Polymorphism in the Spotlight: Studying Its prevalence in Java and Smalltalk

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```java
public abstract class CompositeFigure
        extends AbstractFigure
        implements FigureChangeListener {

  …

  private void _addToQuadTree(Figure f) {
    if (_theQuadTree != null) {
      // Bugfix: Make sure the rectangle
      // is not zero width or height.
      Rectangle r = f.displayBox();

      …
    }
  }

  …
}
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     }
   }
  …
 }
```
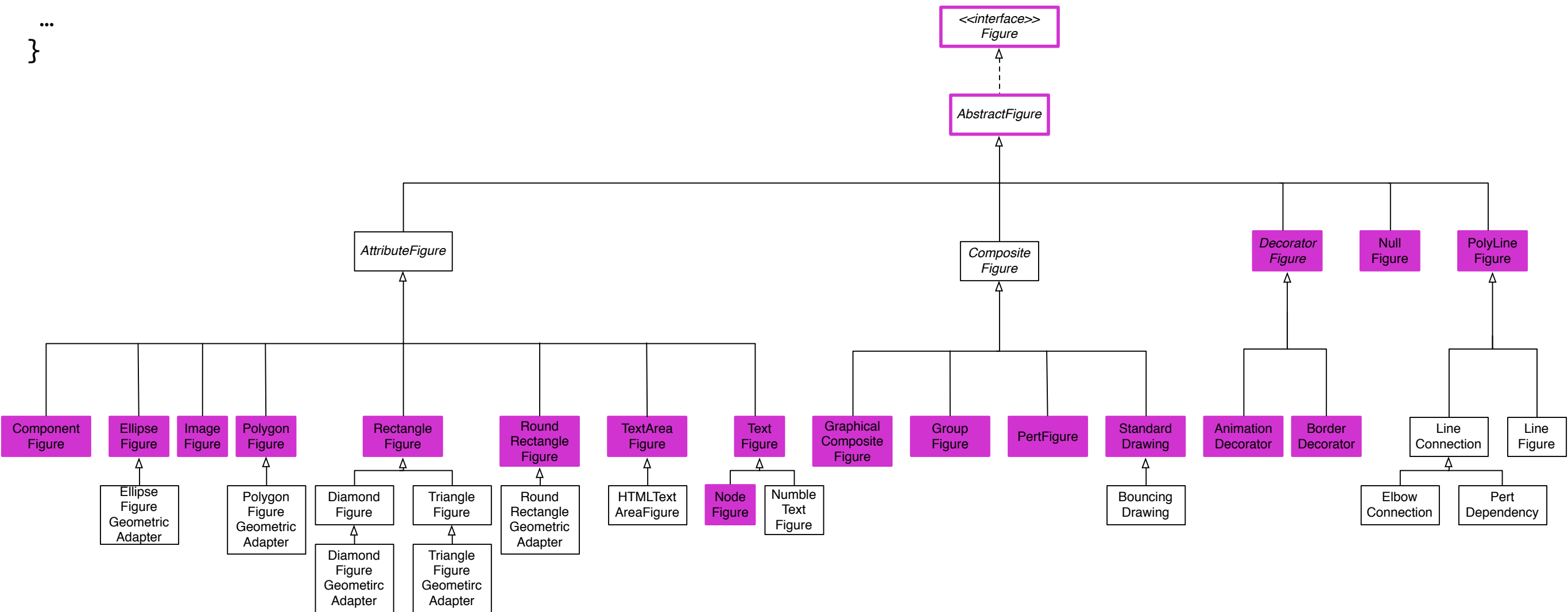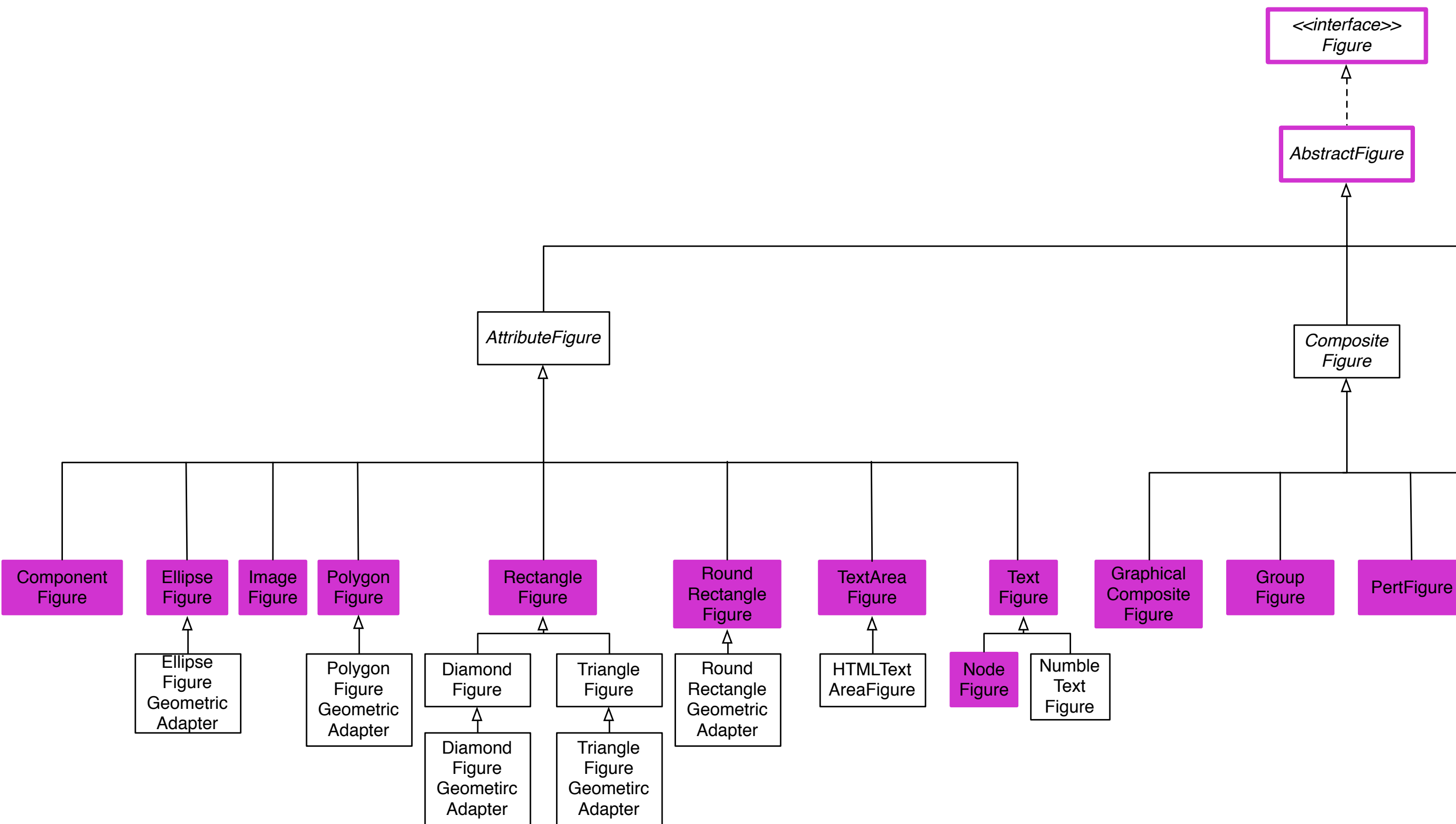
```java
public interface Figure
    extends Storable, Cloneable, Serializable {

 …
 public Rectangle displayBox();

 …
 }
```

```java
public abstract class CompositeFigure
        extends AbstractFigure
        implements FigureChangeListener {
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      …
    }
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…
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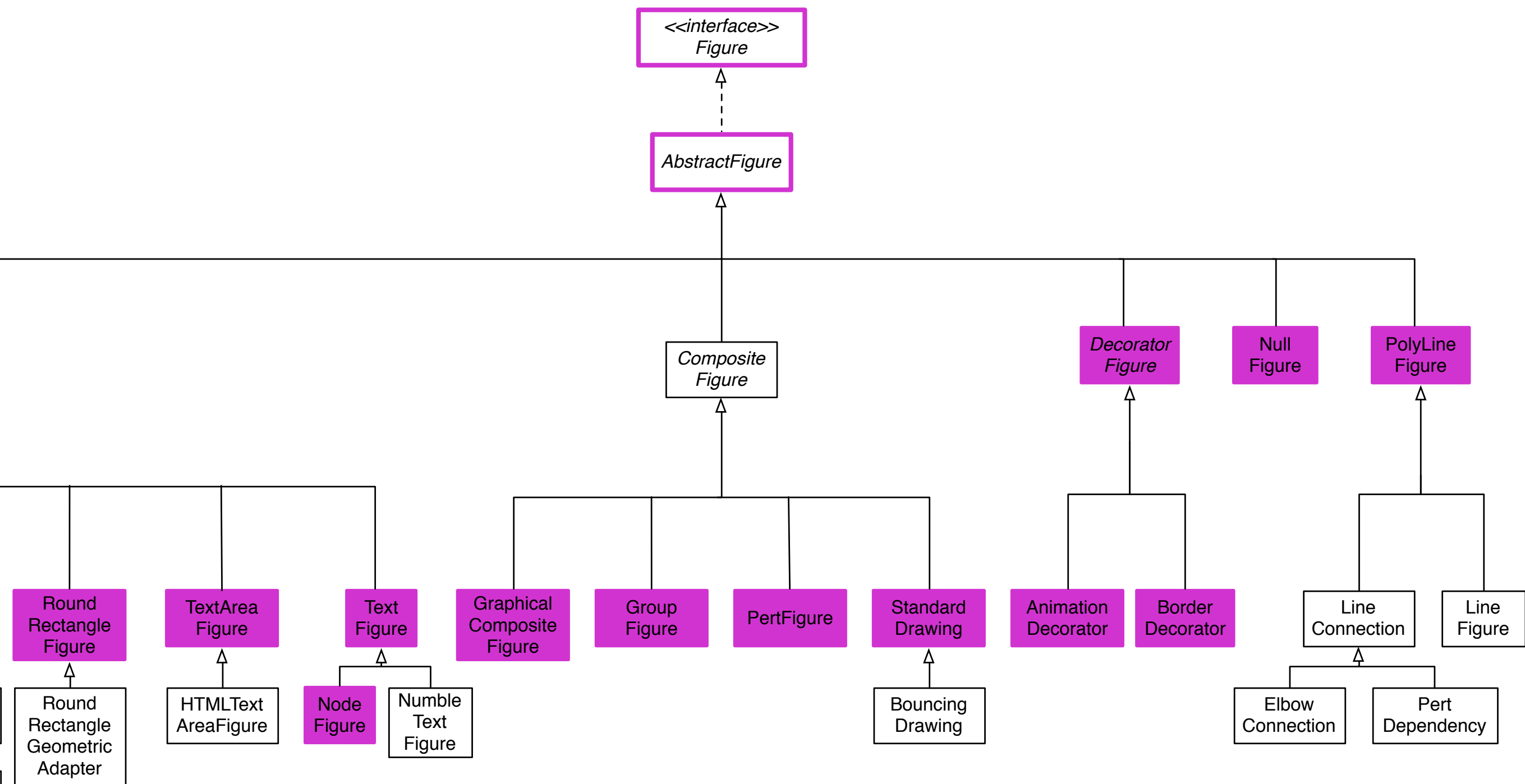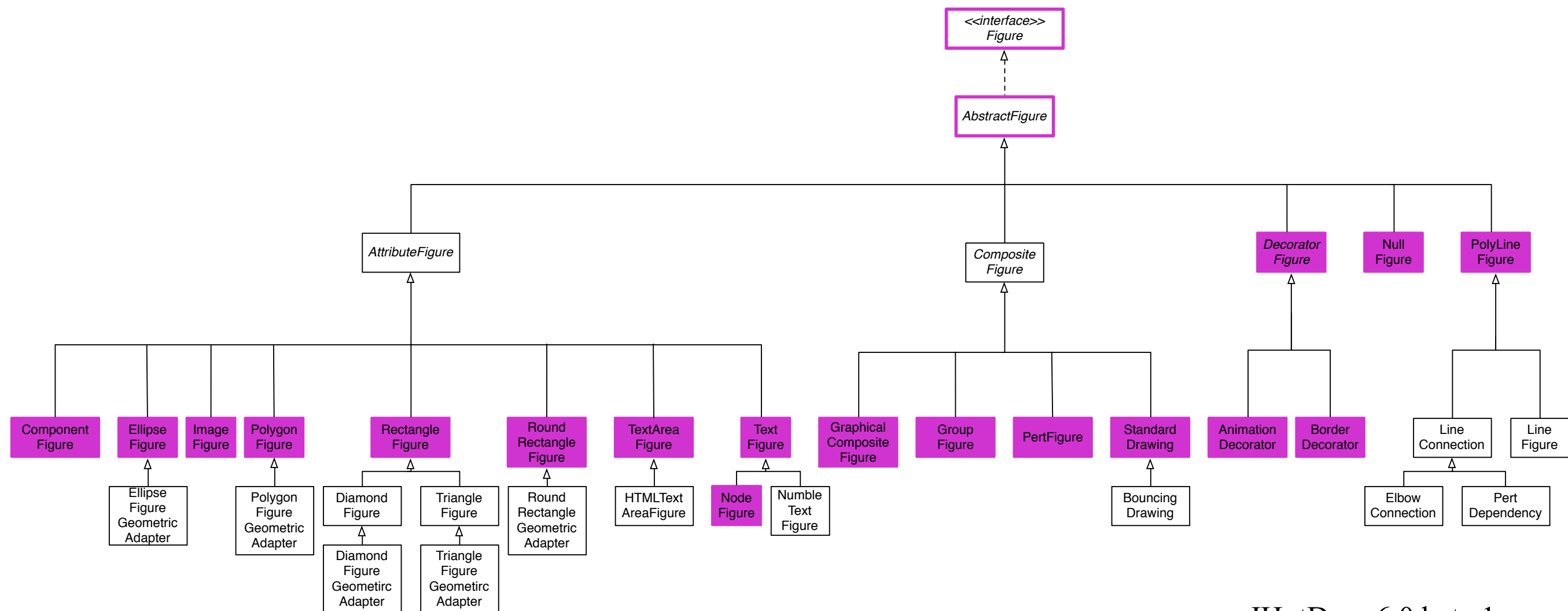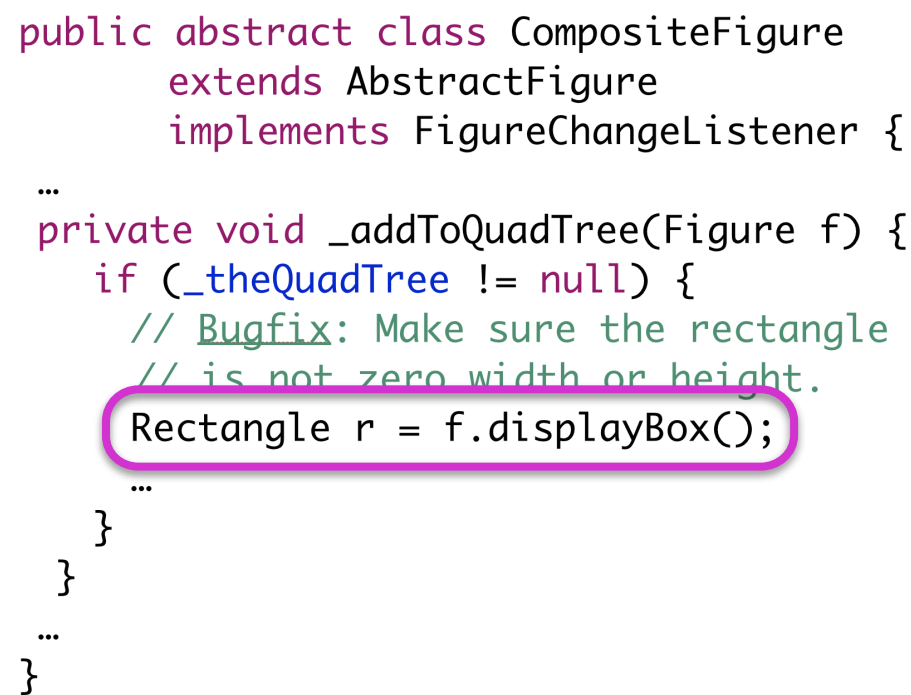
```
<<interface>>
Figure
```
↑
```
AbstractFigure
```
↑

AttributeFigure   **Composite Figure**   **Decorator Figure**   **Null Figure**   **PolyLine Figure**

Component Figure   Ellipse Figure   Image Figure   Polygon Figure   Rectangle Figure   Round Rectangle Figure   TextArea Figure   Text Figure   Graphical Composite Figure   Group Figure   PertFigure   Standard Drawing   Animation Decorator   Border Decorator   Line Connection   Line Figure

Ellipse Figure Geometric Adapter

Polygon Figure Geometric Adapter

Diamond Figure

Triangle Figure

Round Rectangle Geometric Adapter

HTMLText AreaFigure

Node Figure   Numble Text Figure

Bouncing Drawing

Elbow Connection   Pert Dependency

Diamond Figure Geometirc Adapter

Triangle Figure Geometirc Adapter

source: JHotDraw6.0 beta 1
http://www.jhotdraw.org/

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```
                                        ┌─────────────┐
                                        │ <<interface>>│
                                        │   Figure     │
                                        └─────────────┘
                                               △
                                               ┊
                                        ┌─────────────┐
                                        │ AbstractFigure│
                                        └─────────────┘
                                               △
                   ┌───────────────────────────┴───────────────┐
            ┌──────────────┐                            ┌──────────────┐
            │ AttributeFigure│                          │  Composite   │
            └──────────────┘                            │   Figure     │
                   △                                    └──────────────┘
                                                               △
```

| Component Figure | Ellipse Figure | Image Figure | Polygon Figure | Rectangle Figure | Round Rectangle Figure | TextArea Figure | Text Figure | Graphical Composite Figure | Group Figure | PertFigure |

```
                    △                  △              △                      △                △
              ┌───────────┐      ┌───────────┐  ┌──────────┬──────────┐ ┌──────────┐  ┌──────────┐   ┌────────┬────────┐
              │  Ellipse  │      │  Polygon  │  │ Diamond  │ Triangle │ │  Round   │  │ HTMLText │   │  Node  │ Numble │
              │  Figure   │      │  Figure   │  │  Figure  │  Figure  │ │Rectangle │  │AreaFigure│   │ Figure │  Text  │
              │ Geometric │      │ Geometric │  │          │          │ │ Geometric│  │          │   │        │ Figure │
              │  Adapter  │      │  Adapter  │  └──────────┴──────────┘ │  Adapter │  └──────────┘   └────────┴────────┘
              └───────────┘      └───────────┘       △          △      └──────────┘
                                               ┌──────────┐┌──────────┐
                                               │ Diamond  ││ Triangle │
                                               │  Figure  ││  Figure  │
                                               │ Geometirc││ Geometirc│
                                               │  Adapter ││  Adapter │
                                               └──────────┘└──────────┘
```

source: JHotDraw6.0 beta 1
http://www.jhotdraw.org/

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}
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```java
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      // is not zero width or height.
      Rectangle r = f.displayBox();
      …
    }
  }
…
}
```

cs = f.displayBox()

sel(cs) = displayBox()

rec(cs) = Figure

cardinality (cs) = 18

def(cs) = CompositeFigure._addToQuadTree(Figure)

=> isp(cs) = true

=> isp(sel(cs)) = true

source: JHotDraw6.0 beta 1
http://www.jhotdraw.org/

RBMessageNode>>receiver: aValueNode
   receiver := aValueNode.
   receiver parent: self

Implementors of parent: [28]		
ASElement (accessing)	parent:	[Athens-SVG]
BlxState (accessing)	parent:	[BlocX-Core]
DynamixEvent (accessing)	parent:	[Dynamix-Core]
FileListGrid (accessing)	parent:	[Tools]
GLMMorphicSingleSpotter (accessing)	parent:	[Glamour-Morphic-Renderer]
GTMetacellerItemDifference (accessing)	parent:	[GT-Metaceller-Model]
Job (private)	parent:	[Kernel]
MalDisjointSetNode (private-accessing)	parent:	[Moose-Algos-Graph]
MalHgNode (accessing)	parent:	[Moose-Algos-HierarchicalGraph]
MalHgTestModelSimple (accessing)	parent:	[Moose-Tests-Algos-HierarchicalGraph]
MenuRegistration (accessing)	parent:	[MenuRegistration]
MetacelloVersionMethodSection (accessing)	parent:	[Metacello-Core]
MorphTreeNodeMorph (accessing)	parent:	[Morphic-Base]
MTDependency (accessing)	parent:	[Versionner-Core-DependenciesModel]
ObjectExplorerWrapper (accessing)	parent:	[Tools]
PPParserDebuggerResult (accessing)	parent:	[PetitGui]
PragmaMenuAndShortcutRegistration (menu protocol)	parent:	[MenuRegistration]
PragmaMenuAndShortcutRegistrationItem (menu protocol)	parent:	[MenuRegistration]
RBProgramNode (accessing)	parent:	[AST-Core]
RBPatternVariableNode (accessing)	parent:	[AST-Core]
RGElementDefinition (generic parent api)	parent:	[Ring-Core-Kernel]
RTExploraTestTree (accessing)	parent:	[Roassal2]
SettingNode (accessing)	parent:	[System-Settings]
SettingNodeBuilder (public declaration accessing)	parent:	[System-Settings]
SmalltalkScope (accessing)	parent:	[Moose-SmalltalkImporter]
XMLNode (accessing)	parent:	[XML-Parser]
XMLAttribute (accessing)	parent:	[XML-Parser]
ZipEncoderNode (accessing)	parent:	[Compression]

source: AST-Core
http://smalltalkhub.com/mc/Pharo/Pharo30/main

RBMessageNode>>receiver: aValueNode
    receiver := aValueNode.
    receiver parent: self

```
×  –  □            Implementors of parent: [28]                              ▾
```

ASElement (accessing)	parent:	[Athens-SVG]
BlxState (accessing)	parent:	[BlocX-Core]
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ZipEncoderNode (accessing)	parent:	[Compression]

source: AST-Core
http://smalltalkhub.com/mc/Pharo/Pharo30/main

> RBMessageNode>>receiver: aValueNode
>   receiver := aValueNode.
>   receiver parent: self

cs = receiver parent: self

sel(cs) = parent:

rec(cs) = ?

cardinality(cs) = 28

=> isp(cs) = true

=> isp(sel(cs)) = true

def(cs) = RBMessageNode>>receiver:

130 000 classes
1 086 000 methods

125 000 classes
1 637 000 methods

130 000 classes
1 086 000 methods

125 000 classes
1 637 000 methods

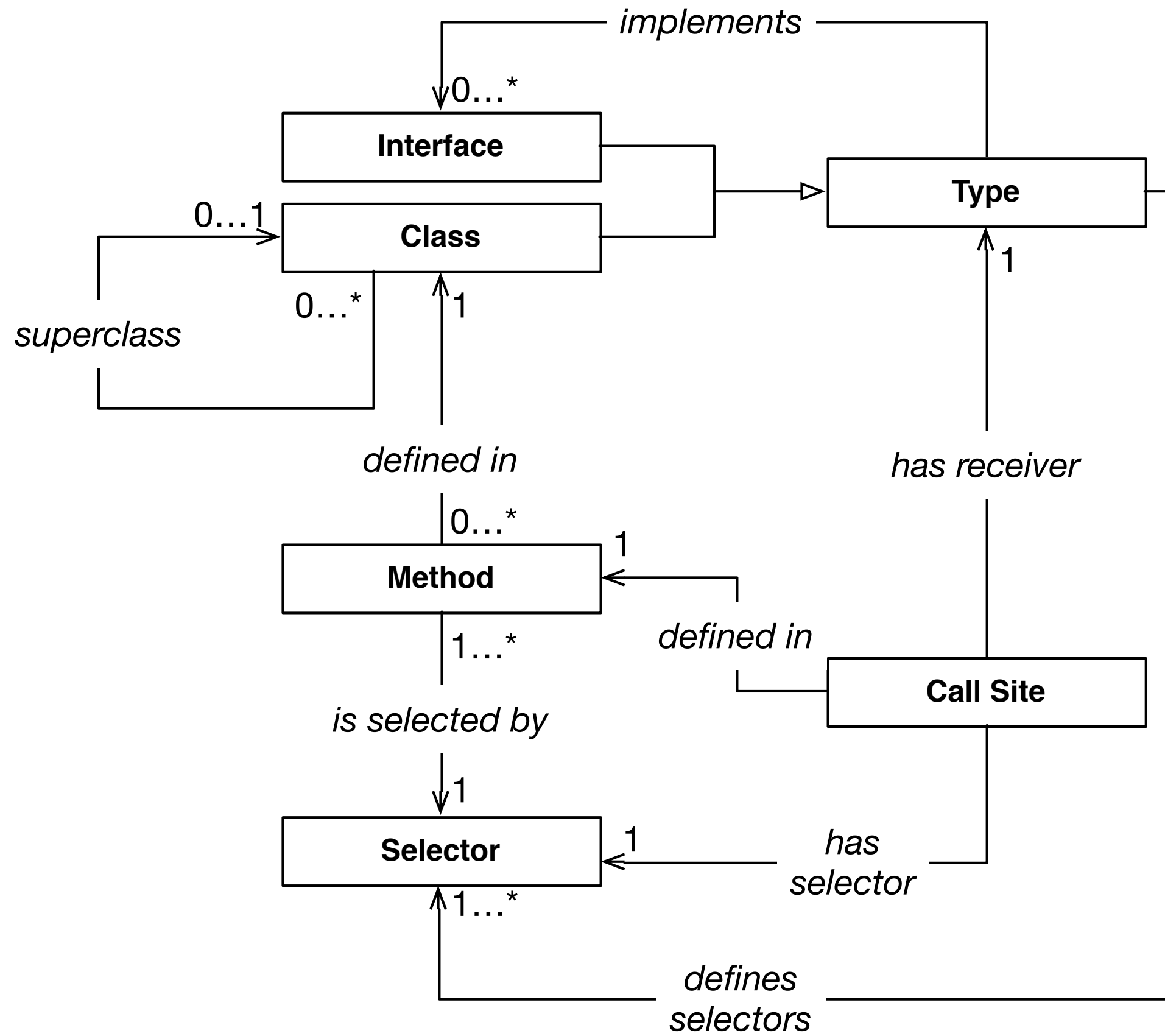|	Java	Smalltalk
% of methods defining polymorphic selectors	24%	31%
% of polymorphic call sites	16%	24%

Cardinality of the Polymorphic Call Sites
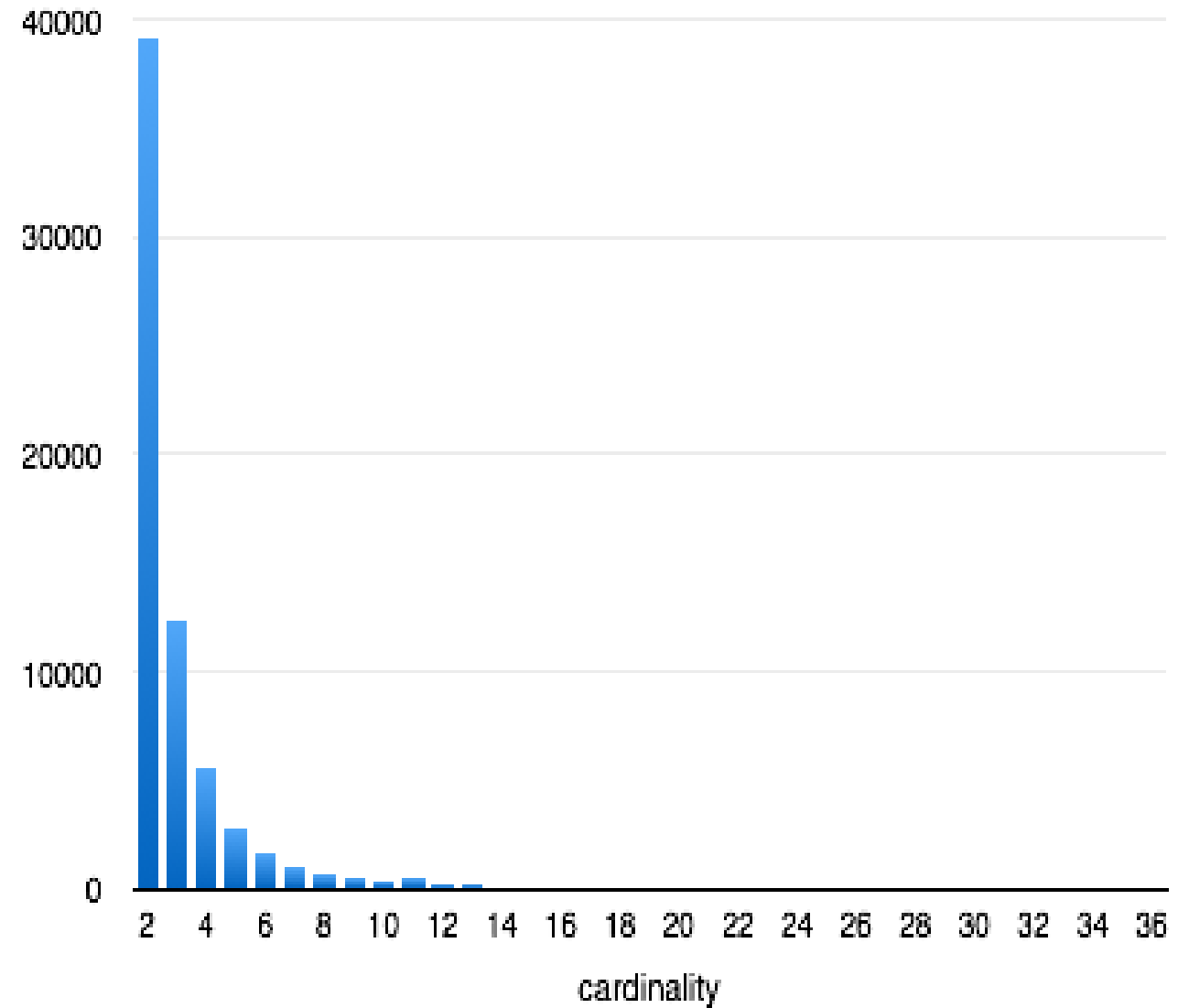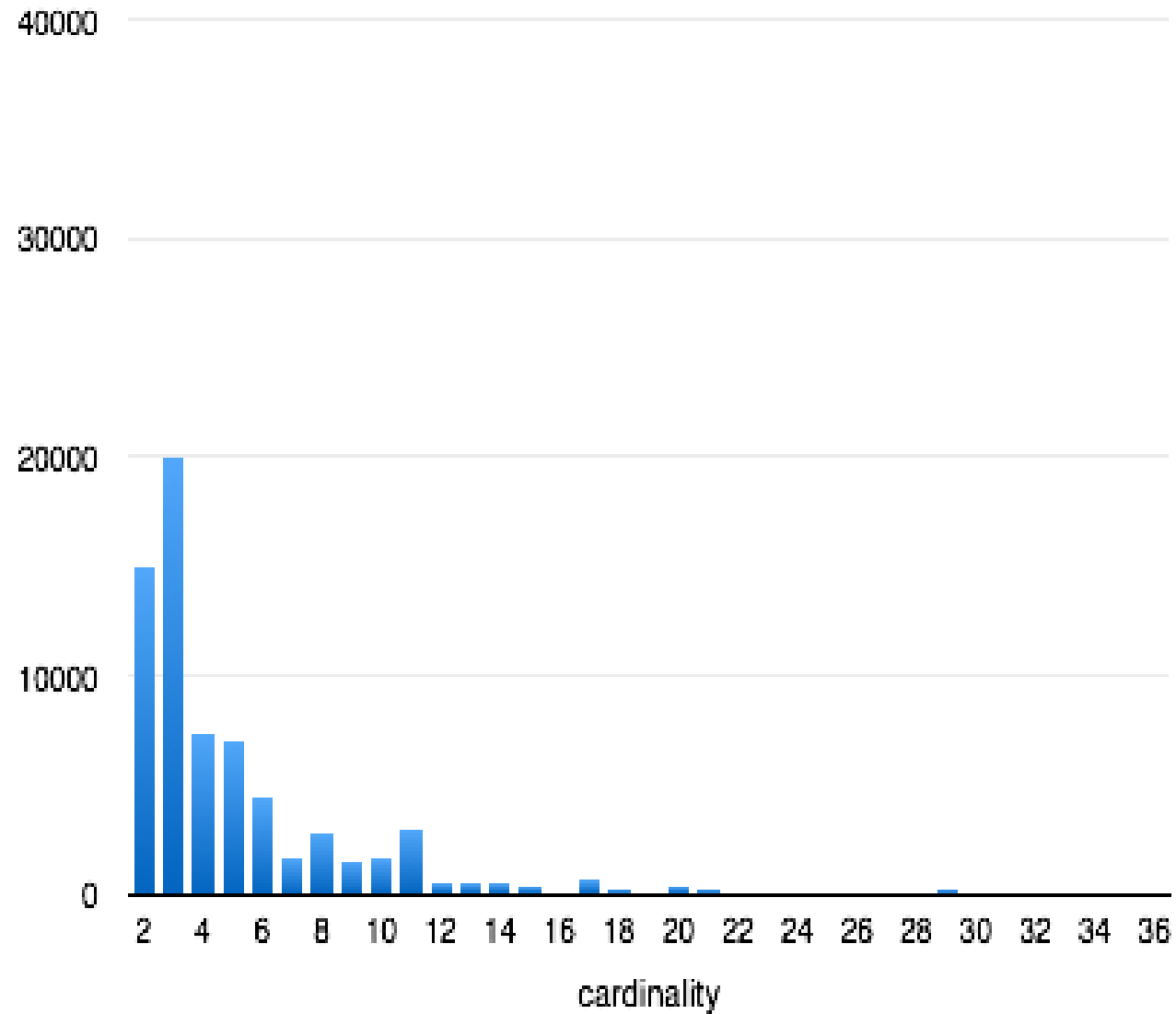
Overview

```
cs = f.displayBox()
sel(cs) = displayBox()
rec(cs) = Figure
cardinality (cs) = 18
```


Defining Polymorphic Selectors	24%	31%
Proportion of Polymorphic Call Sites	16%	24%
cardinality	90% < 12	90% <6

$$subh(t) = \begin{cases} (sup^{-1})^*(t) \cup t, \text{if } t \in C \\ \{(sup^{-1})^*(t'), t' \in t^* \cap C\} \cup t^* \quad (11) \\ \text{where } t^* = t \cup (impl^{-1})^*(t), \text{if } t \in I \end{cases}$$

$$impl(t, s) = \{m \in M | msg(m) = s \wedge$$
$$def_m(m) \in subh(t)\} \quad (12)$$

Smalltalk:

$$undr(c, s) = s \in sel_t(c) \vee undr(sup(c), s) \quad (13)$$

$$intr(s) = \{c \in C | undr(c, s) \wedge \neg undr(sup(c), s)\} \quad (14)$$

$$isp(cs) = (\exists c \in intr(sel(cs)))s.t. \quad (15)$$
$$(|impl(c, sel(cs))| > 1)$$

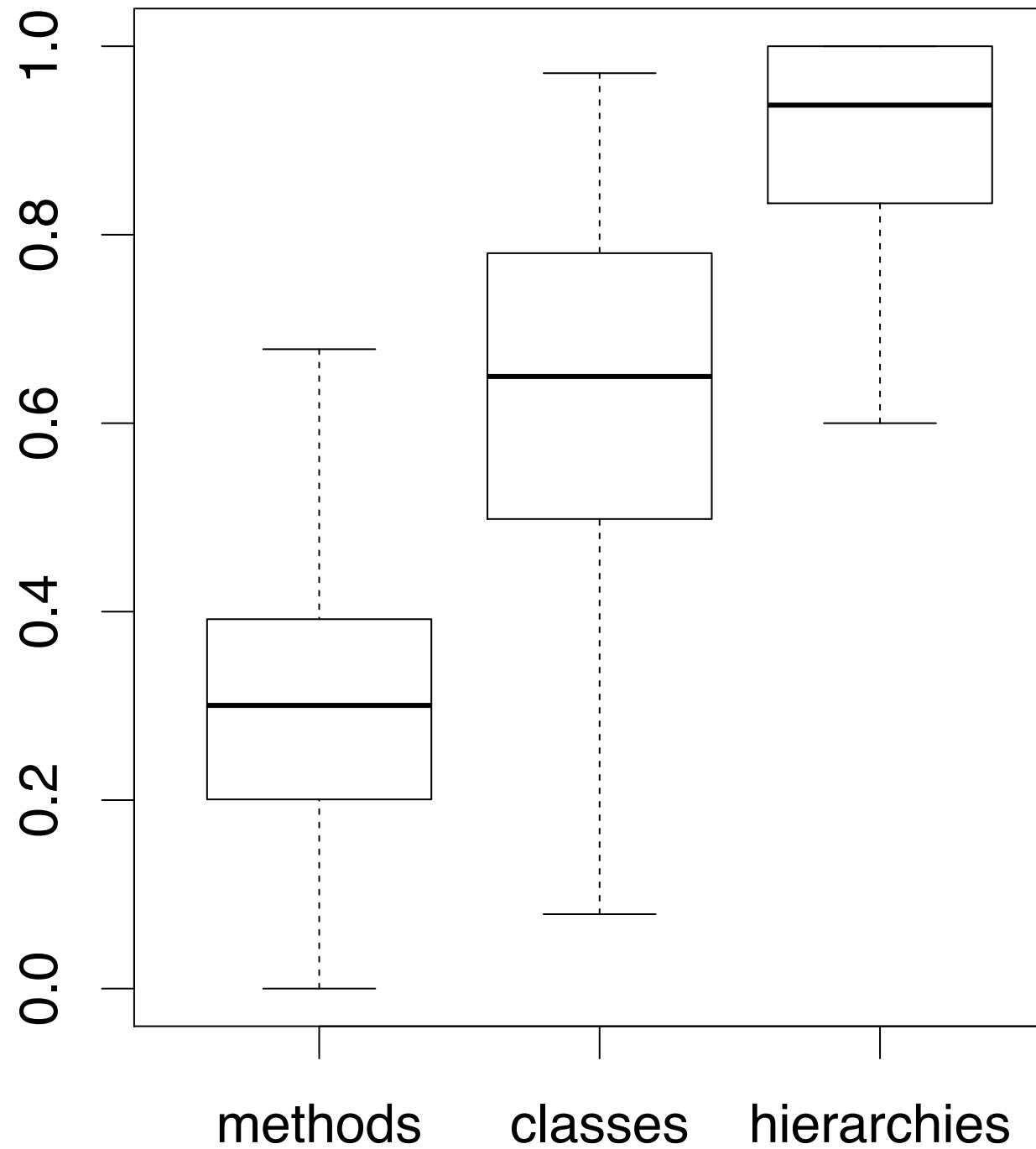$$isp(s) = (\exists c \in intr(s))s.t.(|impl(c, s)| > 1) \quad (16)$$

Java:

$$isp_t(cs) = |impl(t, sel(cs))| > 1 \quad (17)$$

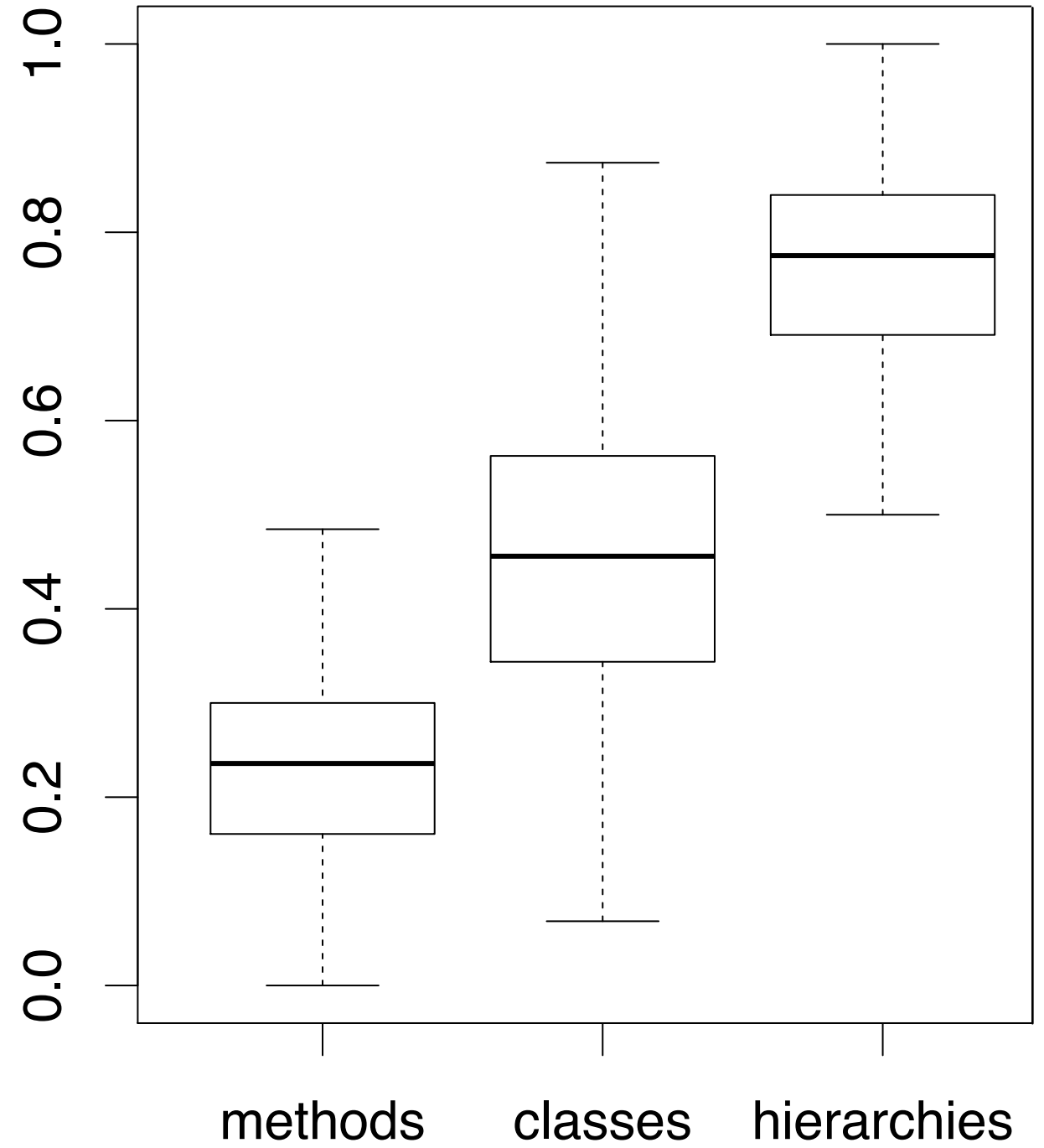$$isp_t(s) = (\exists t \in T)s.t.(|impl(t, s)| > 1) \quad (18)$$

Fig. 5: Computing polymorphic metrics

Defining Polymorphic Selectors

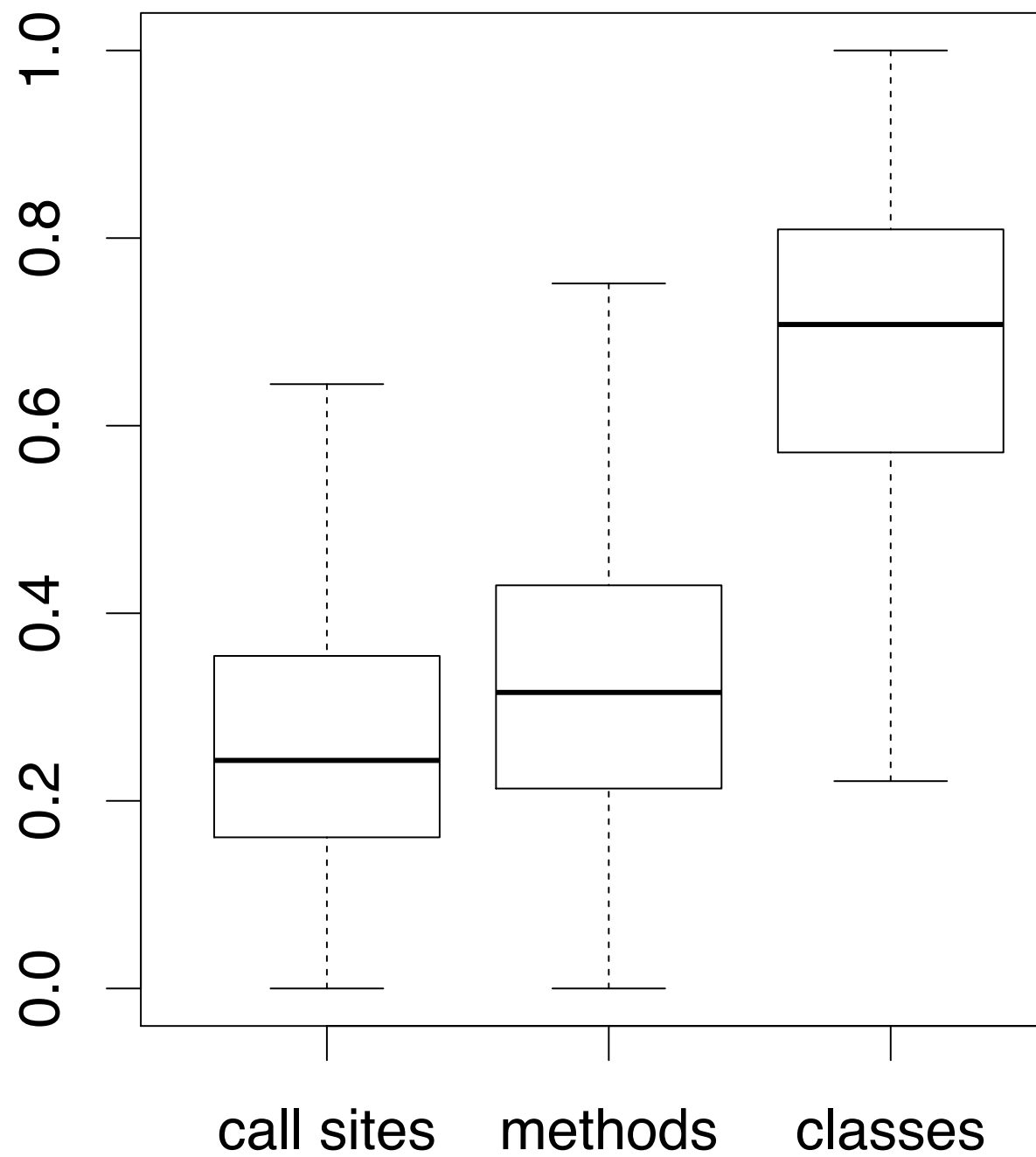Proportion of Polymorphic Call Sites

(a) Smalltalk

(b) Java