RMod Inria Université de Lille cnrs IMT Nord Europe École Mines-Télécom IMT-Université de Lille CRIStAL Centre de Recherche en Informatique, Signal et Automatique de Lille

# Polyphemus Ease Virtual Machine Level Tooling

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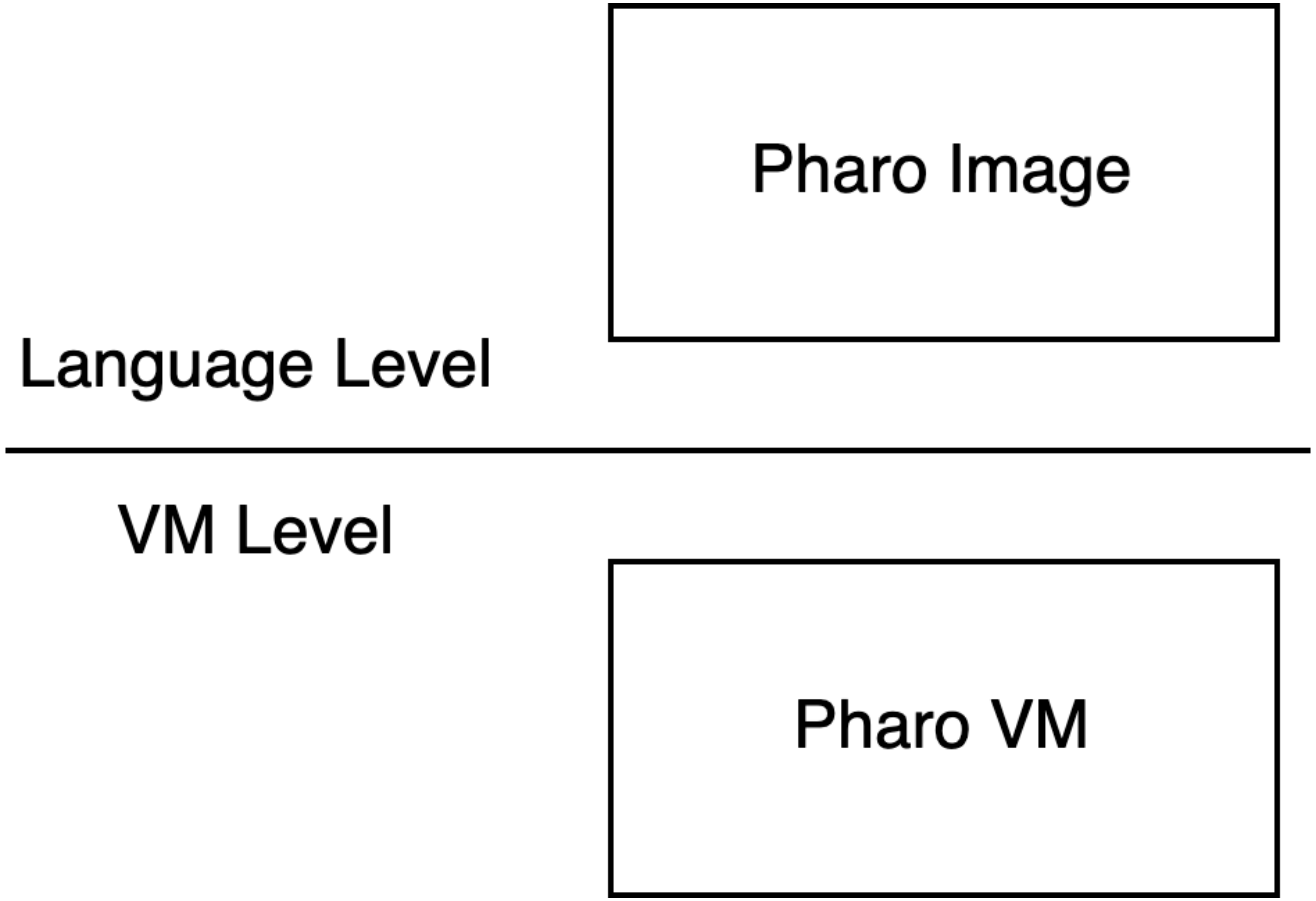
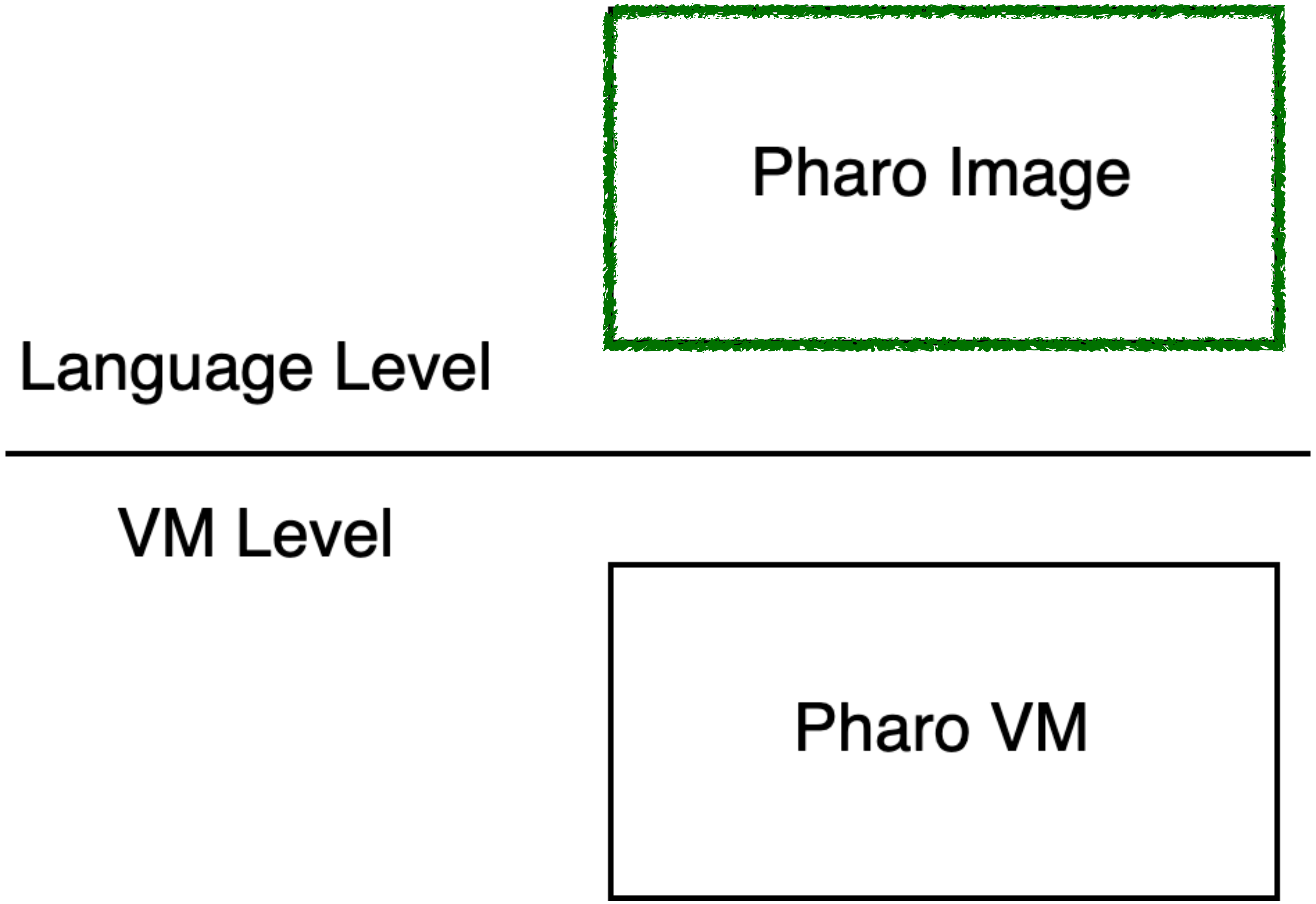
# Who Does Not Love Tools ?

## Tooling Levels



# Who Does Not Love Tools ?

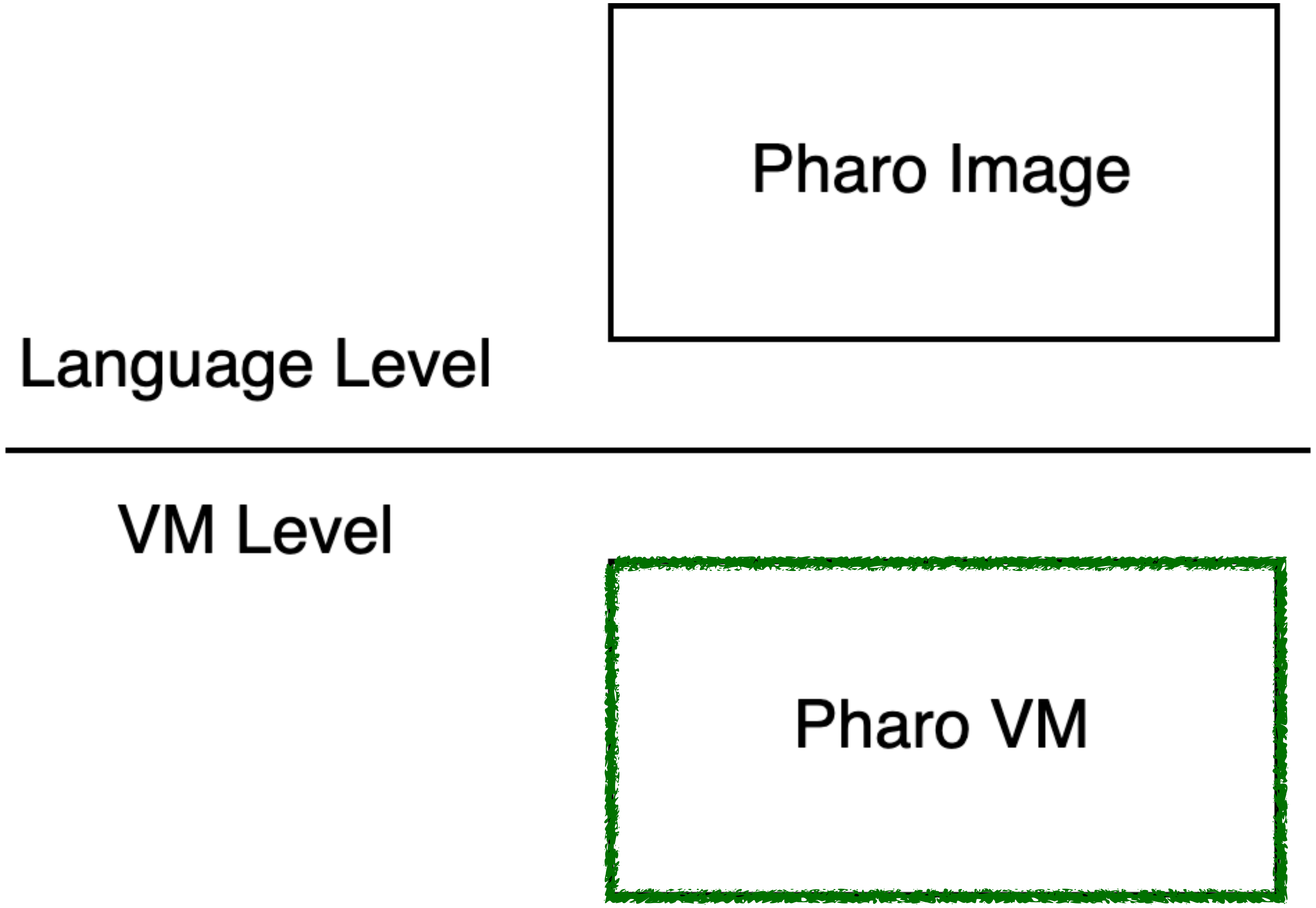
## Tools at the Language Level

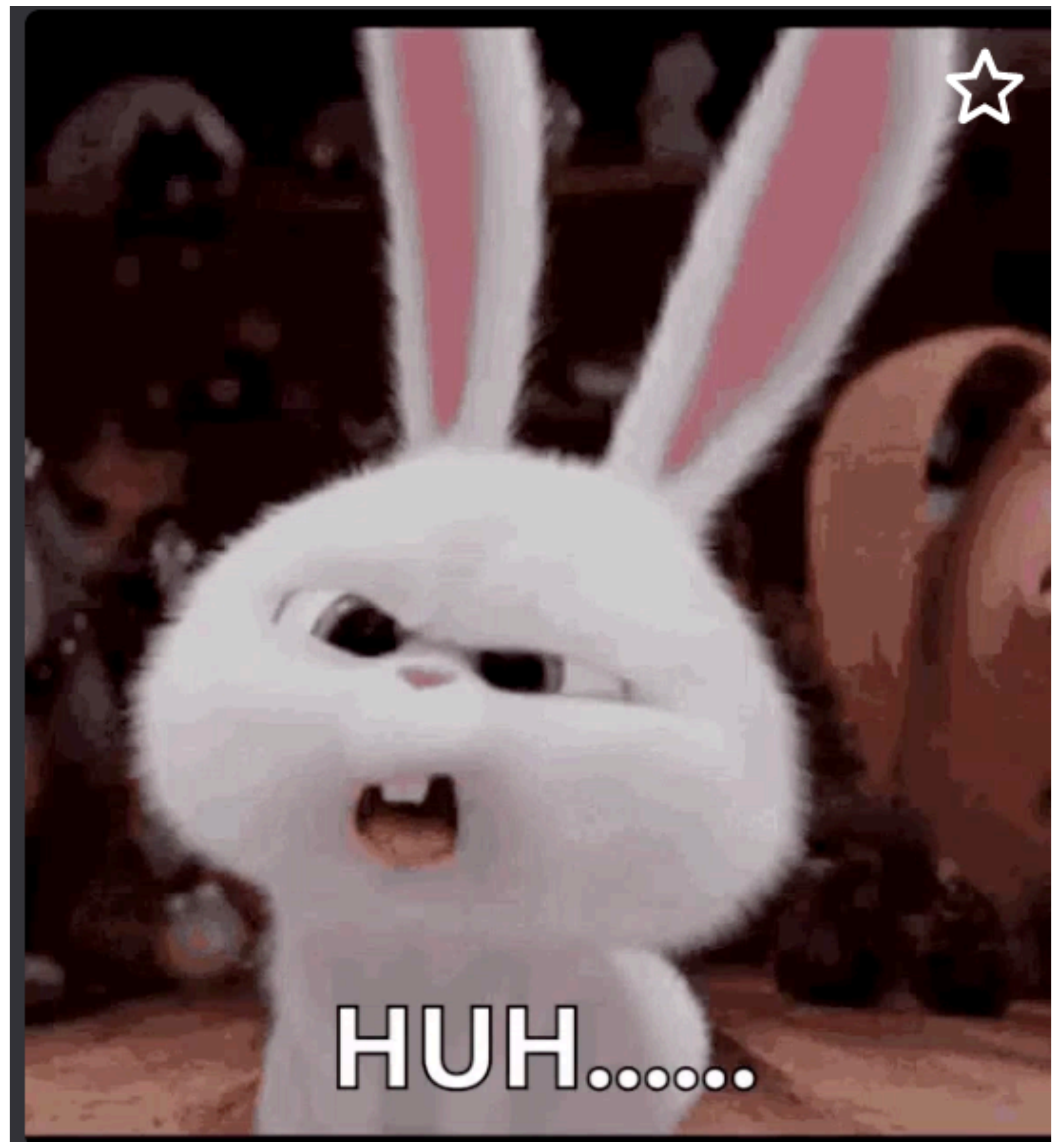


NewTools, Moose, Roassal,
Calypso, SUnit, Iceberg, Refactoring, Epicea
… … …

# Who Does Not Love Tools ?

## Tools at the VM Level





Bootstrap, VM machine code debugger
Others ?

Not many things a Pharo developer cares about !

# Who Does Not Love Tools ?

## Why Should we Care About VM Level Tools ?

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

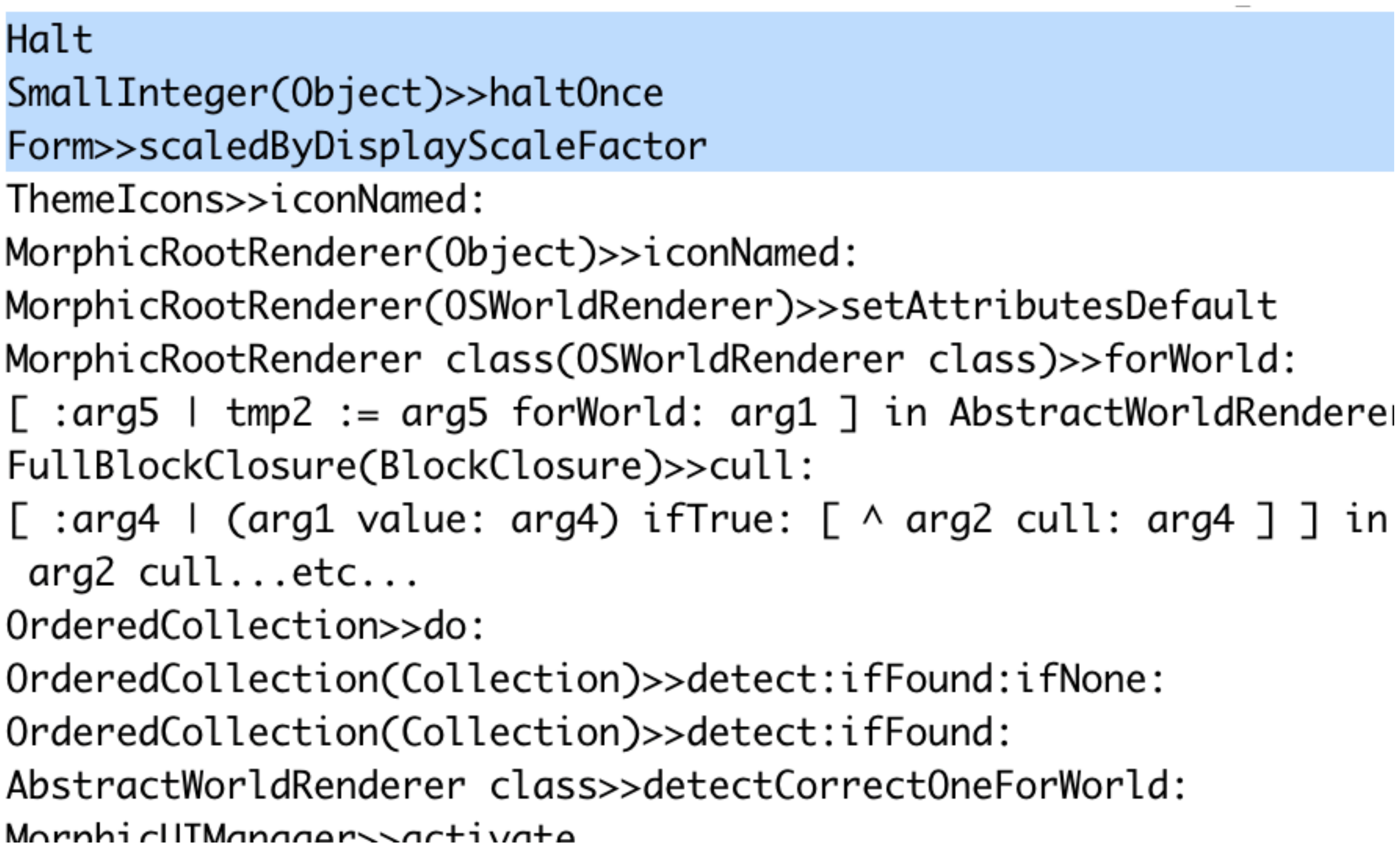
# Who Does Not Love Tools ?

## Don’t Save It !

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

# Who Does Not Love Tools ?

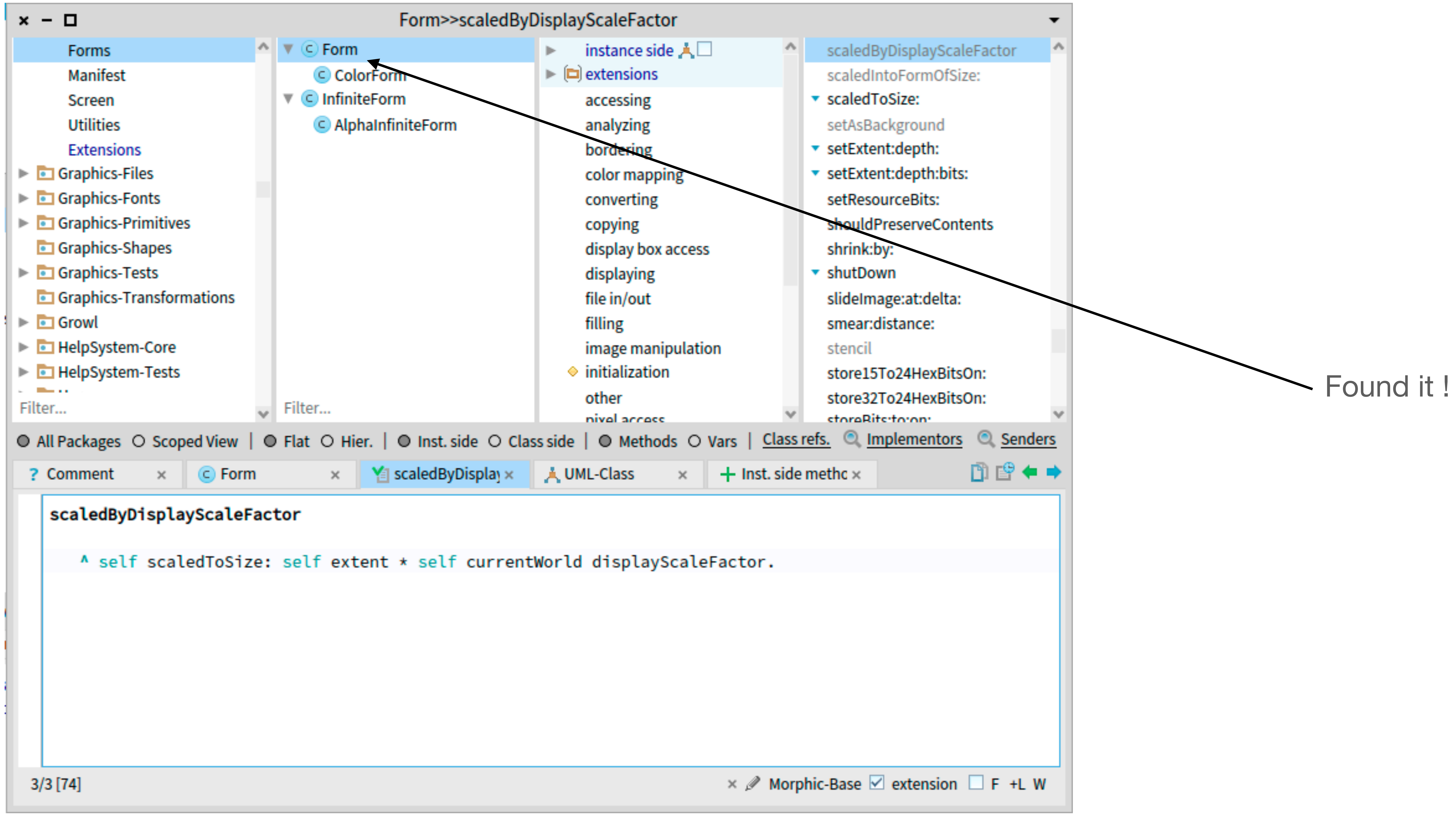
## Too Late !



```
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:
MorphicUIManager>>activate
```

# Let’s Code VM Level Tools !

## Let’s Find the Class Form …



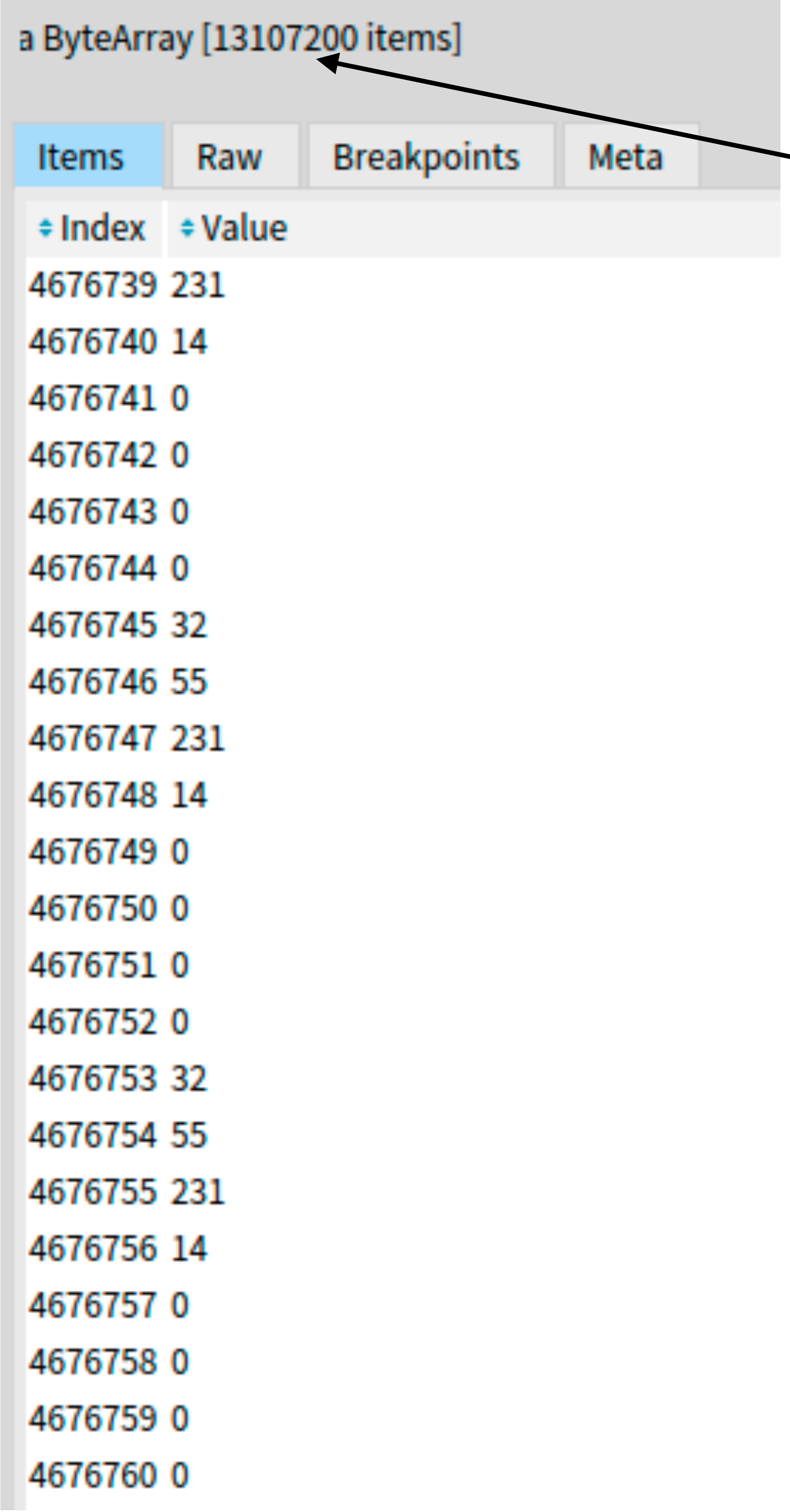
```
scaledByDisplayScaleFactor

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

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: address.
                className := memory convertStringOopToStringObject: classNameOop.
                className = aClassName ifTrue: [ ^ aClassOop ]]].
    ^ memory nilOOP
```

memory findClassNamed: Form >>> 406749864

# Let’s Code VM Level Tools !

## Why do I Have to Code Like That ?

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

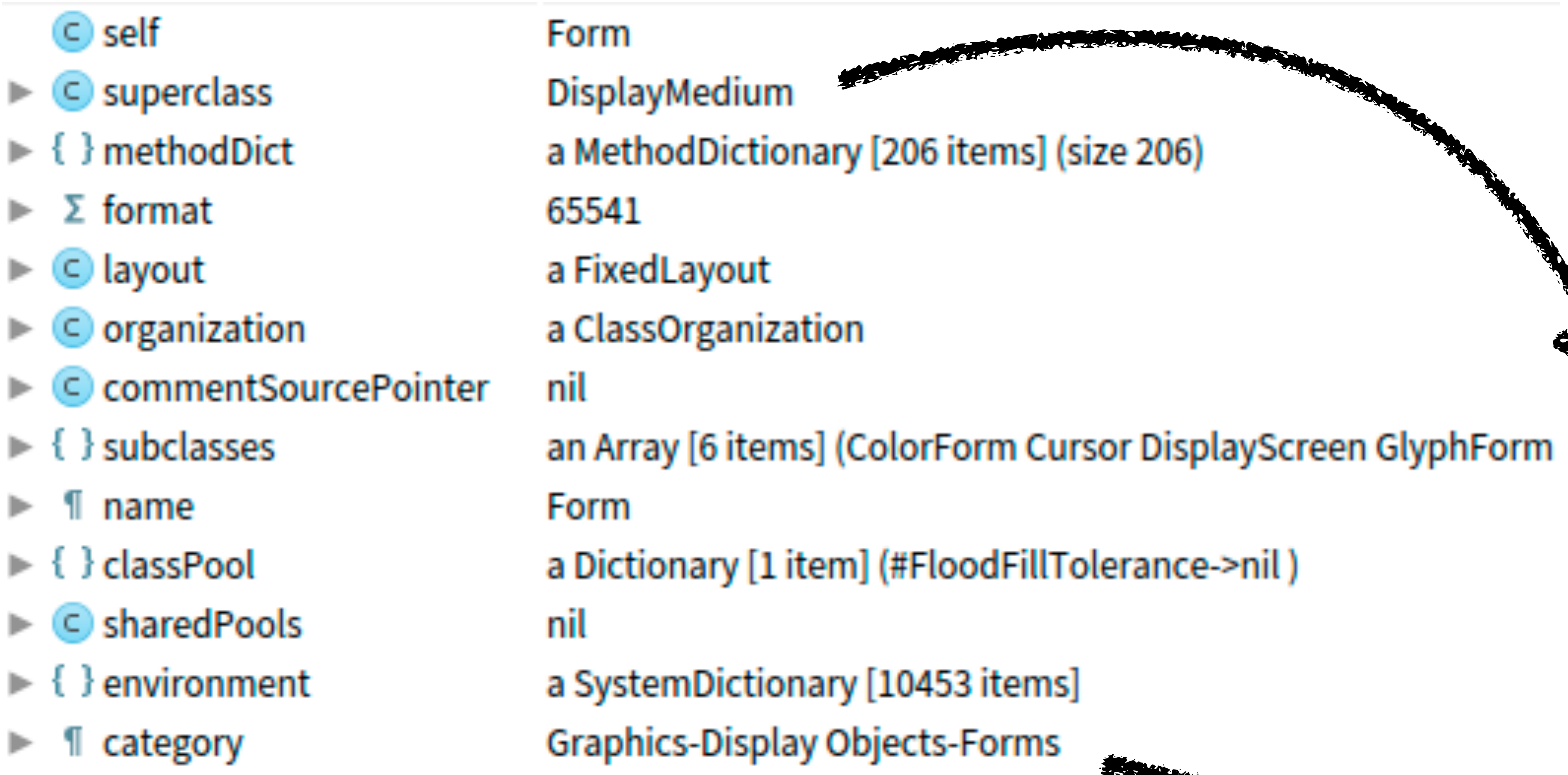
Solutions

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

# Polyphemus

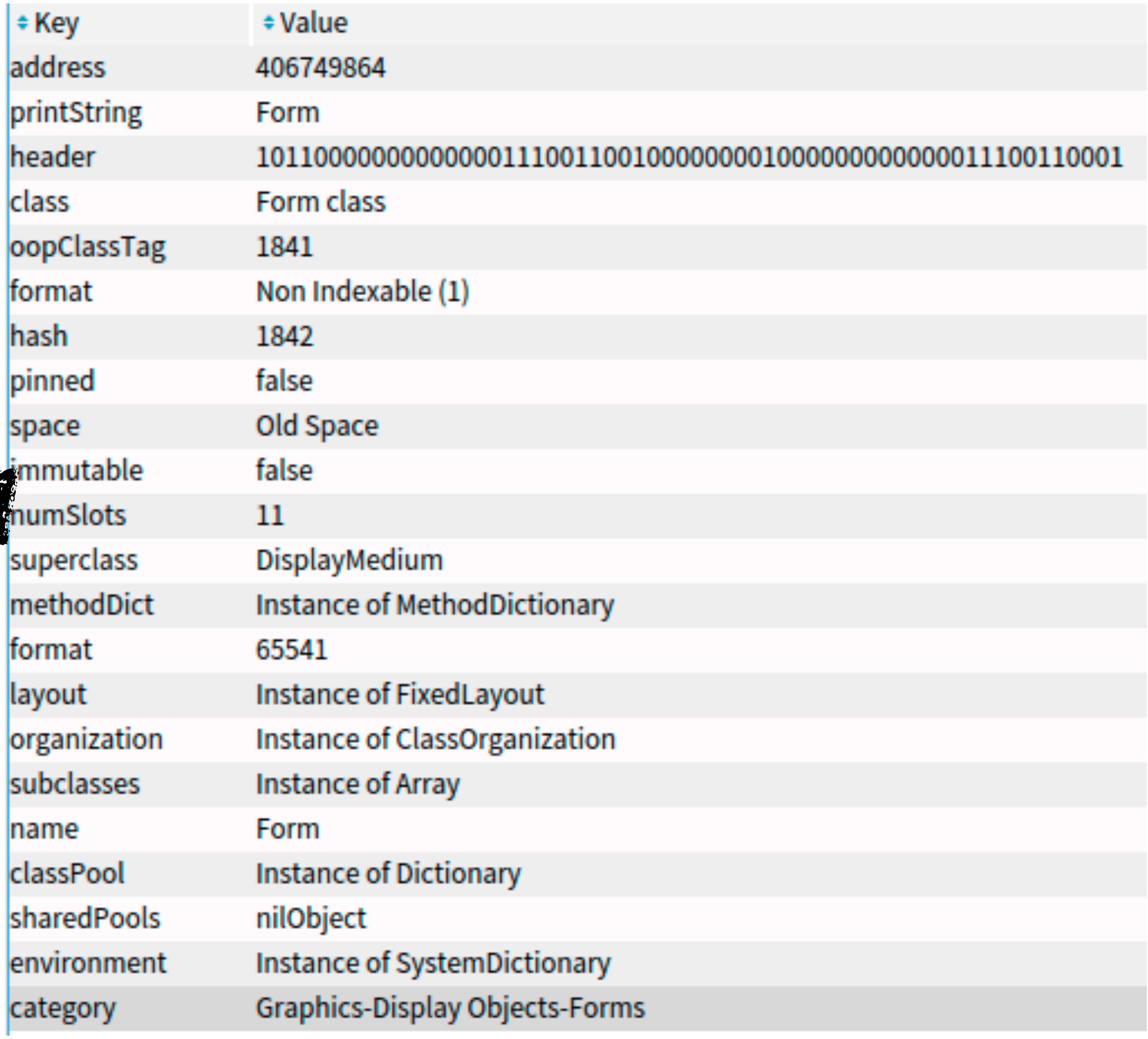
## Objects Instead of OOPs

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 | 1011000000000000011100110010000000010000000000000111001100 01 |
| 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

## LLOOPs are Just The Start

- Object specific behavior
- Inspectors
- Memory visualisation

- Many more and more VM level tooling

# Polyphemus

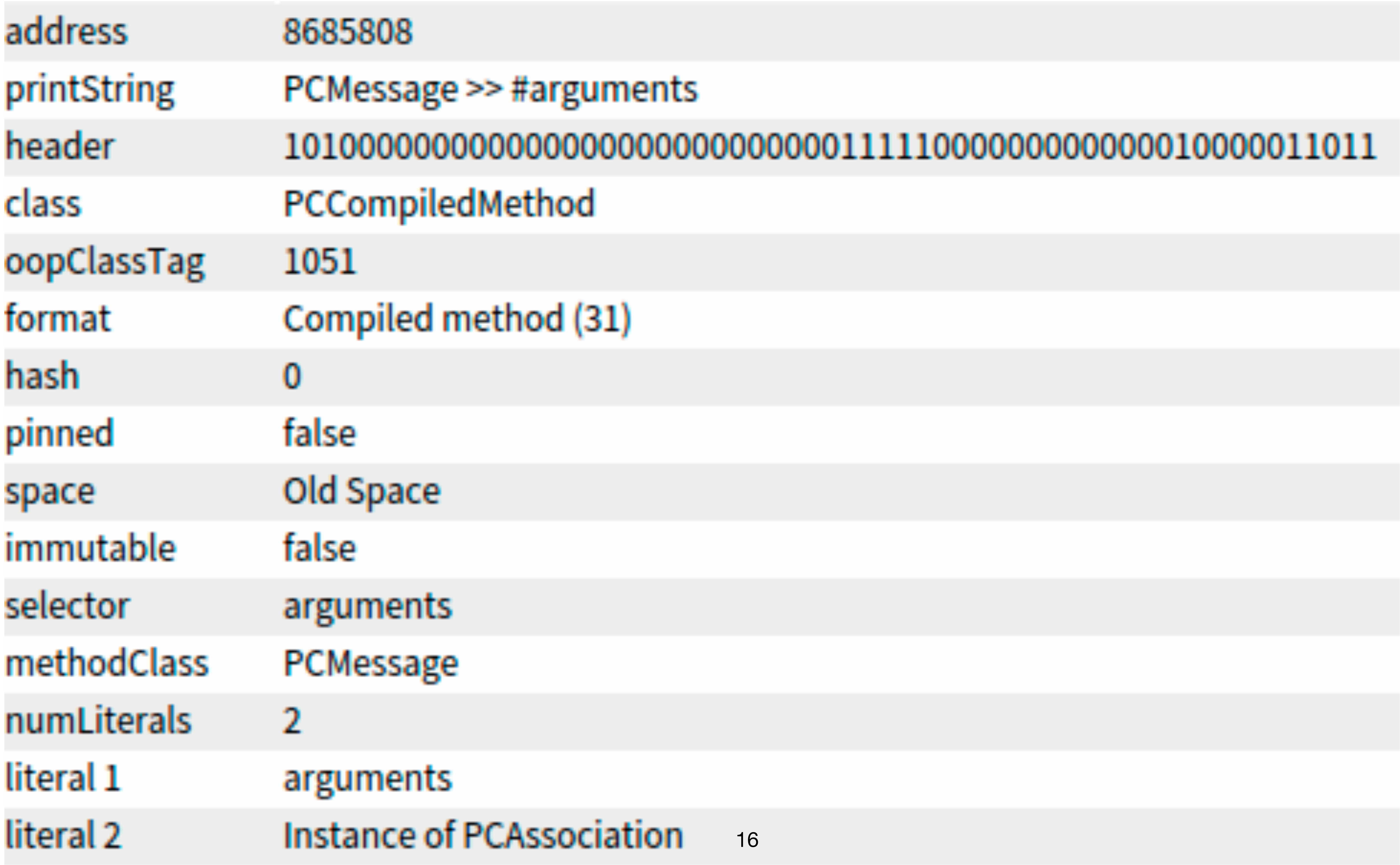
## Object Specific Behavior

- Classes have subclasses
- A class table page is a VM level object that have an index in the Class Table
- Indexable Objects are addressed in the same way

# Polyphemus

## Inspector

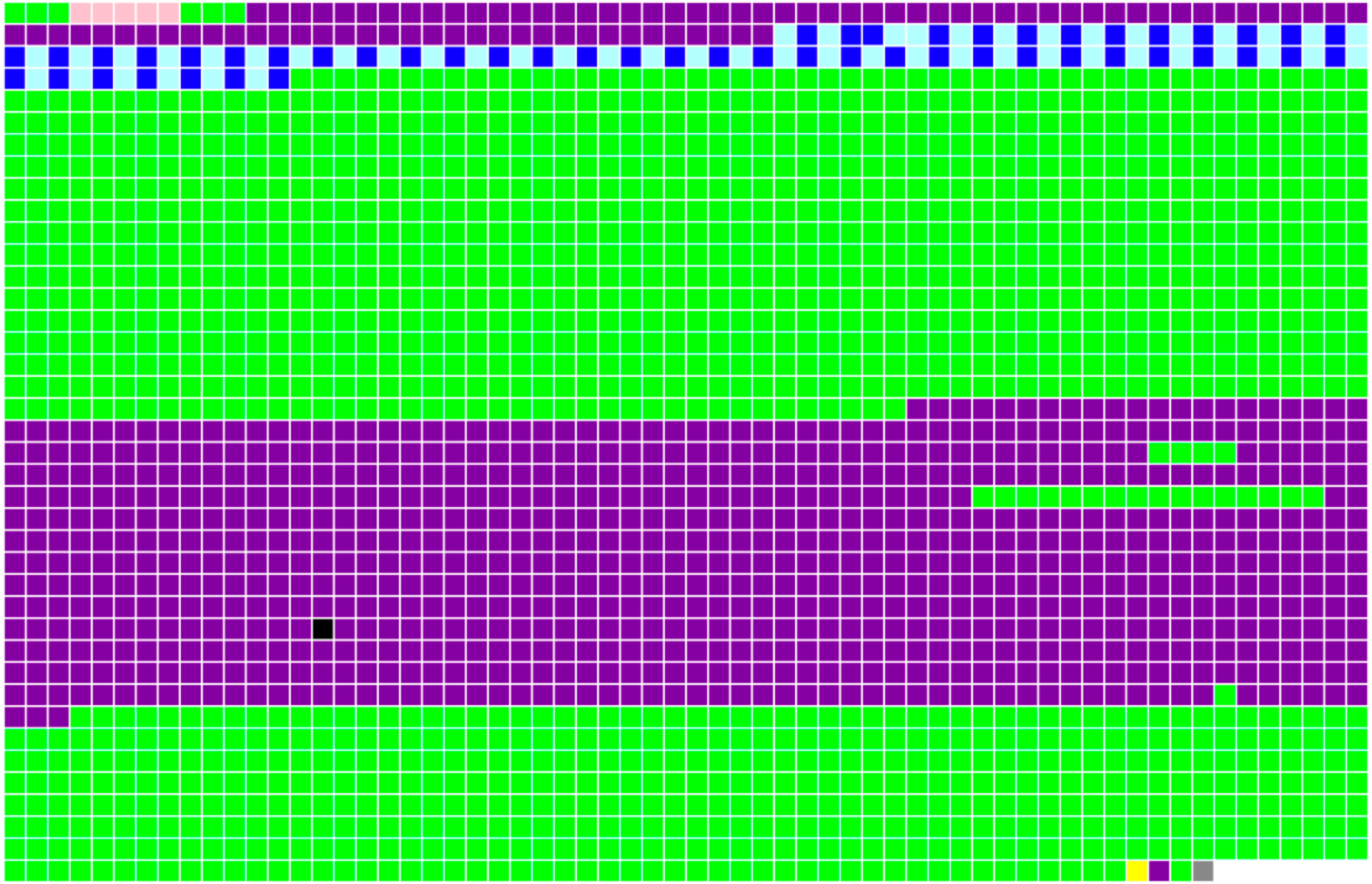
Compiled Method



| | |
|---|---|
| address | 8685808 |
| printString | PCMessage >> #arguments |
| header | 10100000000000000000000000000011111000000000000010000011011 |
| 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

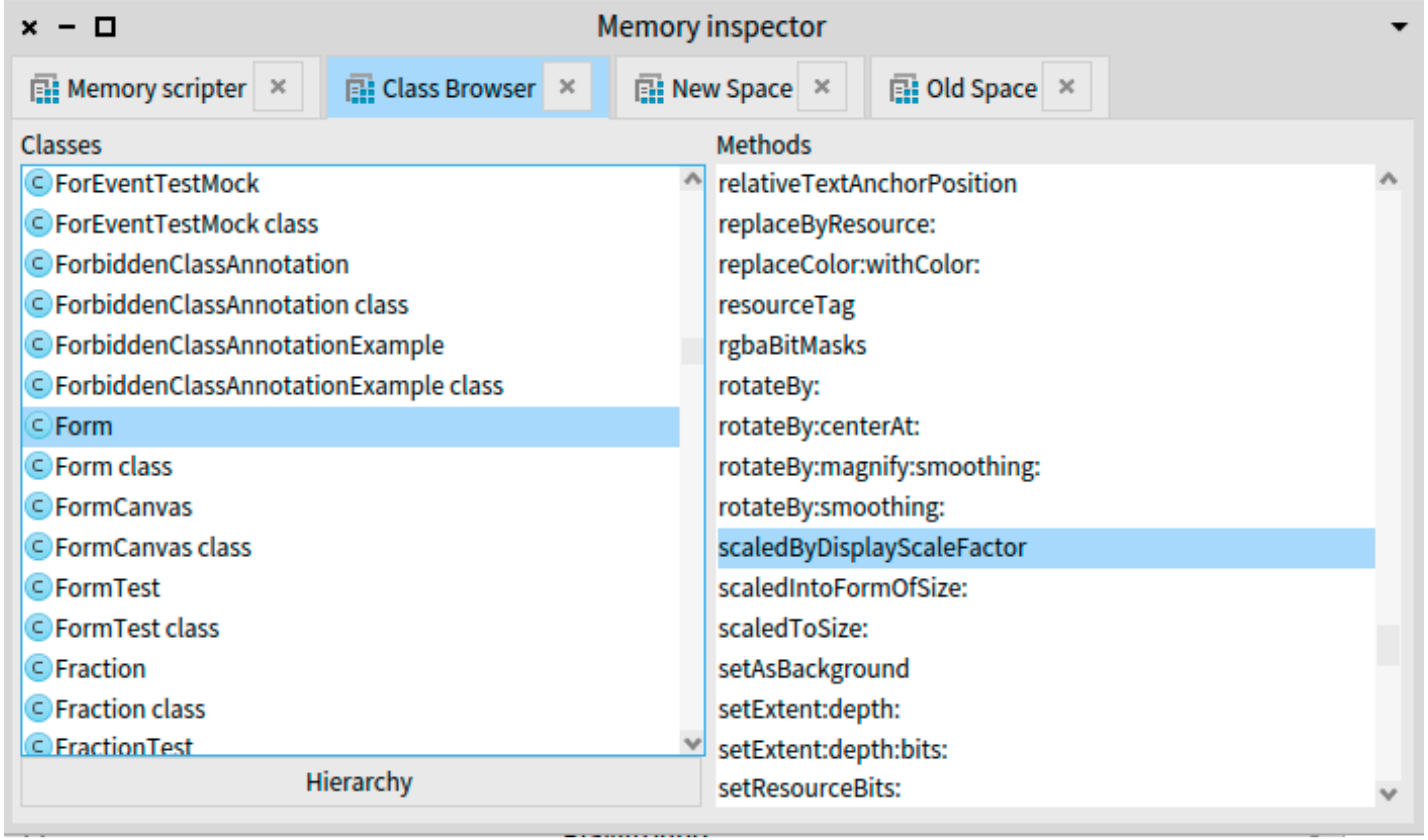
1 ◼ free chunk

1468 🟩 regular object

51 ⬜ metaclass

# Polyphemus

## Memory Visualisation #2



Memory inspector

Memory scripter ×
Class Browser ×
New Space ×
Old Space ×

Classes

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

Hierarchy

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:

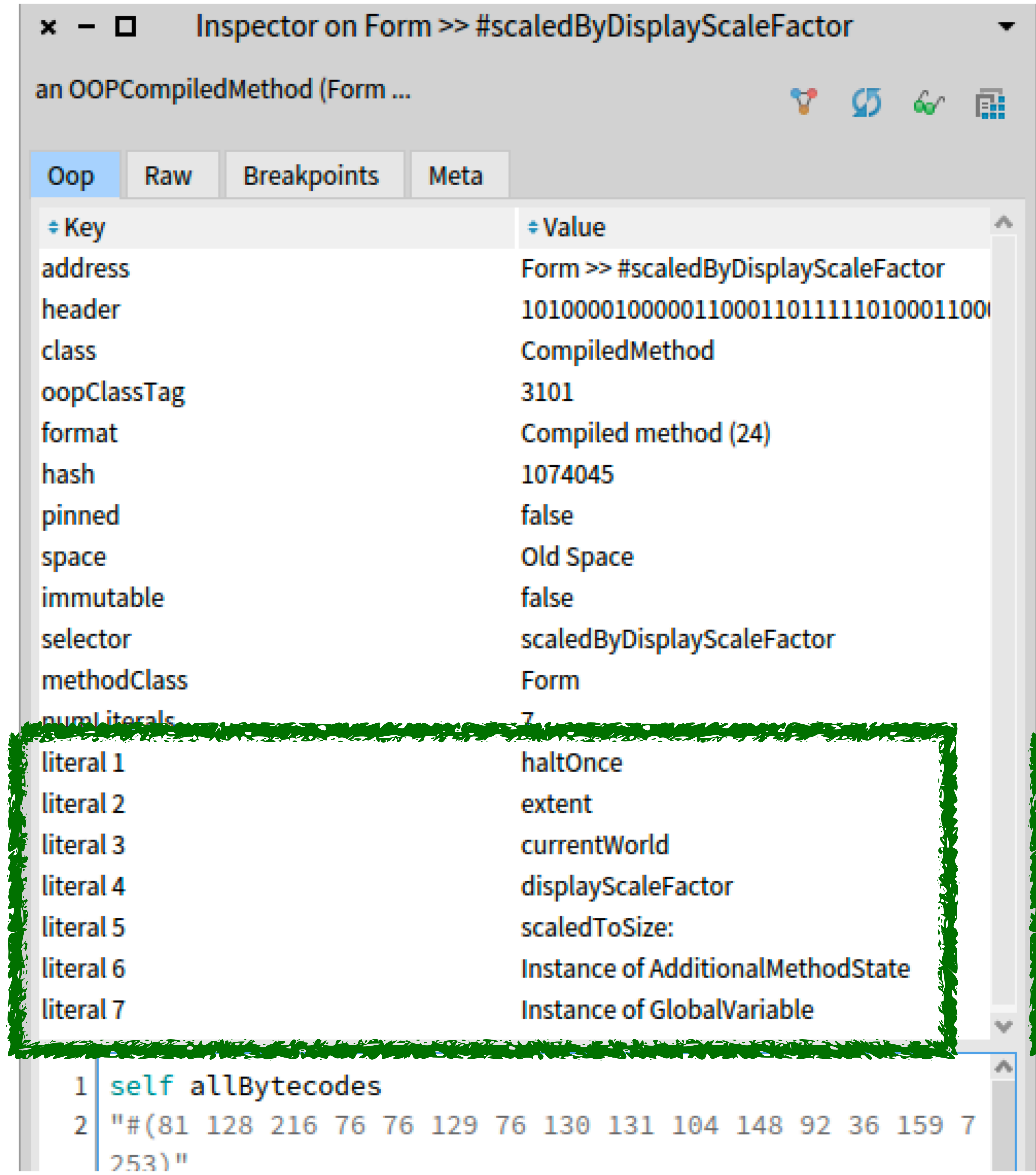
# Real World Bug Fix #1

## Remember This ?

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

# Real World Bug Fix #1

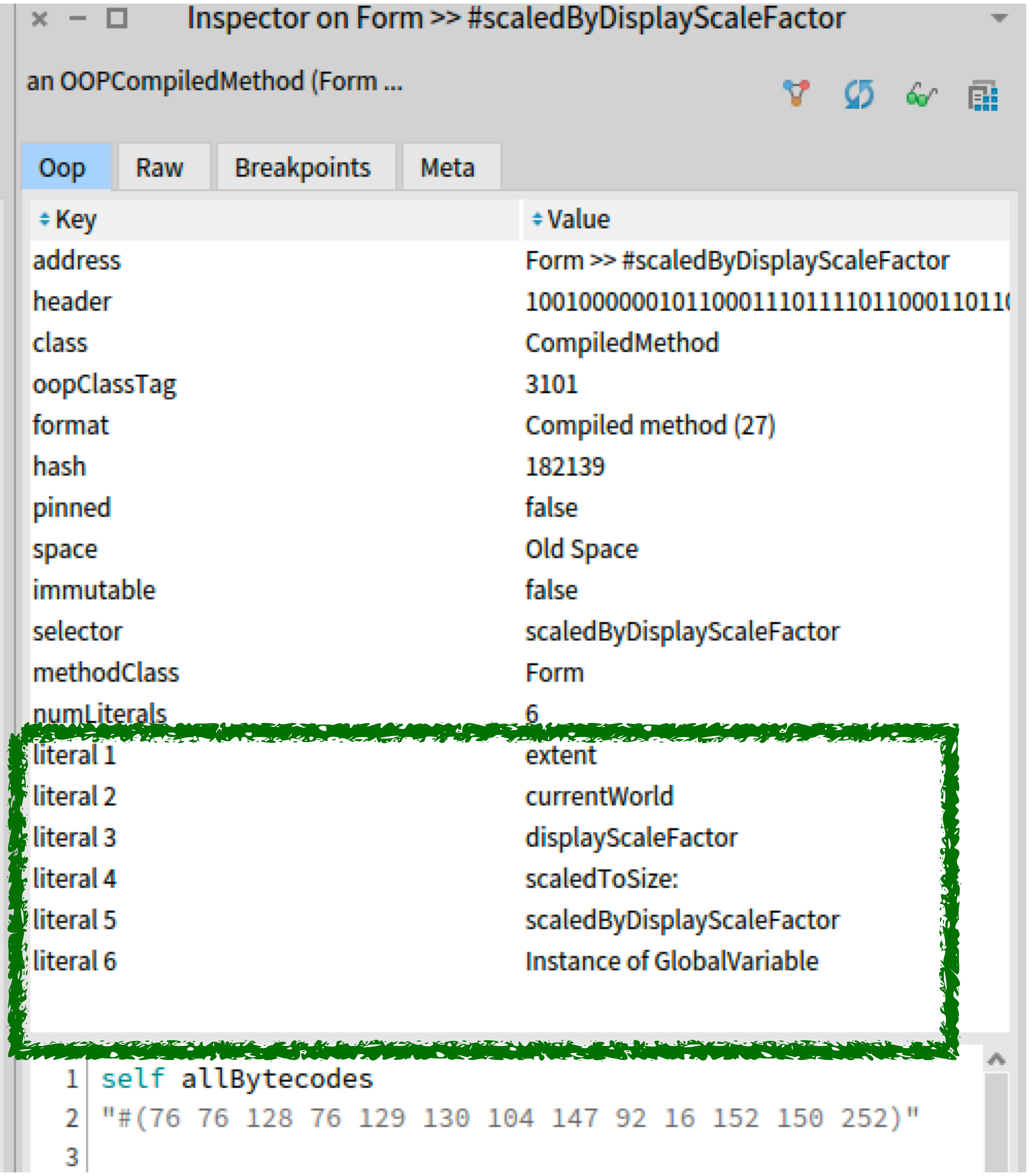
## A Meta-Error Fix



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

| Key | Value |
|---|---|
| address | Form >> #scaledByDisplayScaleFactor |
| header | 101000010000001100011011111010001100 |
| 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)"
```



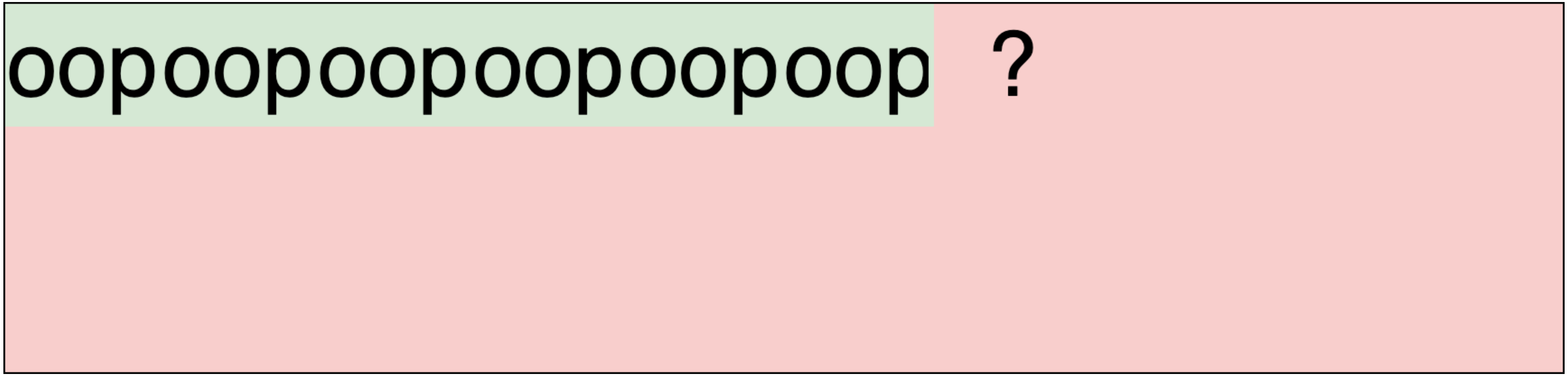
Inspector on Form >> #scaledByDisplayScaleFactor
an OOPCompiledMethod (Form ...
Oop
Raw
Breakpoints
Meta

| Key | Value |
|---|---|
| address | Form >> #scaledByDisplayScaleFactor |
| header | 100100000010110001110111101100011011 |
| 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 #2

## A Memory Corruption

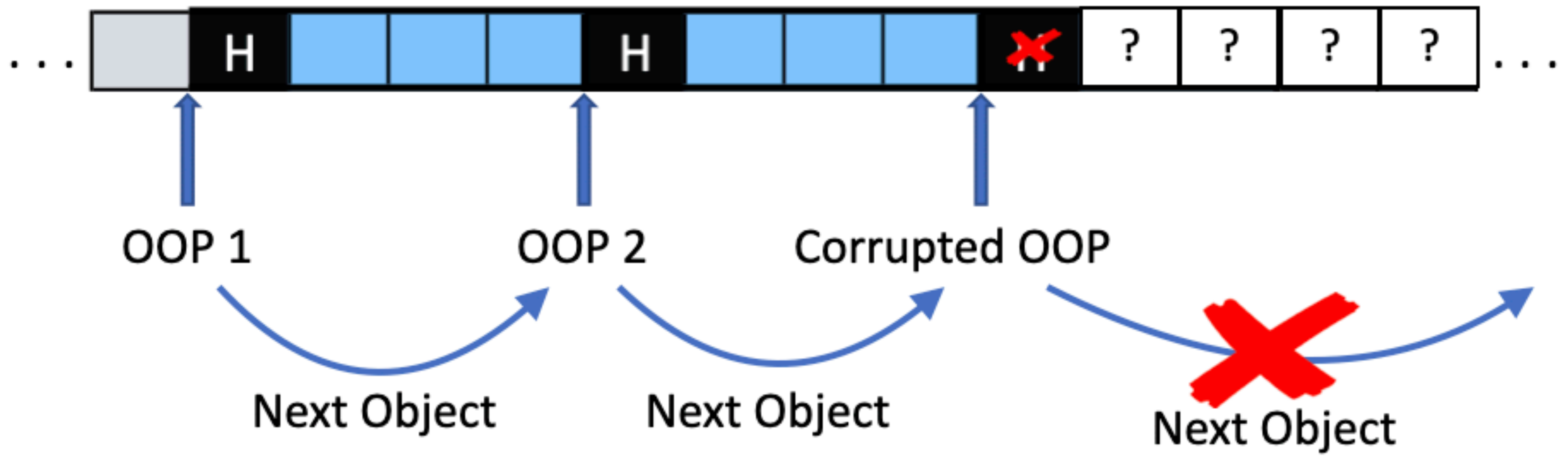


oopoopoopoopoopoop

?

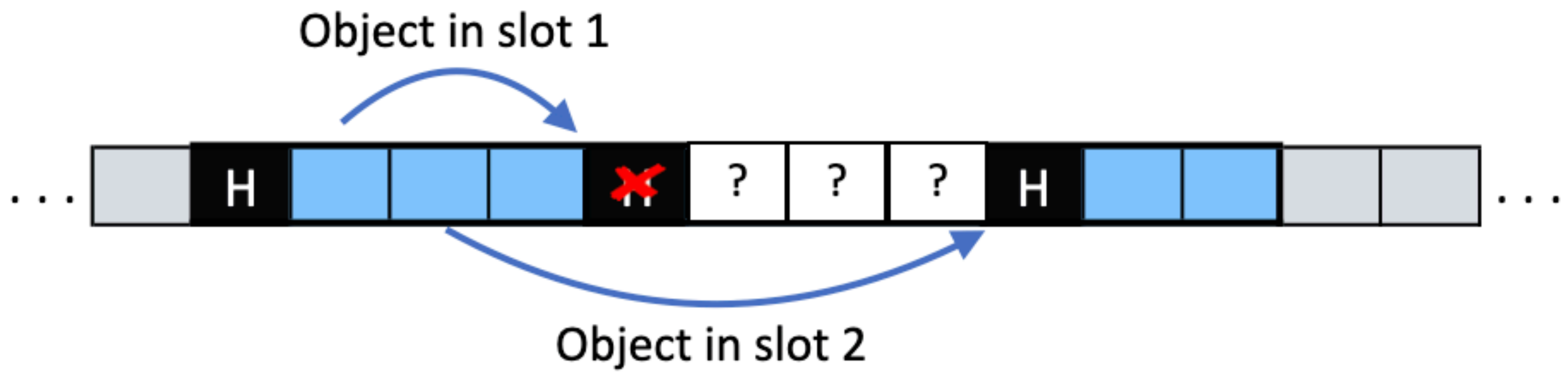
# Real World Bug Fix #2

## Iterating the Corrupted Memory



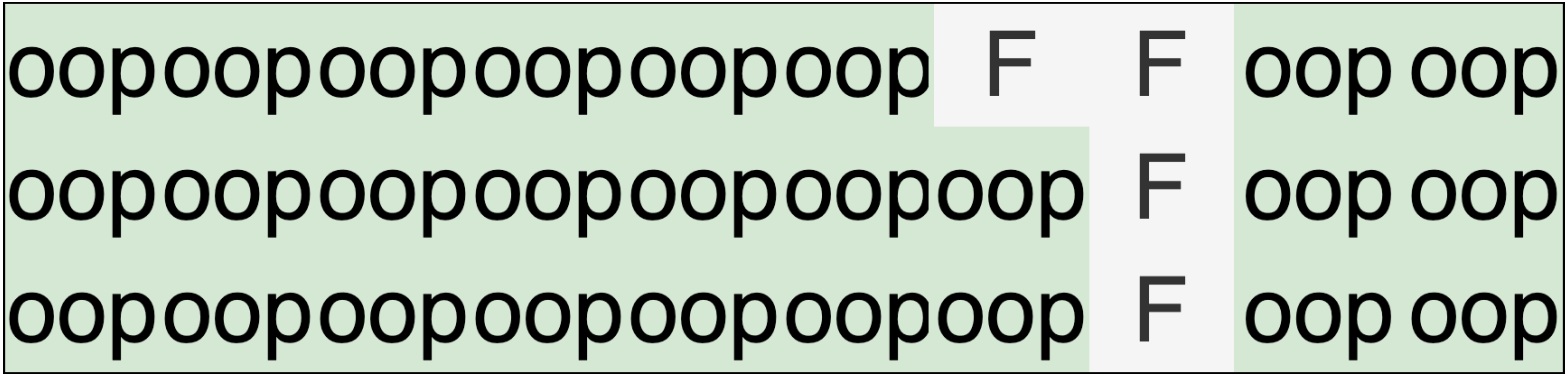
# Real World Bug Fix #2

## Recovering Objects



# Real World Bug Fix #2

## Cleansing corruption



```
oopoopoopoopoopoop F  F oop oop
oopoopoopoopoopoopoop F oop oop
oopoopoopoopoopoopoop F oop oop
```

# Conclusion

github.com/hogoww/Polyphemus/

VMIL Paper preprint

- Tooling at the VM level **was** hard
- Polyphemus eases such tooling
- Zombie Pharo images are now a thing
- Go nuts !

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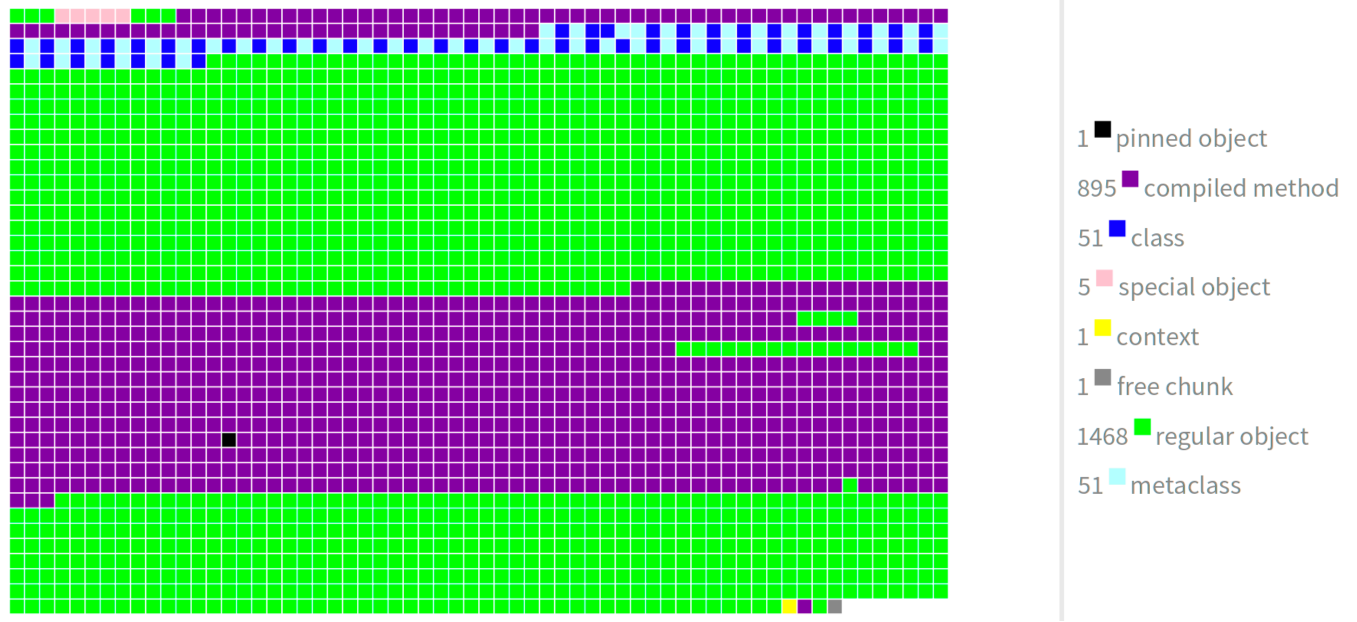
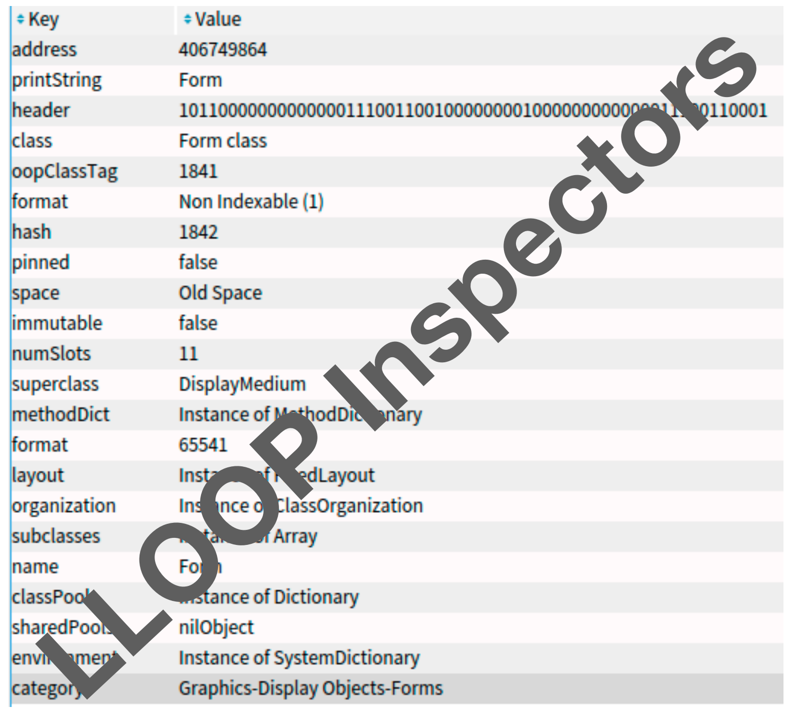
## Visualization



| | |
|---|---|
| 1 ■ | pinned object |
| 895 ■ | compiled method |
| 51 ■ | class |
| 5 ■ | special object |
| 1 ■ | context |
| 1 ■ | free chunk |
| 1468 ■ | regular object |
| 51 ■ | metaclass |



LLOOP Inspectors

| Key | Value |
|---|---|
| address | 406749864 |
| printString | Form |
| header | 1011000000000000011100110010000000010000000000000[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 |