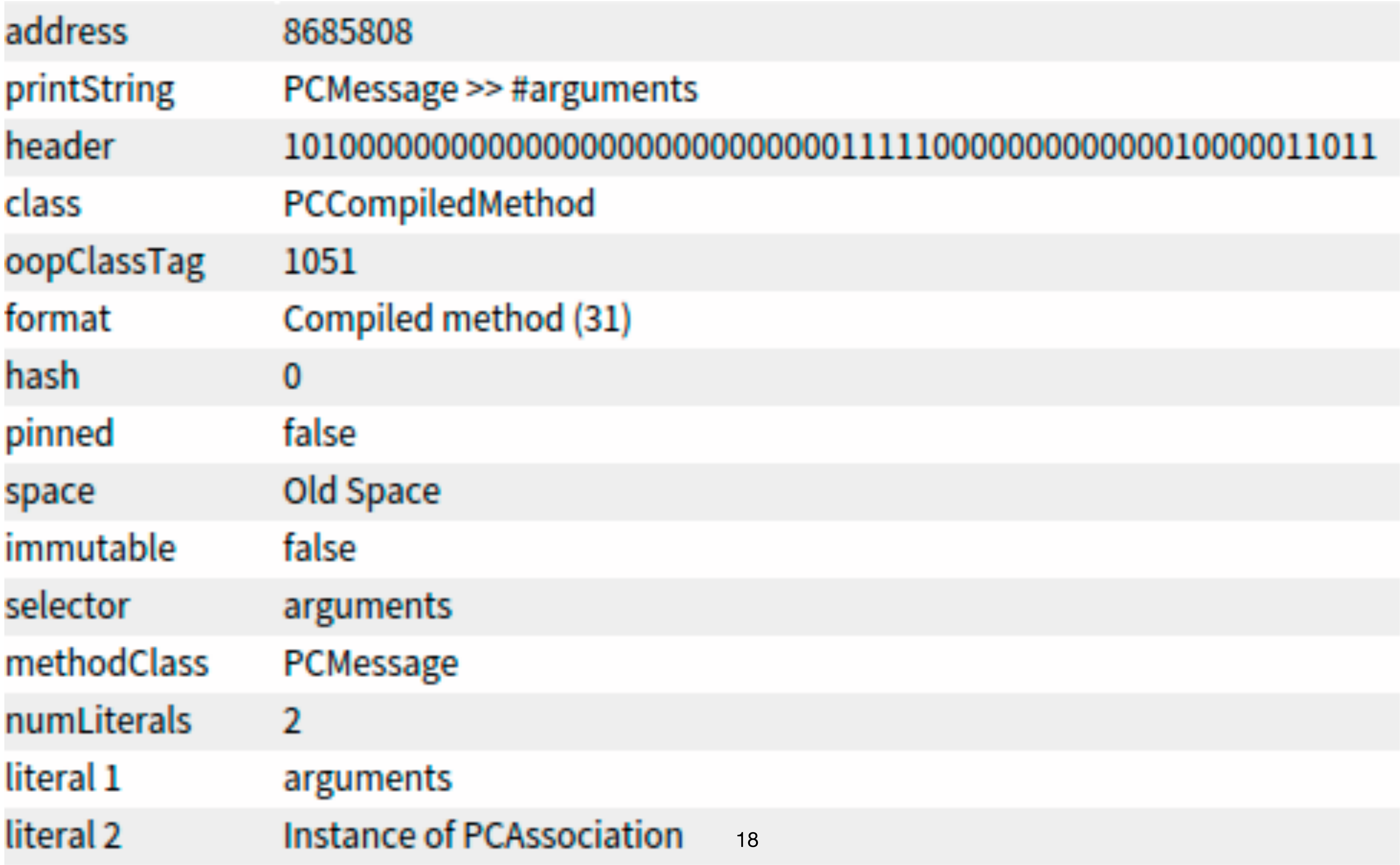


Key	Value
address	406749864
printString	Form
header	1011000000000000011100110010000000010000000000000011100110001
class	Form class
oopClassTag	1841
format	Non Indexable (1)
hash	1842
pinned	false
space	Old Space
immutable	false
numSlots	11
superclass	DisplayMedium
methodDict	Instance of MethodDictionary
format	65541
layout	Instance of FixedLayout
organization	Instance of ClassOrganization
subclasses	Instance of Array
name	Form
classPool	Instance of Dictionary
sharedPools	nilObject
environment	Instance of SystemDictionary
category	Graphics-Display Objects-Forms

Polyphemus

Inspectors #2

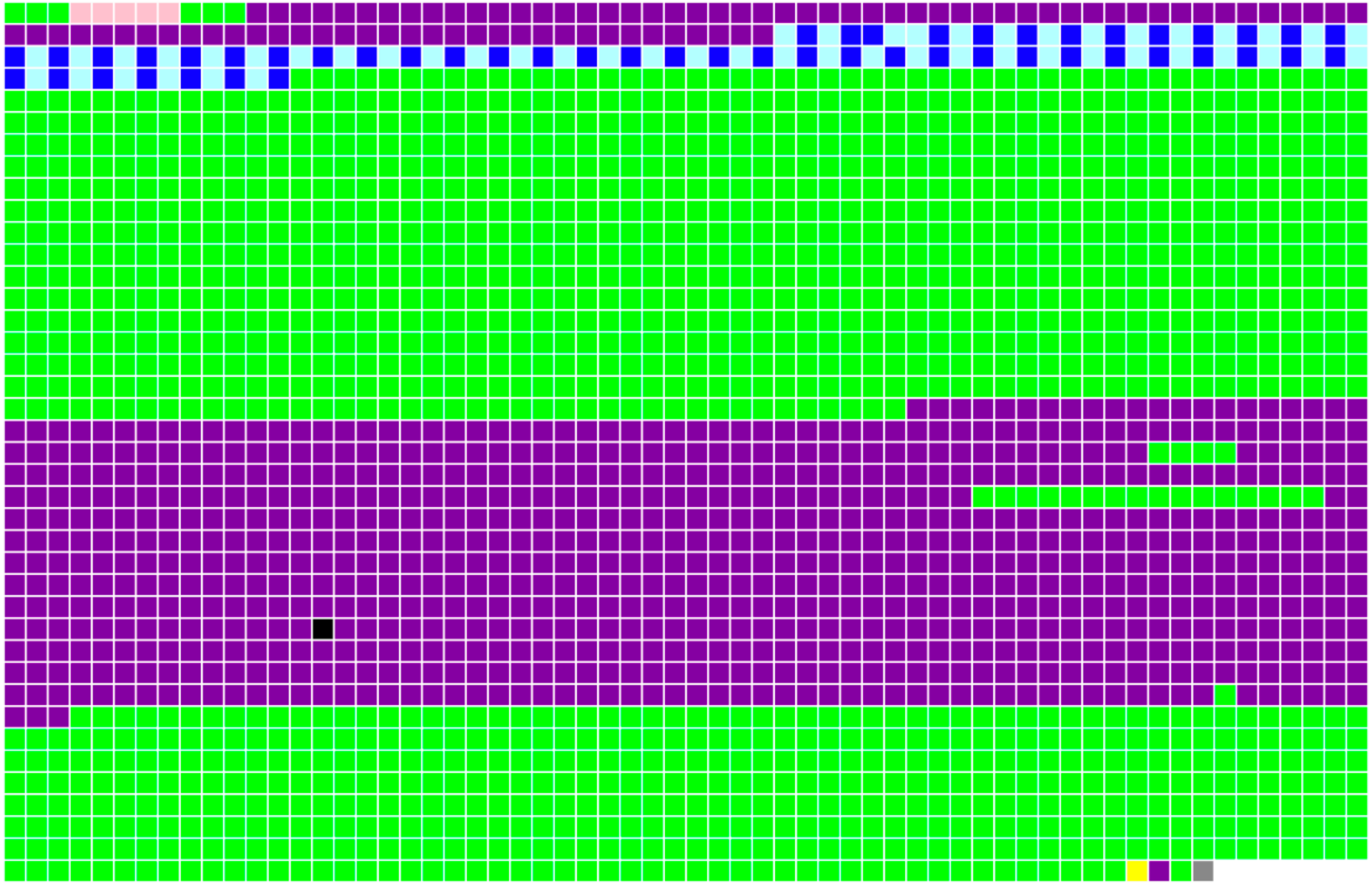
Compiled Method



address	8685808
printString	PCMessage >> #arguments
header	1010000000000000000000000000001111100000000000001000001 1011
class	PCCompiledMethod
oopClassTag	1051
format	Compiled method (31)
hash	0
pinned	false
space	Old Space
immutable	false
selector	arguments
methodClass	PCMessage
numLiterals	2
literal 1	arguments
literal 2	Instance of PCAssociation

Polyphemus

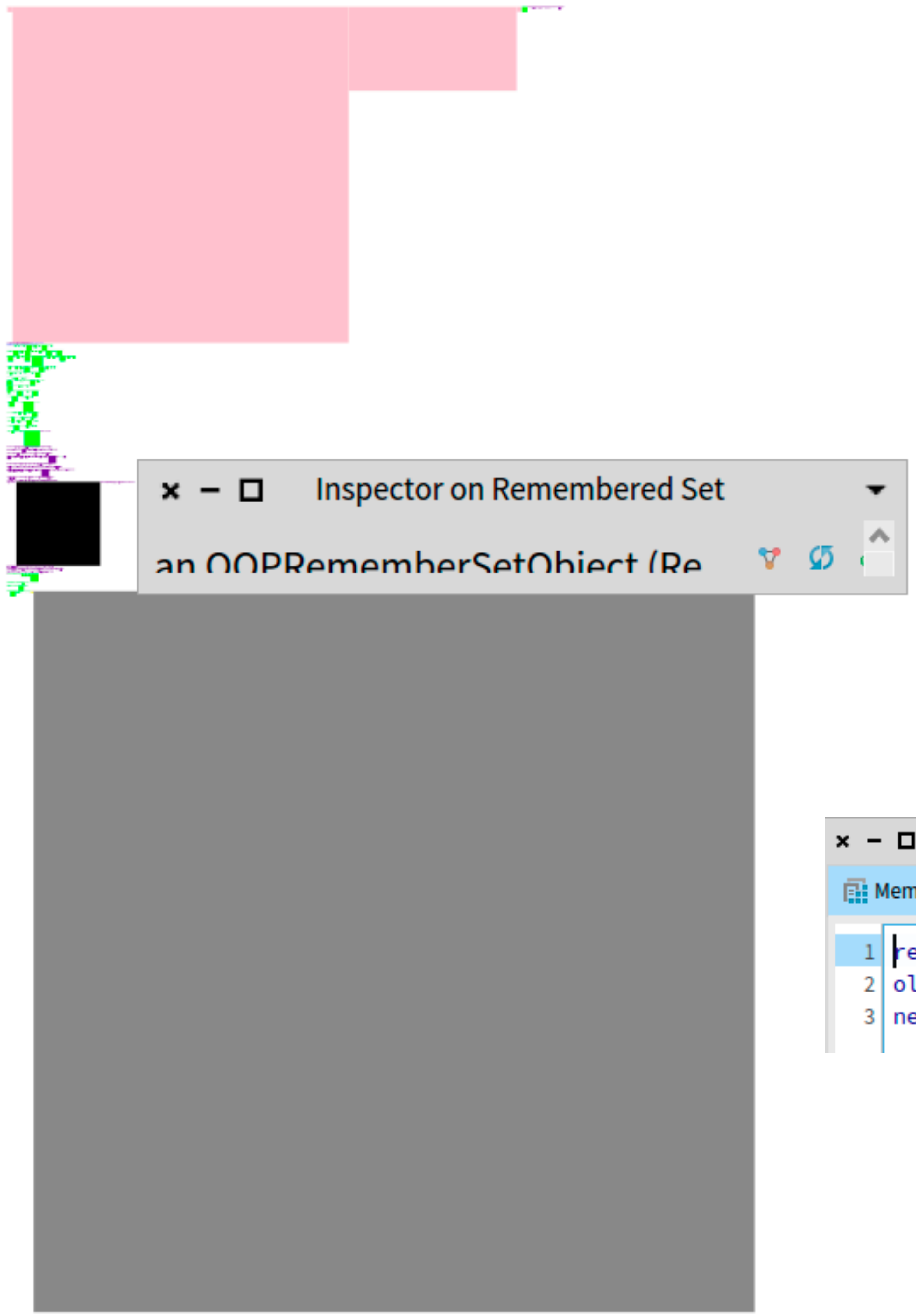
Memory visualisation

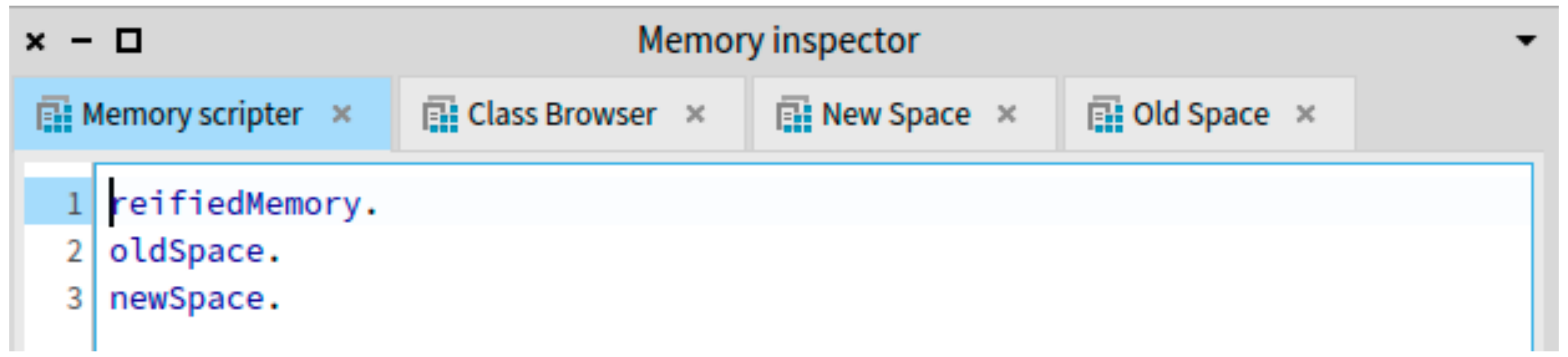


1	■	pinned object
895	🟪	compiled method
51	🟦	class
5	▫	special object
1	🟨	context
1	▪	free chunk
1468	🟩	regular object
51	▫	metaclass

Polyphemus

What’s That ?

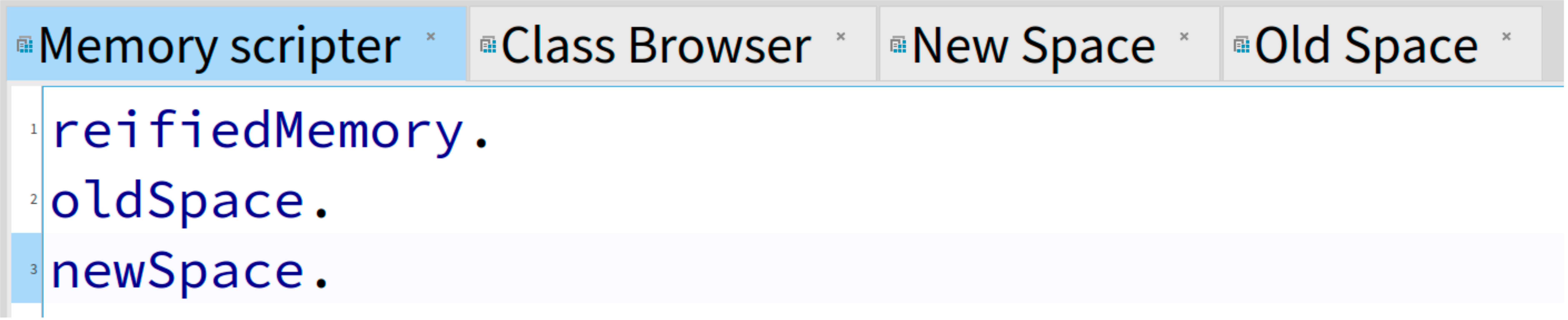




```
reifiedMemory.
oldSpace.
newSpace.
```

Polyphemus

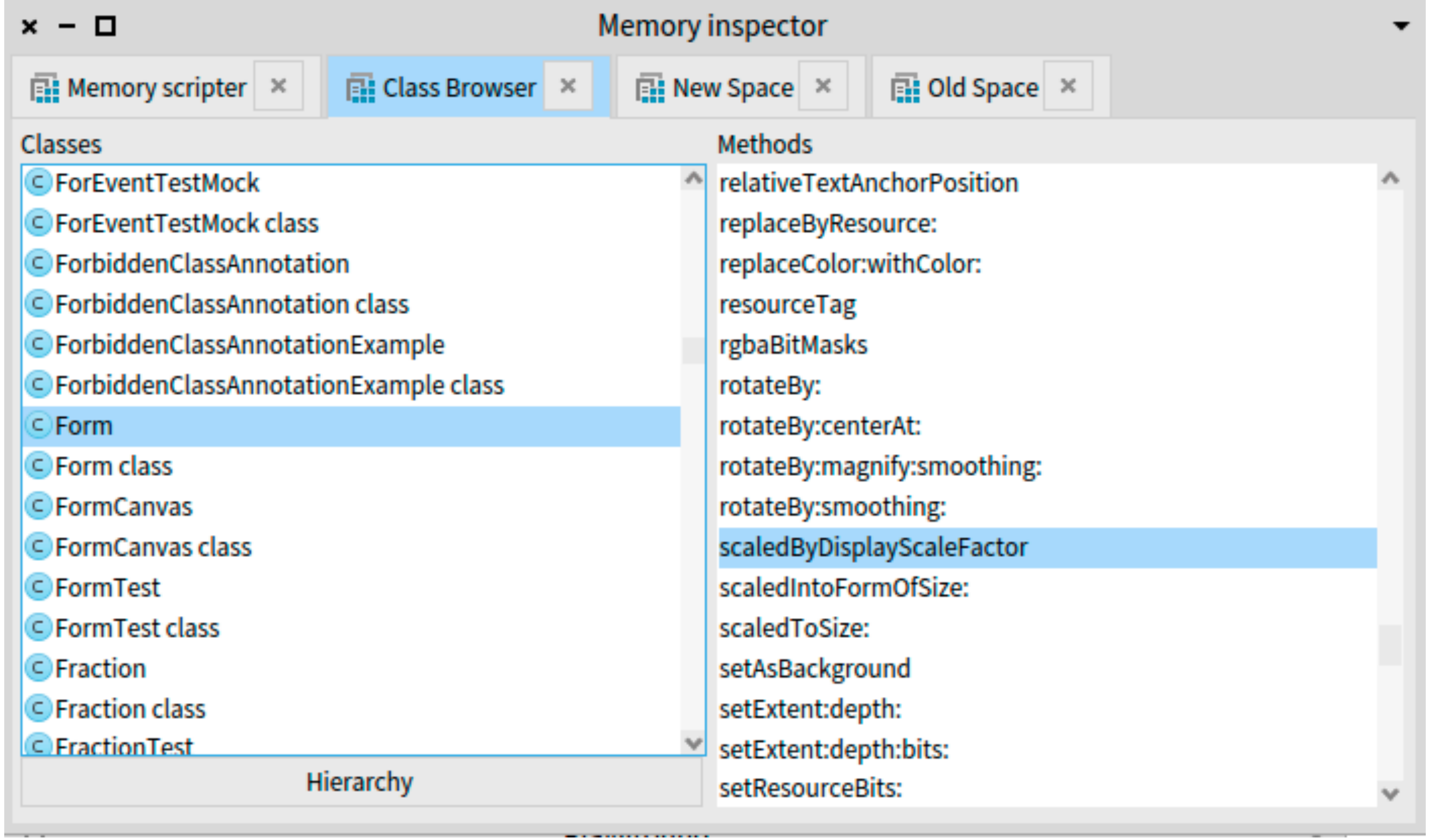
Scripter



```
reifiedMemory.
oldSpace.
newSpace.
```

Polyphemus

Memory Visualisation #2



Classes

- ForEventTestMock
- ForEventTestMock class
- ForbiddenClassAnnotation
- ForbiddenClassAnnotation class
- ForbiddenClassAnnotationExample
- ForbiddenClassAnnotationExample class
- Form
- Form class
- FormCanvas
- FormCanvas class
- FormTest
- FormTest class
- Fraction
- Fraction class
- FractionTest

Methods

- relativeTextAnchorPosition
- replaceByResource:
- replaceColor:withColor:
- resourceTag
- rgbaBitMasks
- rotateBy:
- rotateBy:centerAt:
- rotateBy:magnify:smoothing:
- rotateBy:smoothing:
- scaledByDisplayScaleFactor
- scaledIntoFormOfSize:
- scaledToSize:
- setAsBackground
- setExtent:depth:
- setExtent:depth:bits:
- setResourceBits:

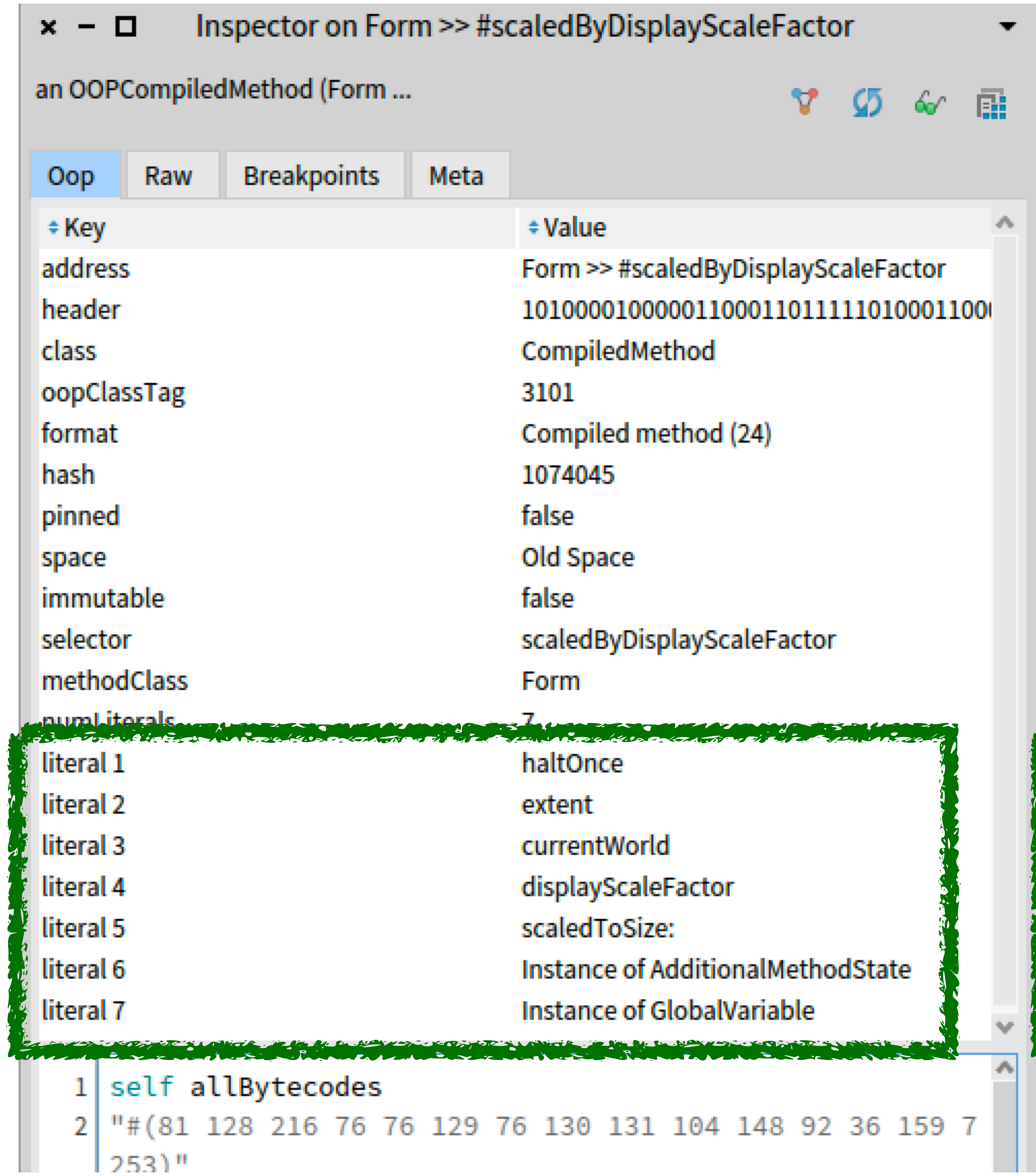
Real World Bug Fix #1

Remember This ?

```
Form >> #scaledByDisplayScaleFactor
         self halt.
         ^ self scaledToSize: self extent * self currentWorld displayScaleFactor.
```

Real World Bug Fix #1

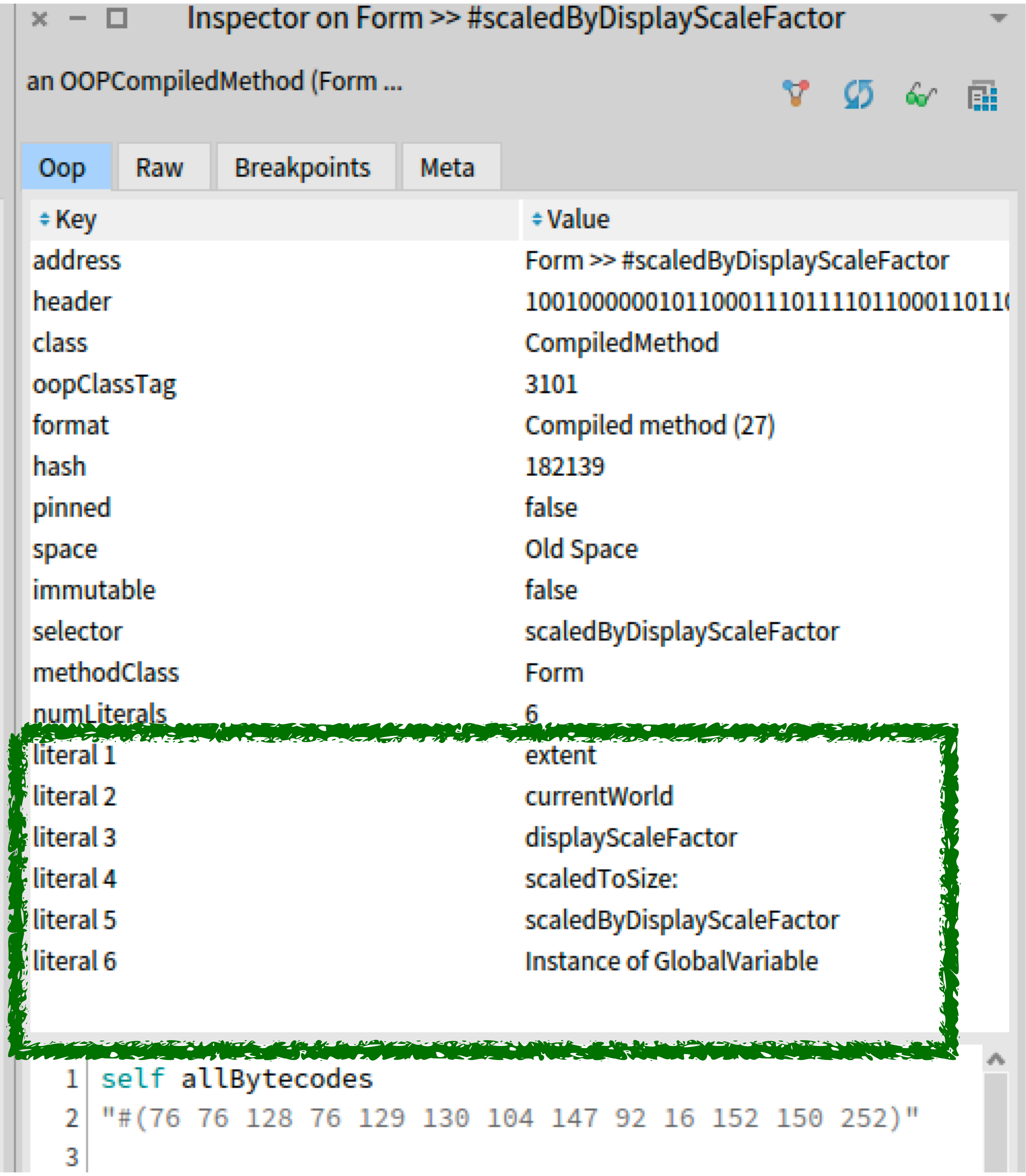
A Meta-Error Fix



Inspector on Form >> #scaledByDisplayScaleFactor
an OOPCompiledMethod (Form ...
Oop
Raw
Breakpoints
Meta

Key	Value
address	Form >> #scaledByDisplayScaleFactor
header	10100001000001100011011111010001100
class	CompiledMethod
oopClassTag	3101
format	Compiled method (24)
hash	1074045
pinned	false
space	Old Space
immutable	false
selector	scaledByDisplayScaleFactor
methodClass	Form
numLiterals	7
literal 1	haltOnce
literal 2	extent
literal 3	currentWorld
literal 4	displayScaleFactor
literal 5	scaledToSize:
literal 6	Instance of AdditionalMethodState
literal 7	Instance of GlobalVariable

```
self allBytecodes
"#(81 128 216 76 76 129 76 130 131 104 148 92 36 159 7
253)"
```



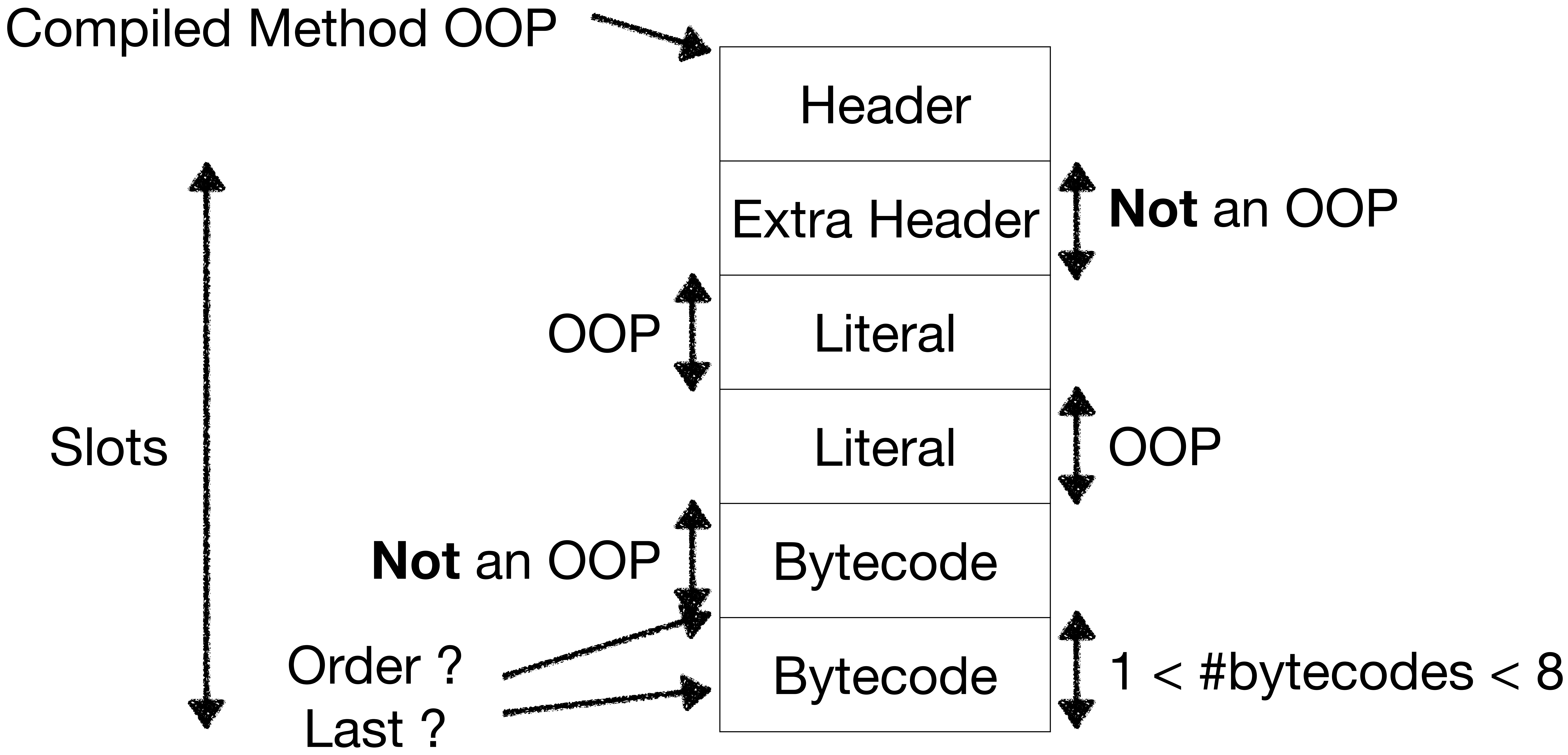
Inspector on Form >> #scaledByDisplayScaleFactor
an OOPCompiledMethod (Form ...
Oop
Raw
Breakpoints
Meta

Key	Value
address	Form >> #scaledByDisplayScaleFactor
header	1001000000101100011101111011000110111
class	CompiledMethod
oopClassTag	3101
format	Compiled method (27)
hash	182139
pinned	false
space	Old Space
immutable	false
selector	scaledByDisplayScaleFactor
methodClass	Form
numLiterals	6
literal 1	extent
literal 2	currentWorld
literal 3	displayScaleFactor
literal 4	scaledToSize:
literal 5	scaledByDisplayScaleFactor
literal 6	Instance of GlobalVariable

```
self allBytecodes
"#(76 76 128 76 129 130 104 147 92 16 152 150 252)"

```

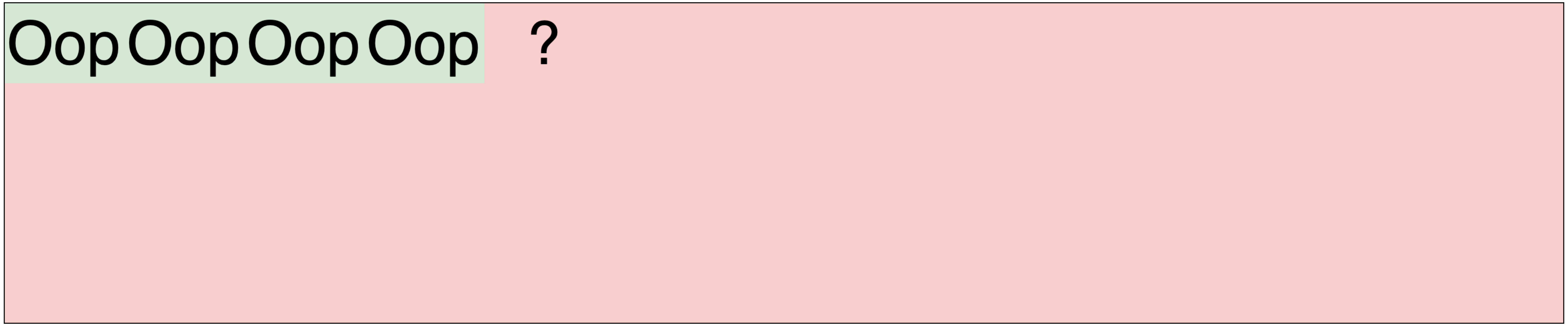
Real World Bug Fix #1

A Meta-Error Fix Analysis



Real World Bug Fix #2

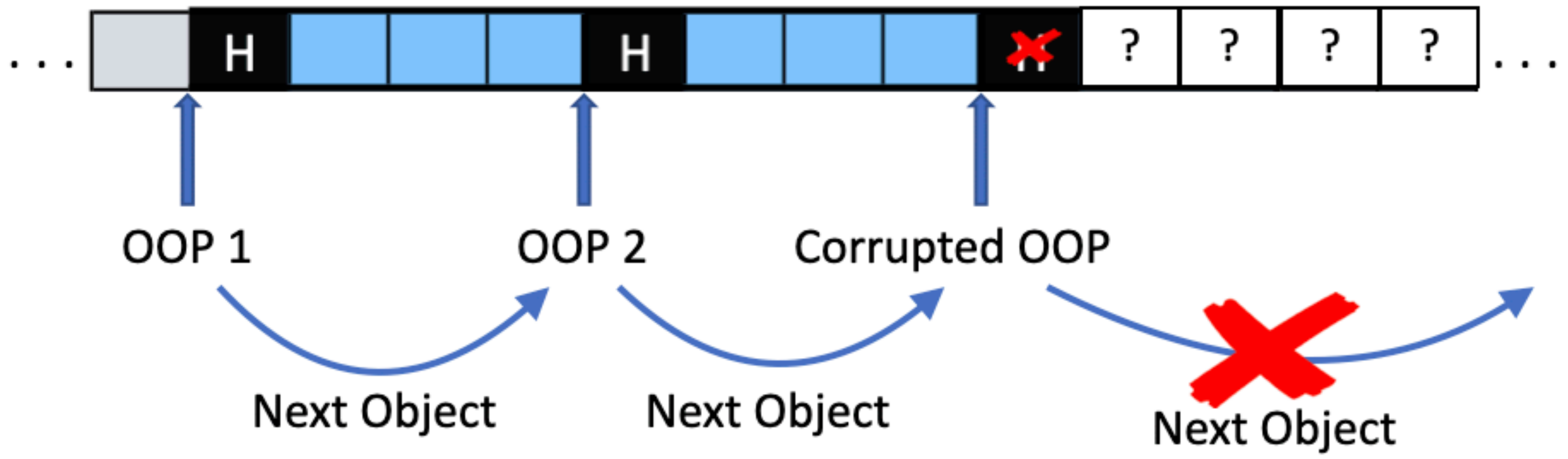
A Memory Corruption



Oop Oop Oop Oop ?

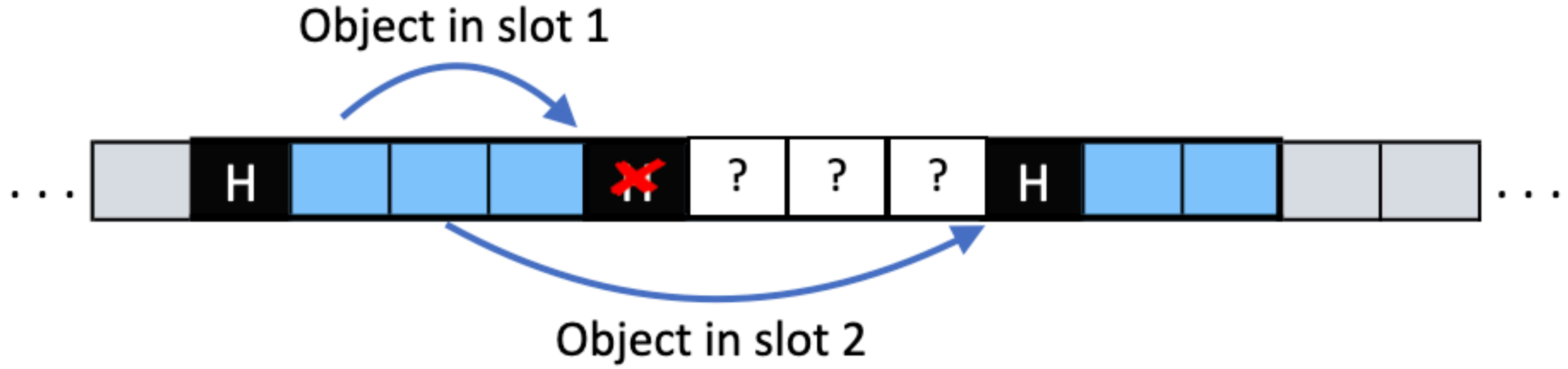
Real World Bug Fix #2

Iterating the Corrupted Memory



Real World Bug Fix #2

Recovering Objects



Real World Bug Fix #2

Cleansing The Corruption

Oop	Oop	Oop	Oop	F	Oop	Oop	Oop	Oop	Oop	Oop	Oop	Oop
F	Oop	Oop	F	Oop	F	Oop	Oop	F	Oop	Oop	Oop	Oop
Oop	Oop	Oop	Oop	Oop	F	Oop	Oop	Oop	Oop	Oop	Oop	Oop
Oop	Oop	Oop	F	Oop	Oop	Oop	Oop	Oop	Oop	Oop	Oop	Oop

Real World Bug Fix #2

Corruption Cleansing Analysis

- Objects’ slots iteration
- Reference patching
- Re-computation of the free lists/tree
- Focus on learning rather than how to look

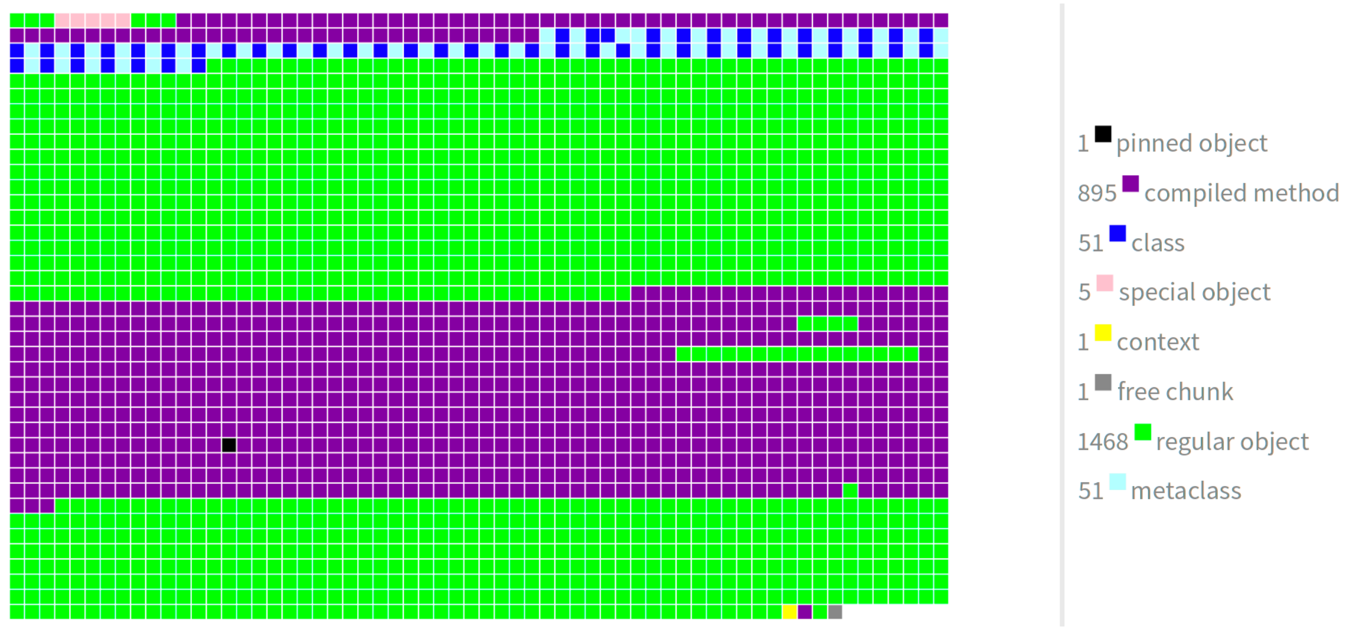
Conclusion

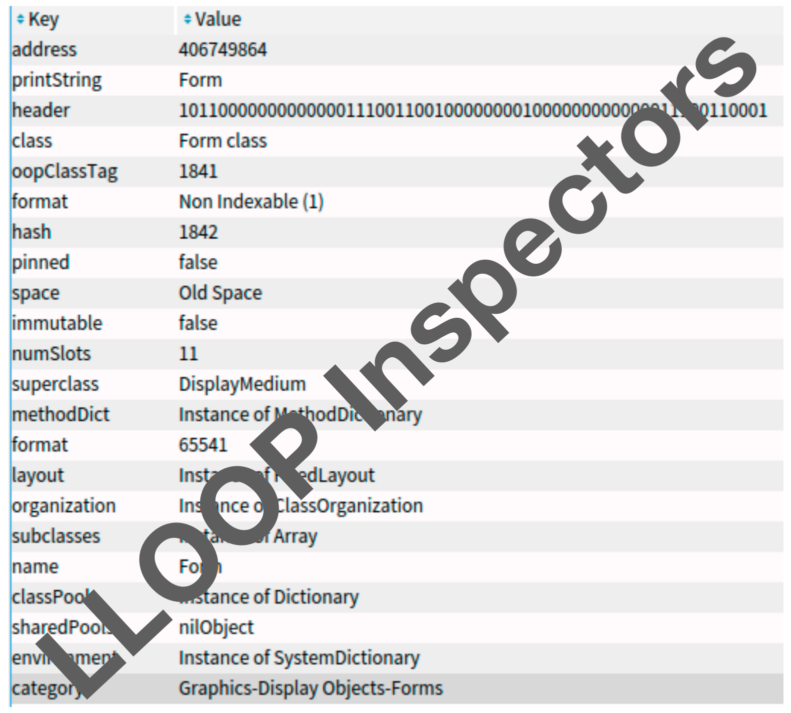
Github

- Tooling at the VM level **was** hard
- LLOOP eases VM level tooling
- Validated with multiple custom tools
- Zombie Pharo images are now a thing

VMIL Paper preprint

Visualization





Key	Value
address	406749864
printString	Form
header	10110000000000000111001100100000000100000000000000[illegible]0110001
class	Form class
oopClassTag	1841
format	Non Indexable (1)
hash	1842
pinned	false
space	Old Space
immutable	false
numSlots	11
superclass	DisplayMedium
methodDict	Instance of MethodDictionary
format	65541
layout	Instance of FixedLayout
organization	Instance of ClassOrganization
subclasses	Instance of Array
name	Form
classPool	Instance of Dictionary
sharedPools	nilObject
environment	Instance of SystemDictionary
category	Graphics-Display Objects-Forms

LLOOP Inspectors

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