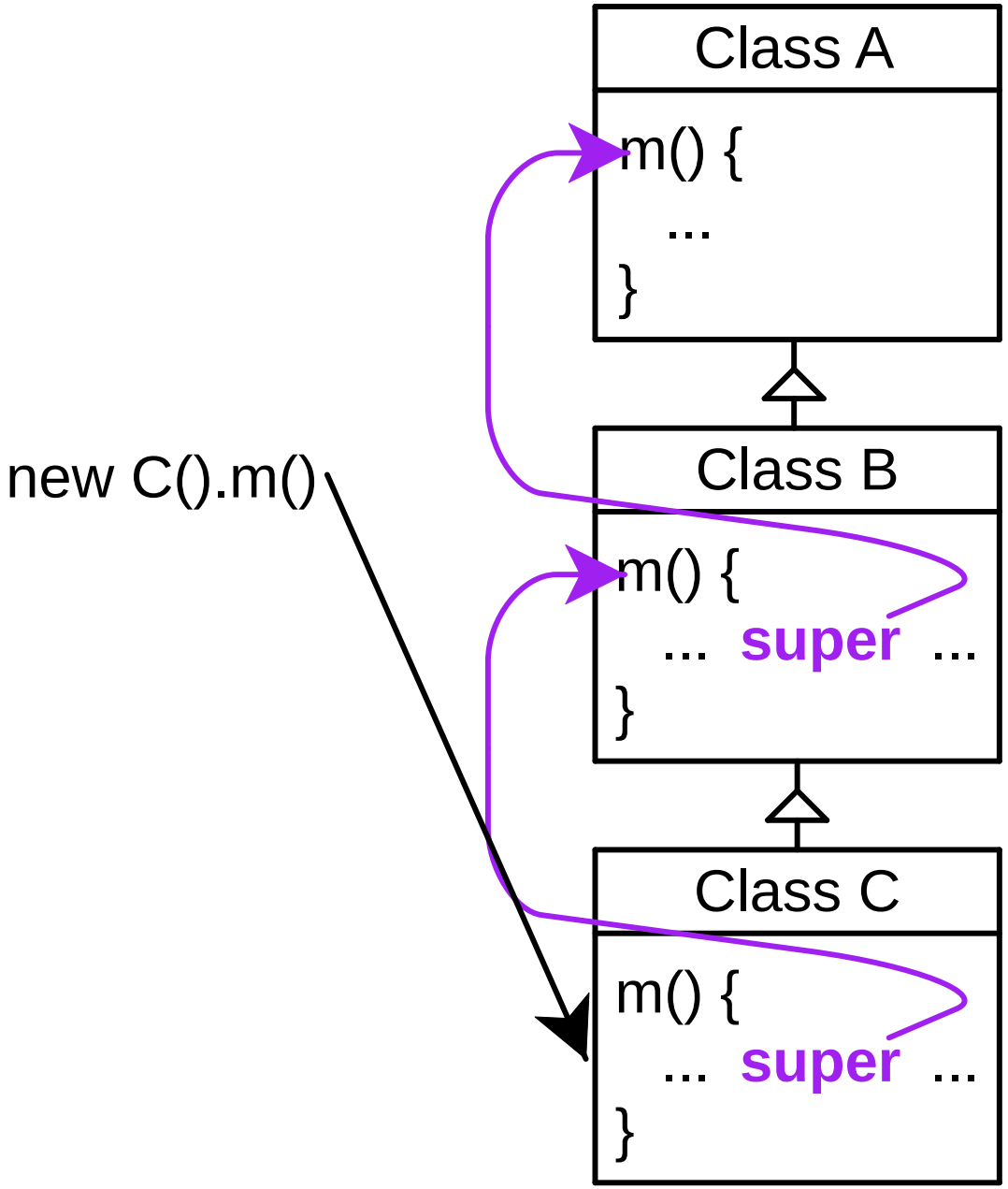
Super and Inner — Together at Last!

David S. Goldberg
University of Utah

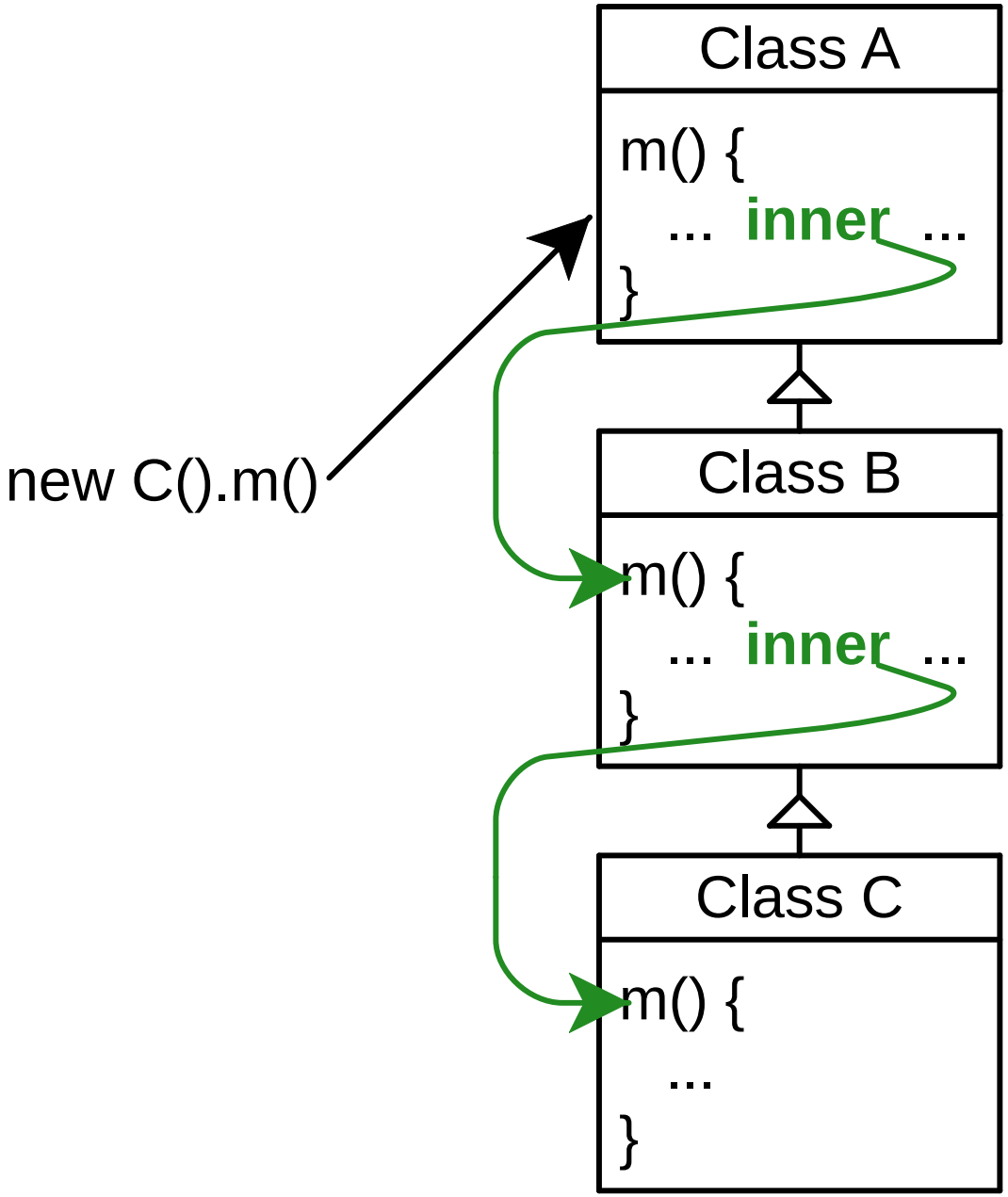
Robert Bruce Findler
University of Chicago

Matthew Flatt
University of Utah

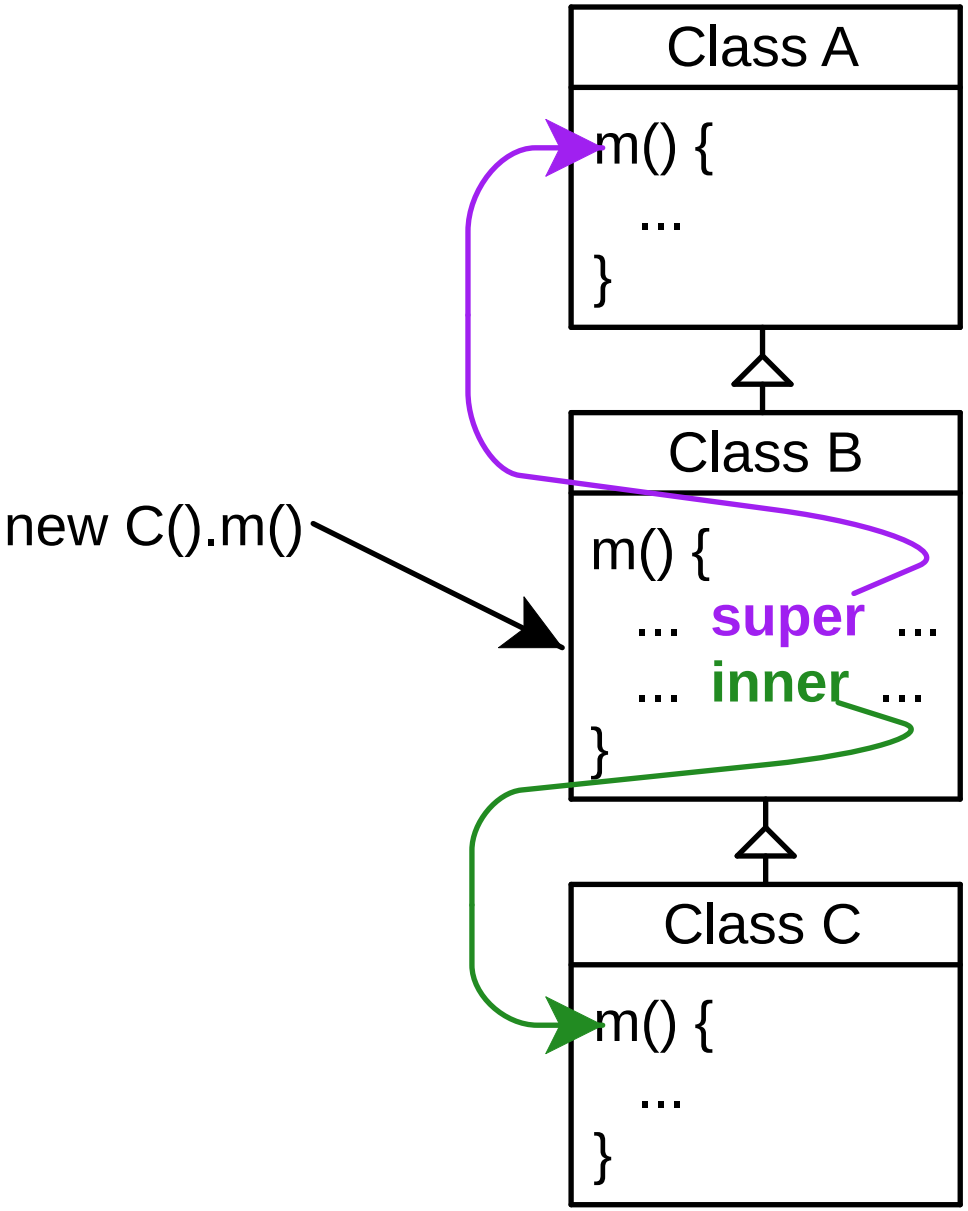
Java-Style Method Overriding



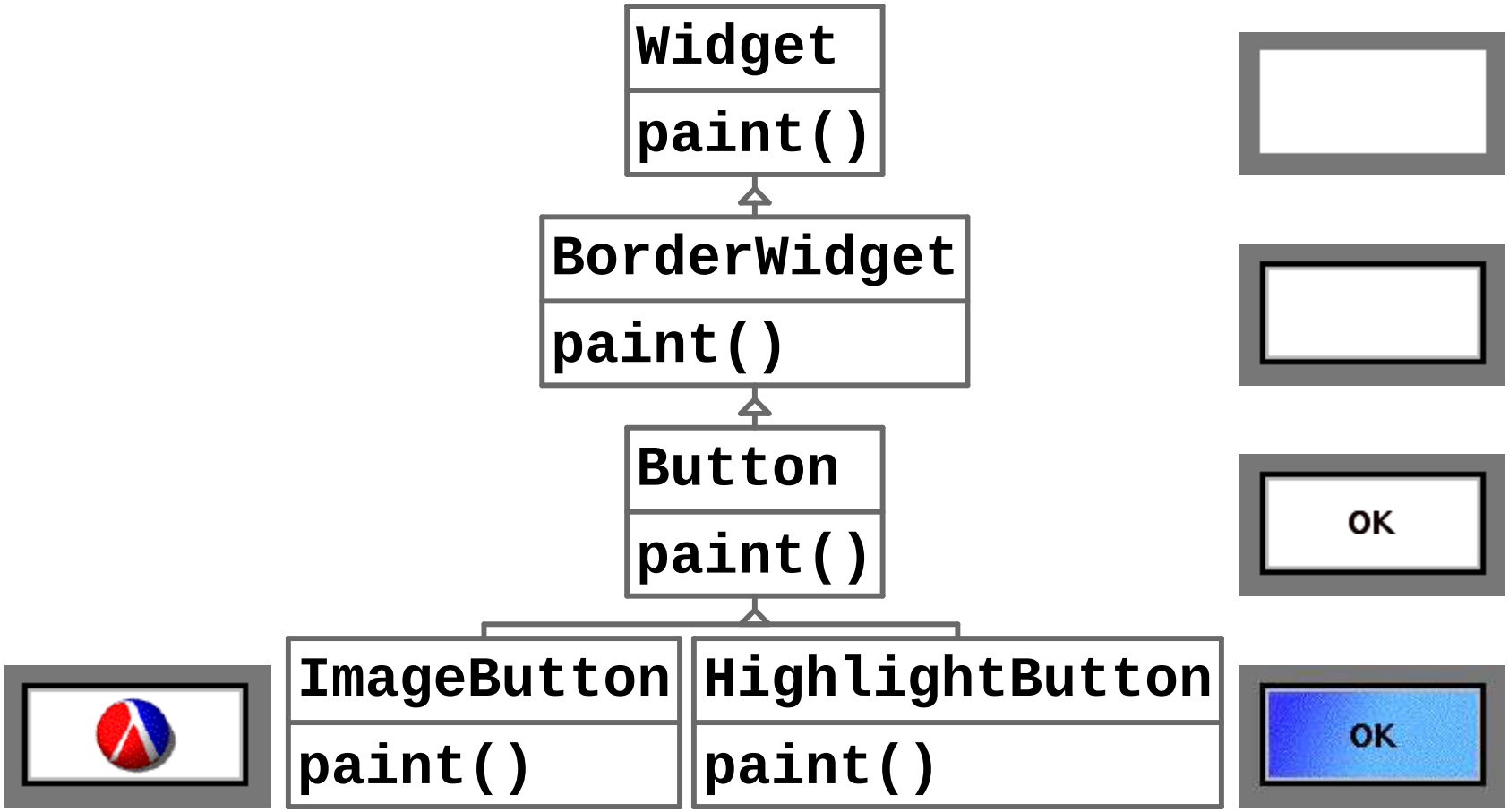
Beta-Style Method Augmentation



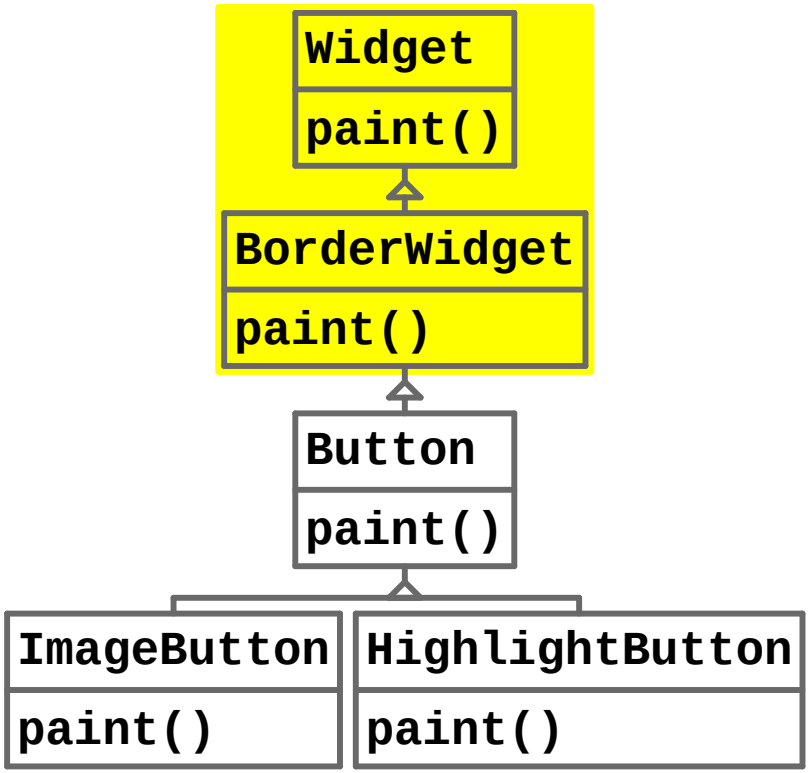
A Combination



Creating a GUI Widget Hierarchy



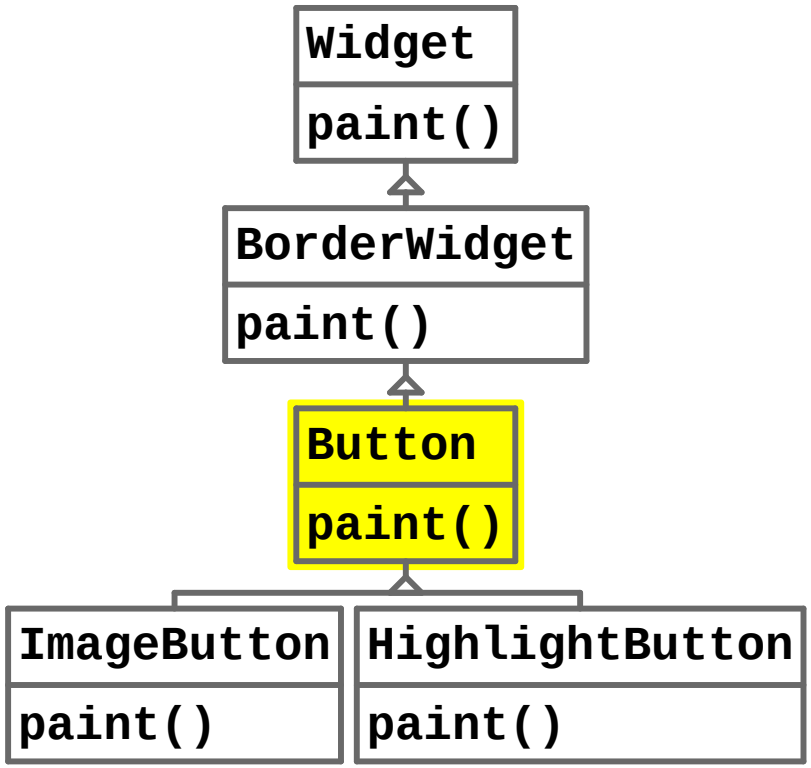
Widget and BorderWidget in Java




```
class Widget ...
  void paint() {
    // paint the background:
    ...;
  }
```

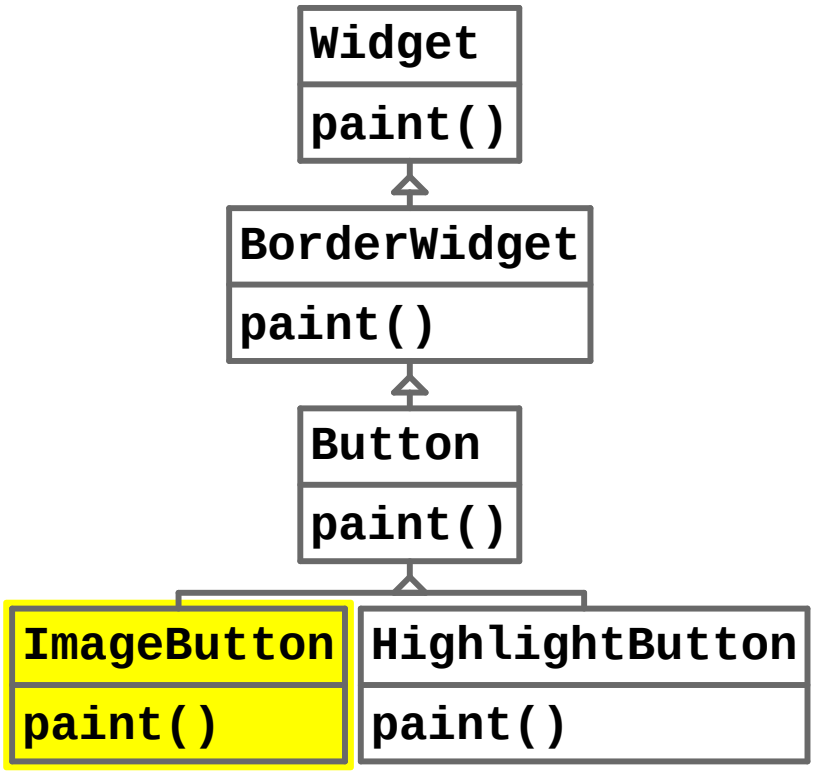
```
class BorderWidget ...
  void paint() {
    // paint background:
    super.paint();
    // draw a border:
    ...;
  }
```

Button in Java



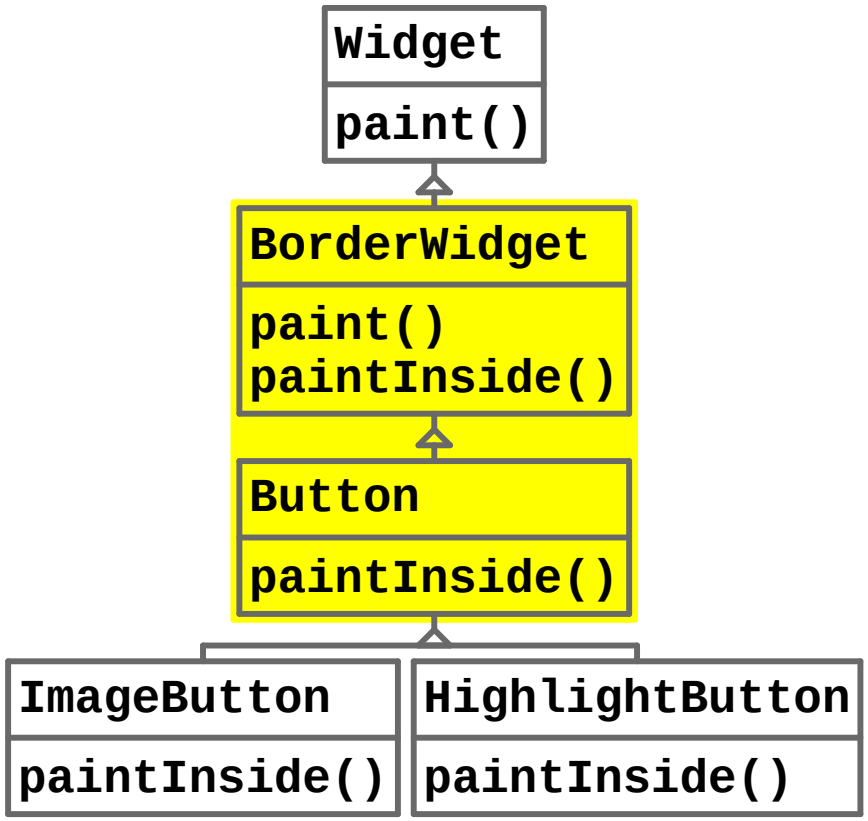

```
class Button ...
  void paint() {
    // paint background, border:
    super.paint();
    // draw a button label:
    ...;
  }
```

ImageButton in Java




```
class ImageButton ...
  void paint() {
    // paints background, border
    // - and label!
    super.paint();
    // draw image
    // must cover label:
    ...;
  }
```

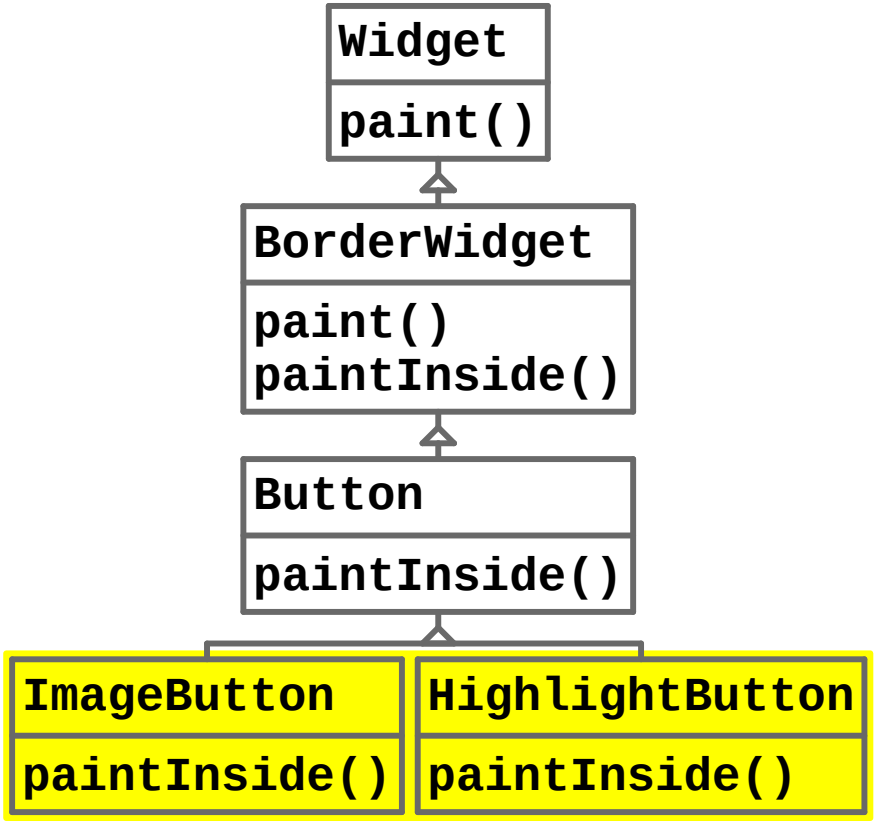
Fixed BorderWidget and Button in Java




```
class BorderWidget ...
  final void paint() {
    // paint background:
    super.paint();
    // paint a border:
    ...;
    paintInside();
  }
  void paintInside() {}
```

```
class Button ...
  void paintInside() {
    // draw label:
    ...;
  }
```

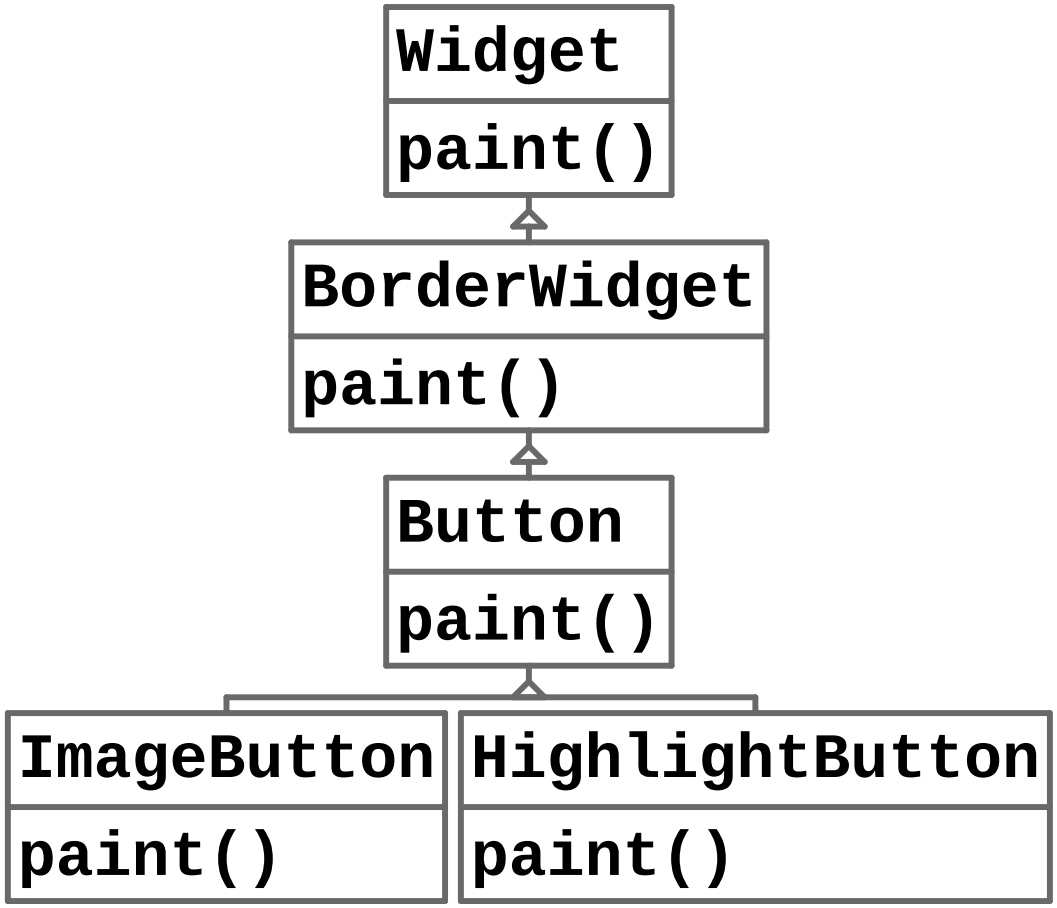
ImageButton and HighlightButton in Java



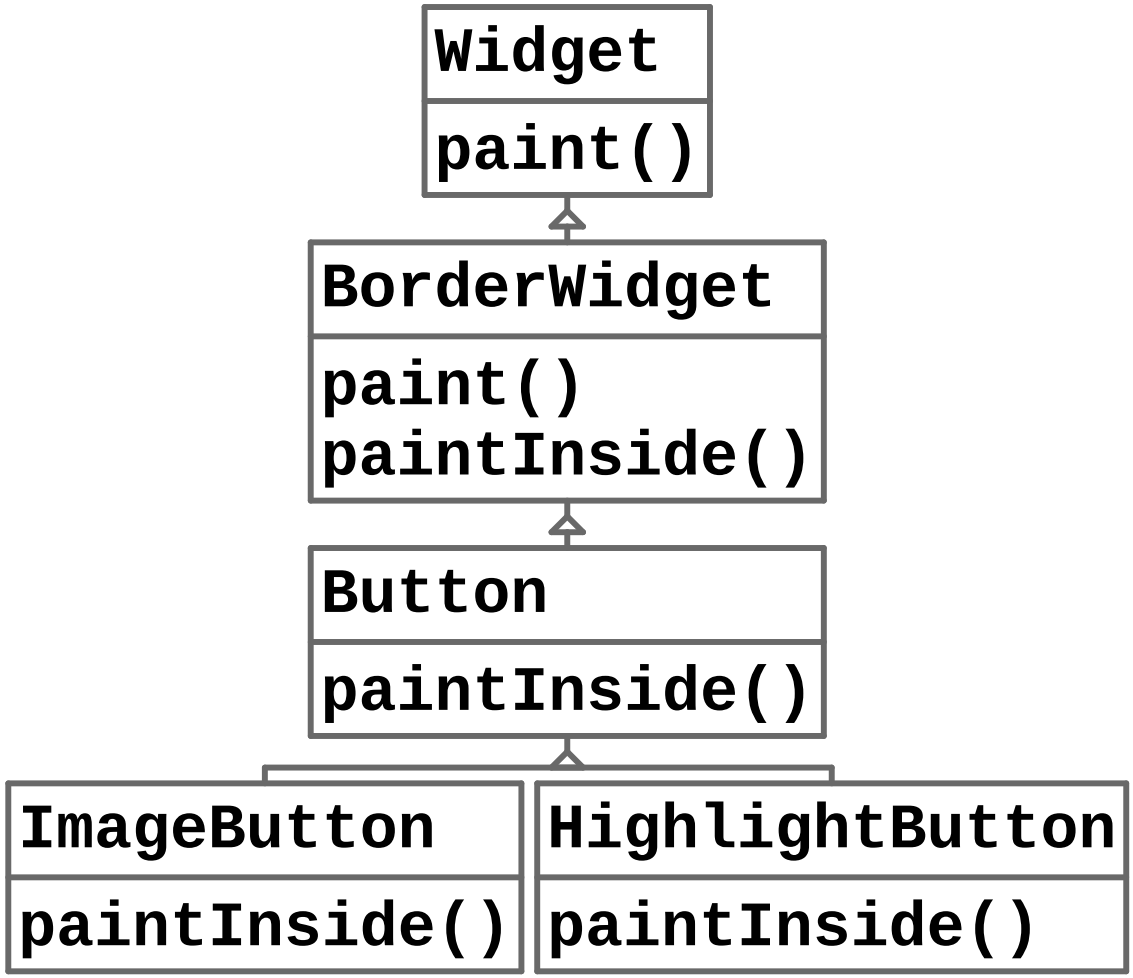

```
class ImageButton ...
  void paintInside() {
    // draws image
    // doesn't call super
    // for label:
    ...;
  }
```

```
class HighlightButton ...
  void paintInside() {
    // replace background with
    // blue gradient:
    ...;
    // draws the label:
    super.paintInside();
  }
```

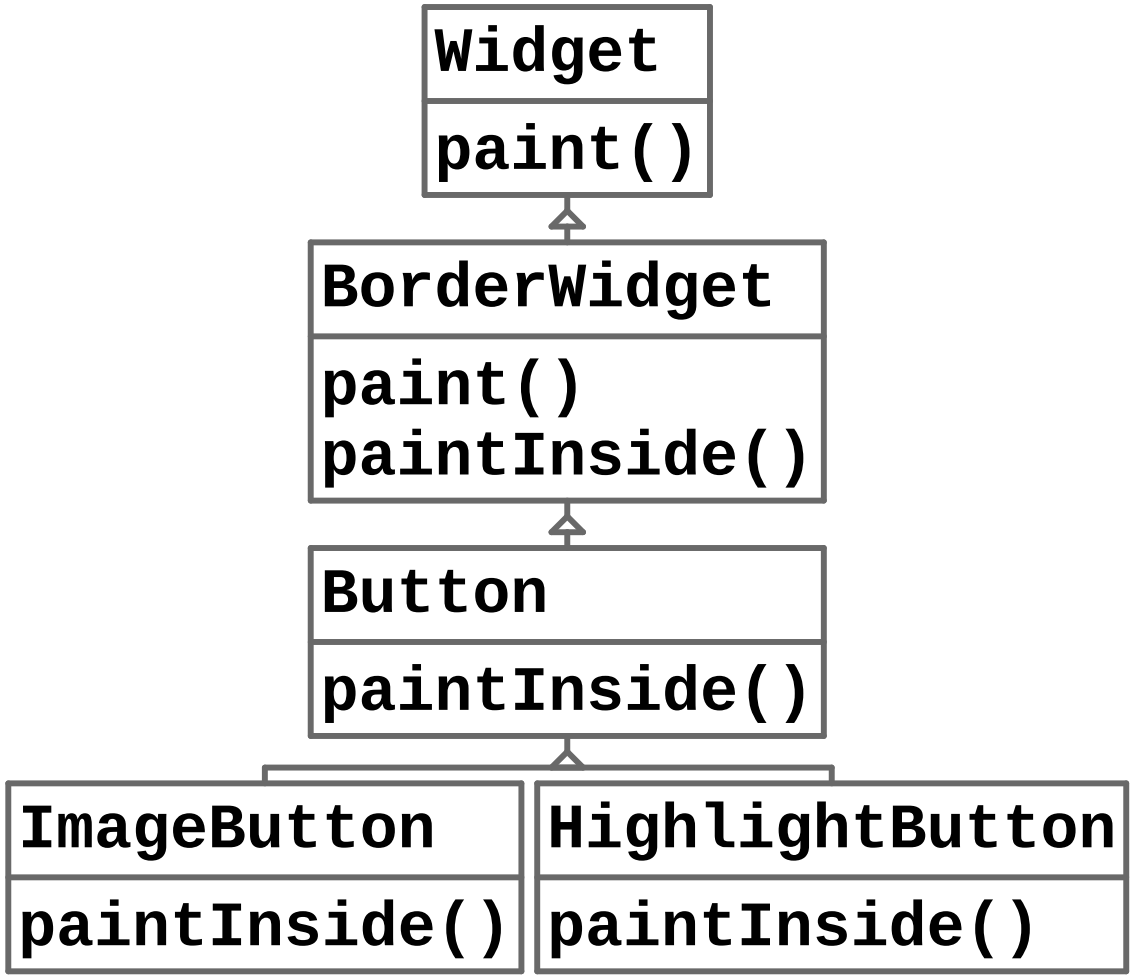
The Problem with Inventing Names



The Problem with Inventing Names

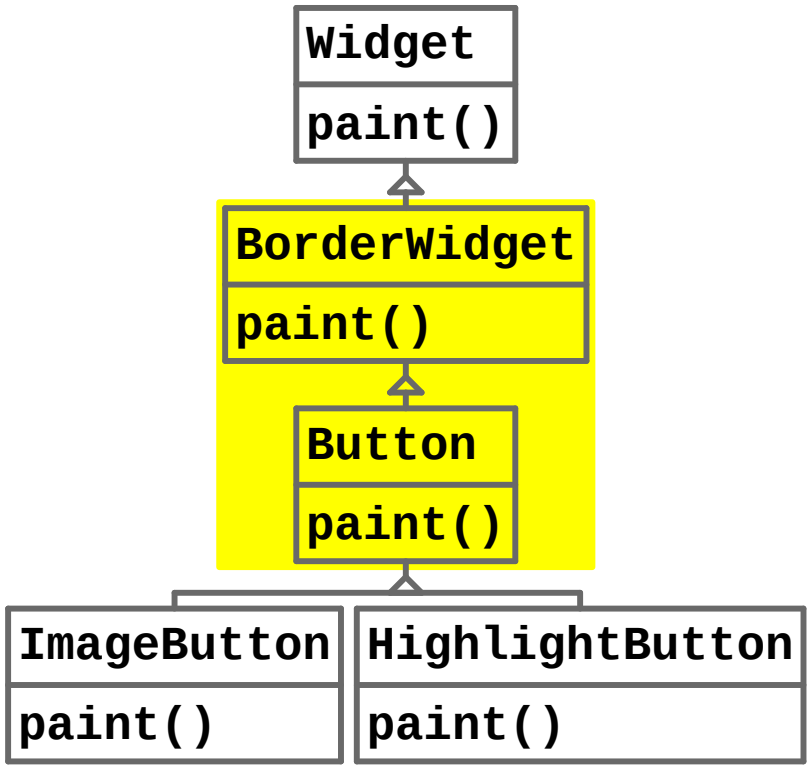


The Problem with Inventing Names



- Other workarounds: Decorators/Delegation, Aspects

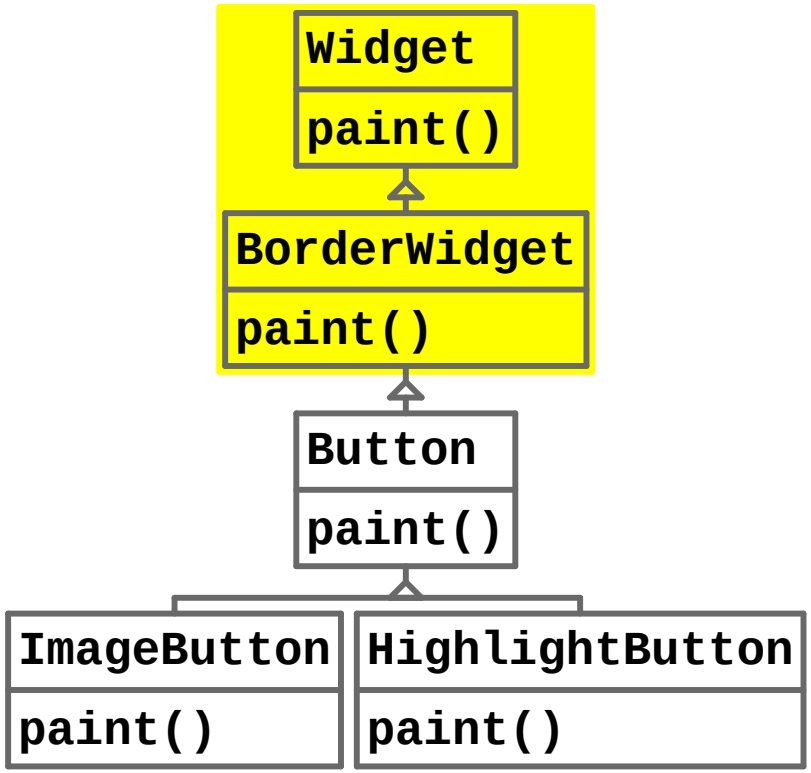
BorderWidget and Button in Beta




```
class BorderWidget ...
  void paint() {
    // draw a border:
    ...;
    inner.paint();
  }
```

```
class Button ...
  void paint() {
    // draw a label:
    ...;
  }
```

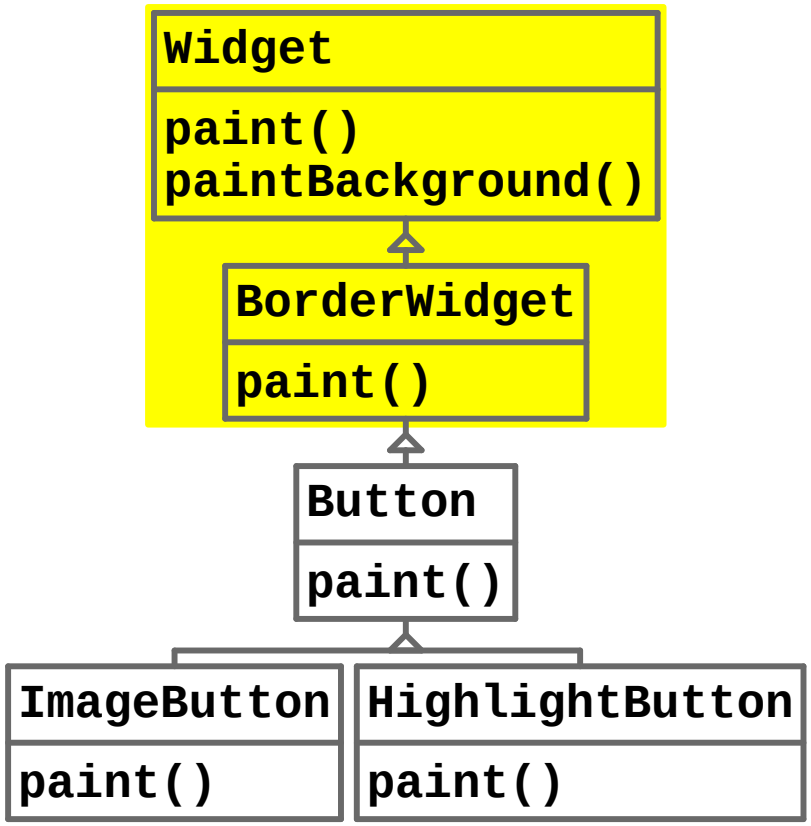
Widget and BorderWidget in Beta




```
class Widget ...
  void paint() {
    // paint the background:
    ...;
    inner.paint();
  }
```

```
class BorderWidget ...
  void paint() {
    // draw a border:
    ...;
    inner.paint();
  }
```

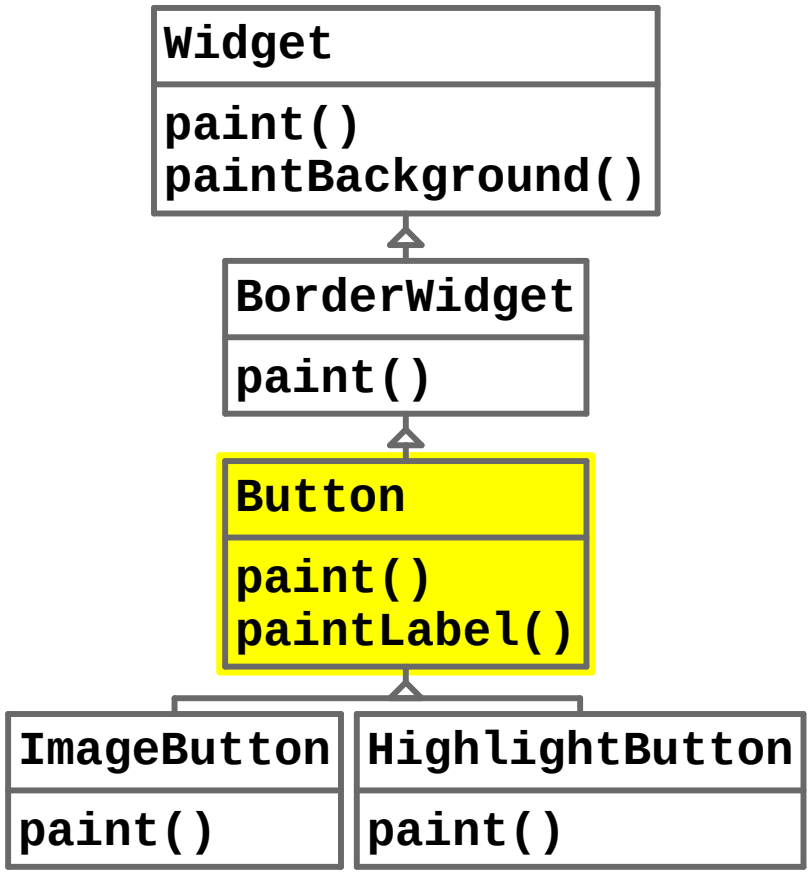
Fixed Widget and BorderWidget in Beta




```
class Widget ...
  void paintBackground() {
    // paint the background:
    ...;
  }
  void paint() {
    inner.paint()
      else paintBackground();
  }
```

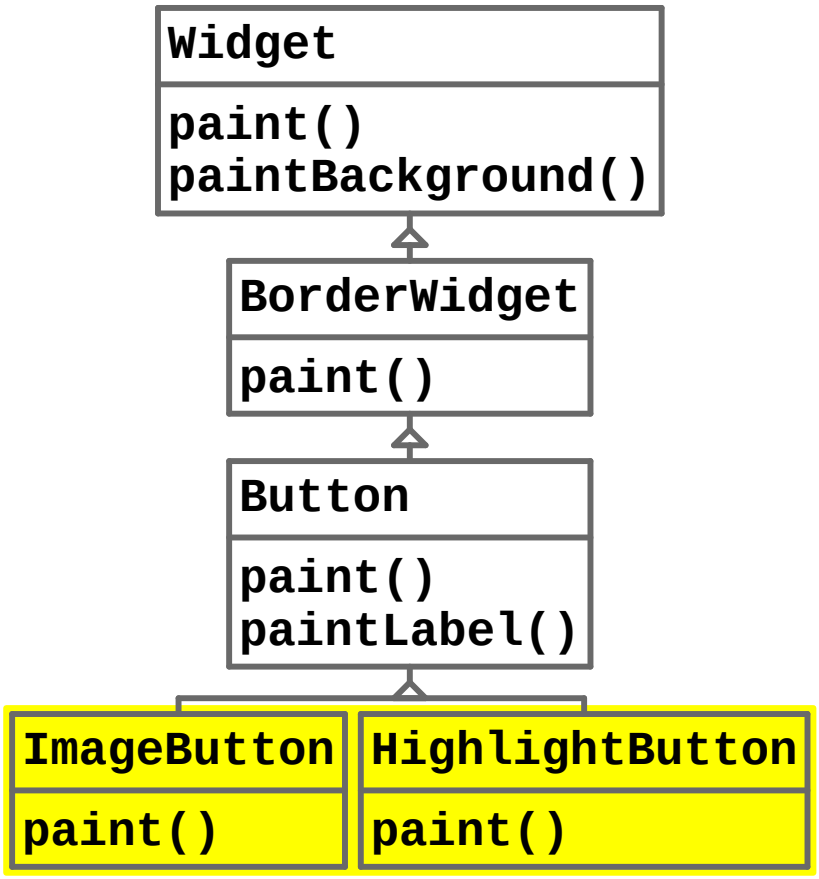
```
class BorderWidget ...
  void paint() {
    paintBackground();
    // draw a border:
    ...;
    inner.paint();
  }
```

Button in Beta




```
class Button ...
  void paintLabel() {
    // draw a button label:
    ...;
  }
  void paint() {
    inner.paint()
      else paintLabel();
  }
```

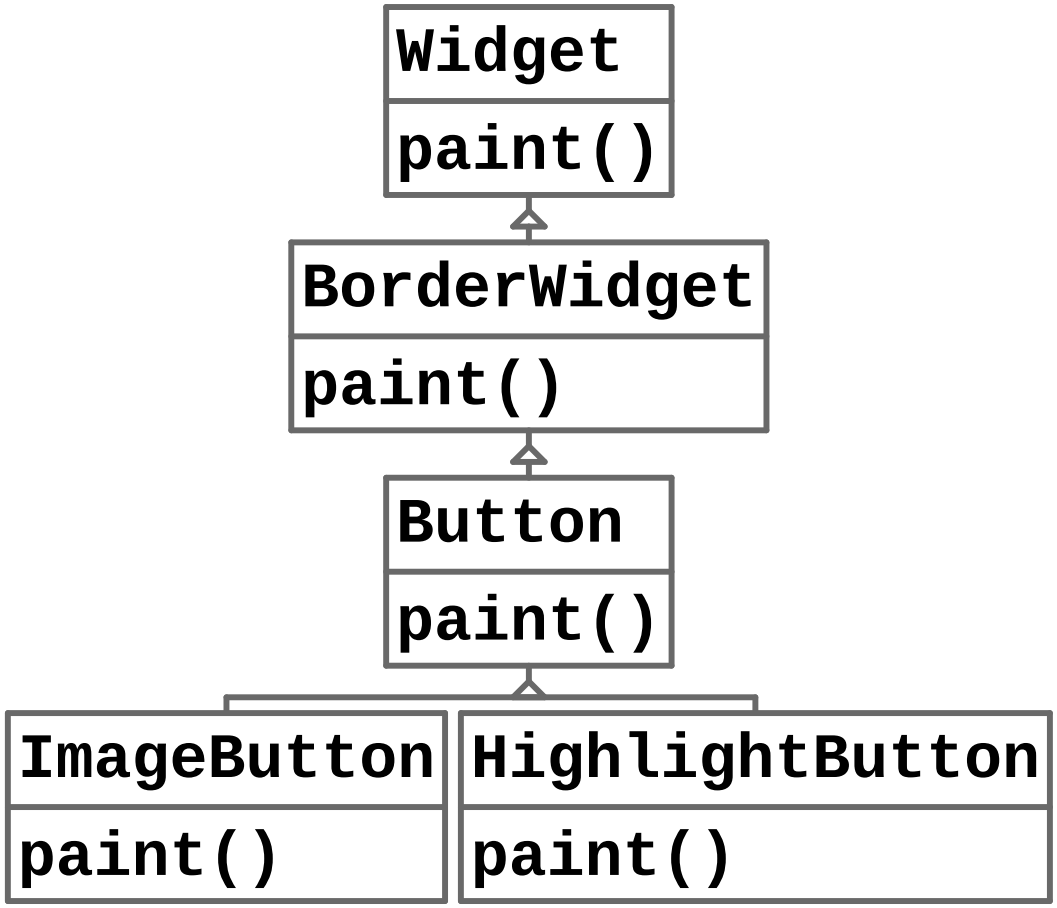
ImageButton and HighlightButton in Beta



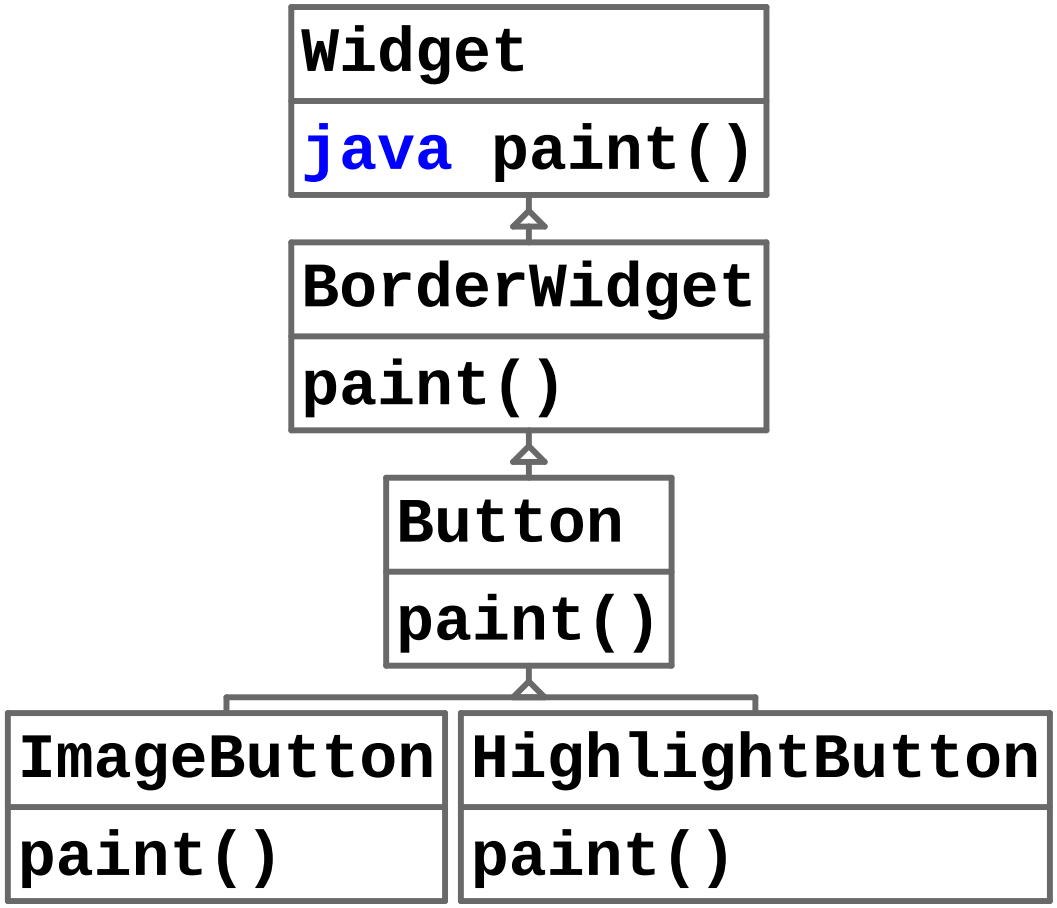

```
class ImageButton ...
  void paint() {
    // draw image
    // (don't call paintLabel):
    ...;
  }
```

```
class HighlightButton ...
  void paint() {
    // replace background with
    // blue gradient:
    ...;
    paintLabel(); // draws label
  }
}
```

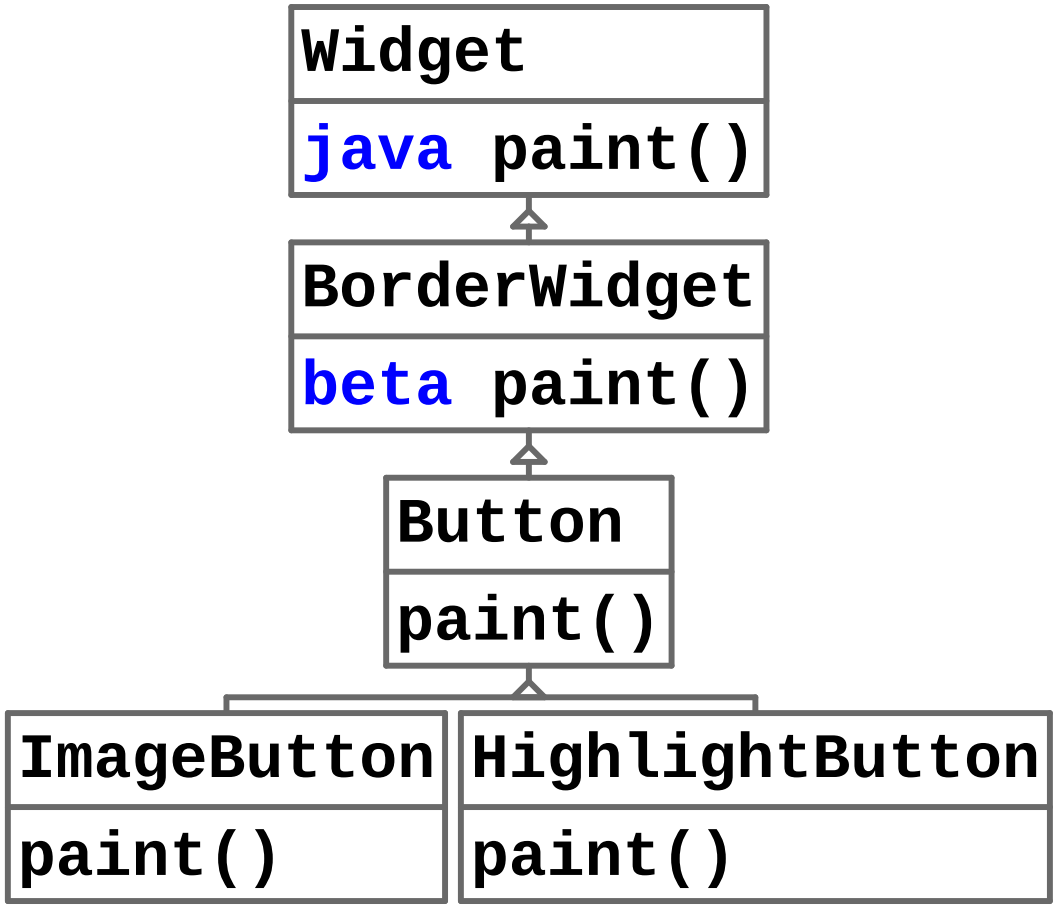
Combining Beta and Java Styles



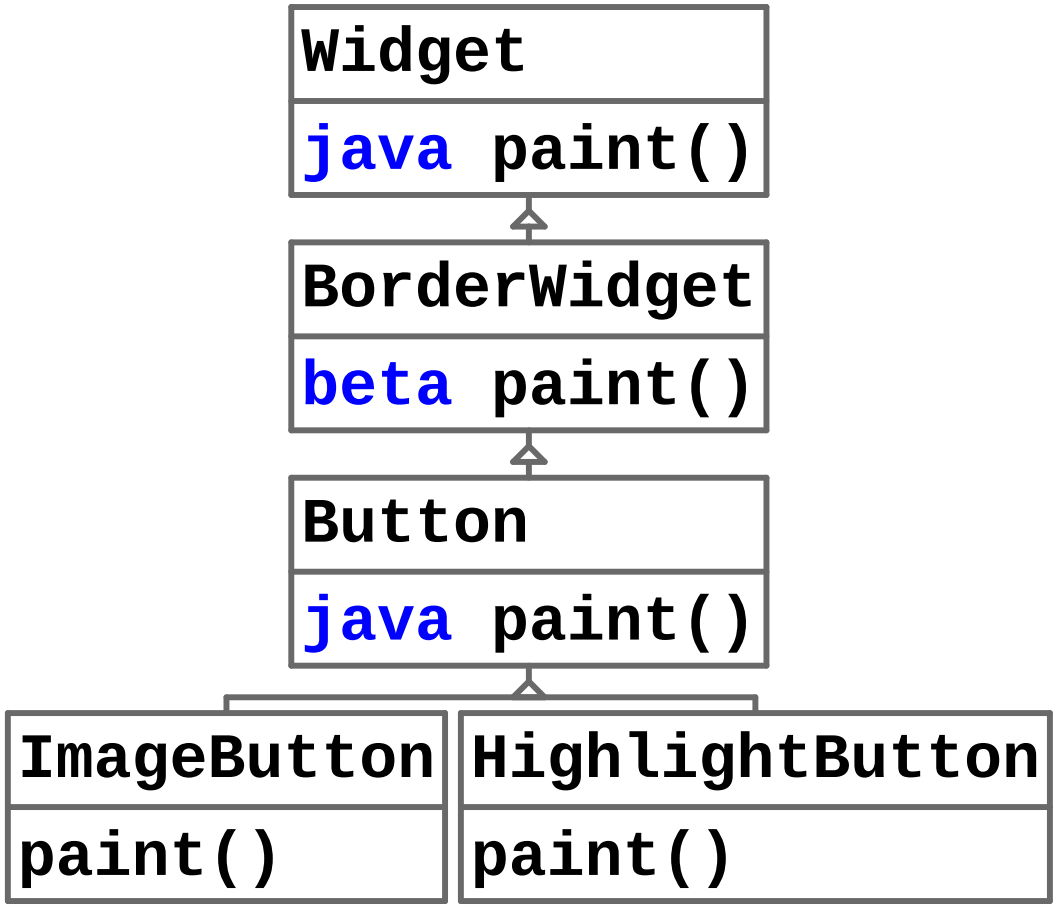
Combining Beta and Java Styles



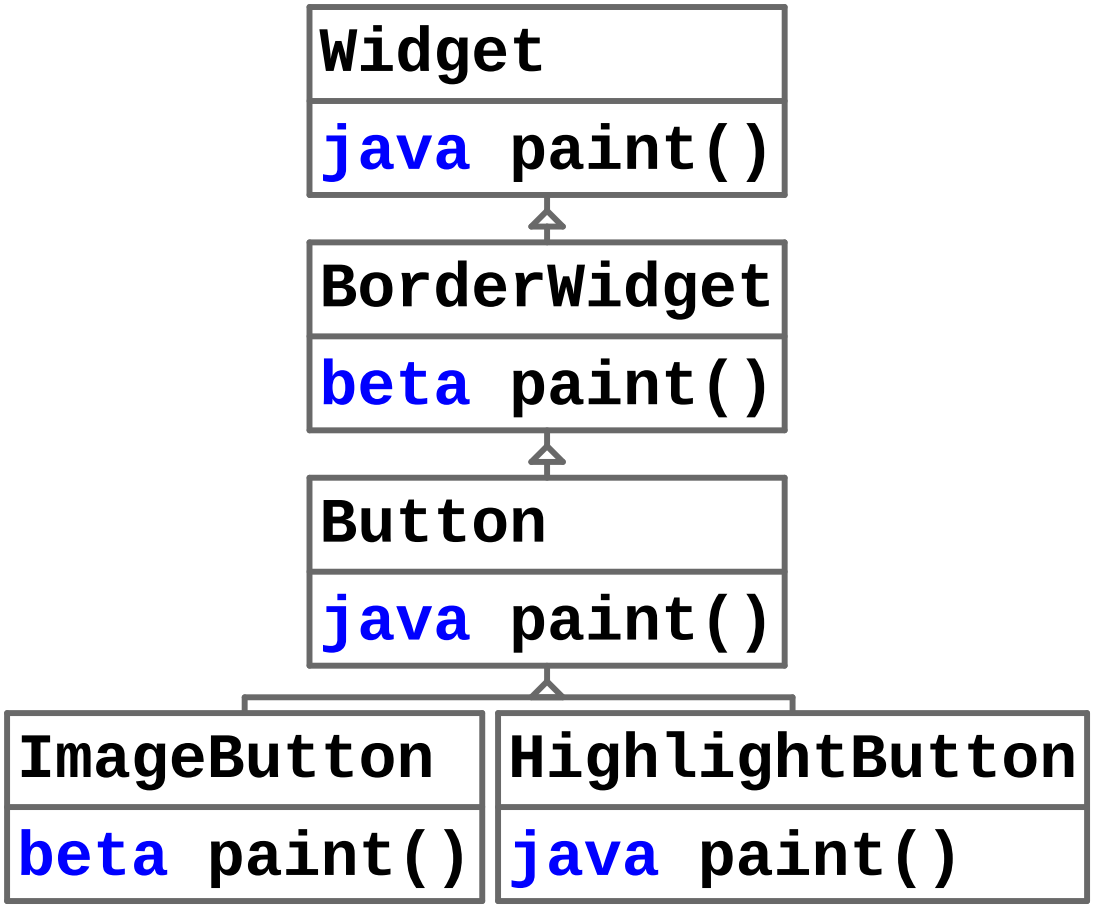
Combining Beta and Java Styles



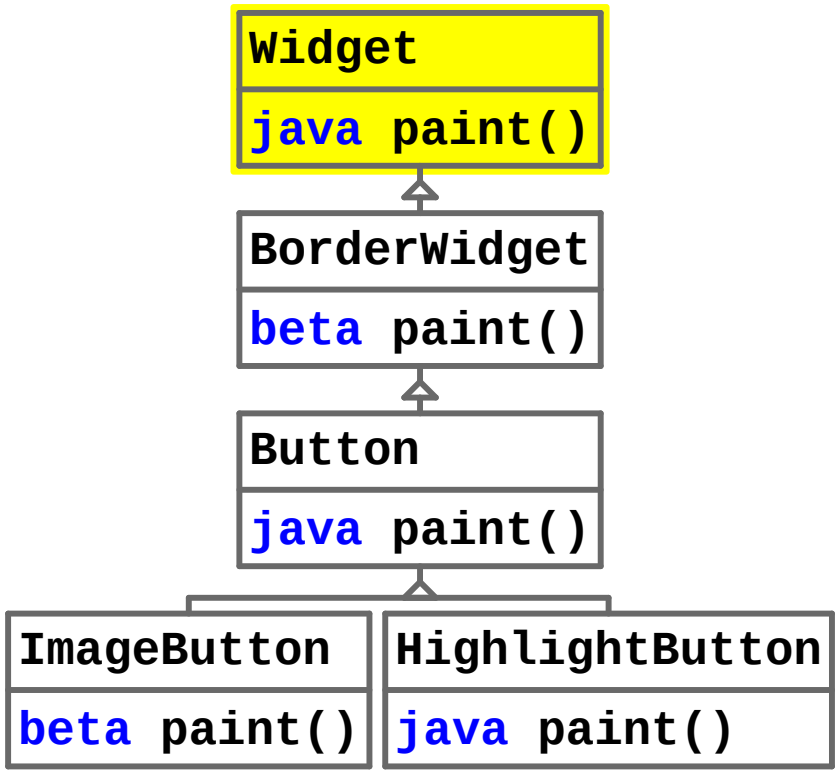
Combining Beta and Java Styles



Combining Beta and Java Styles

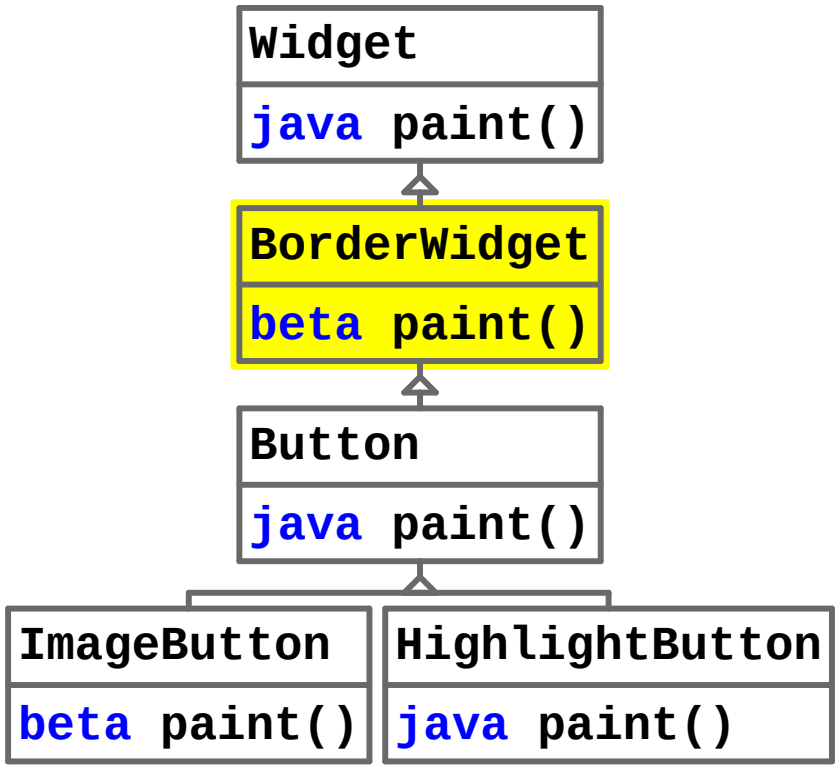


Code for Beta/Java Combination



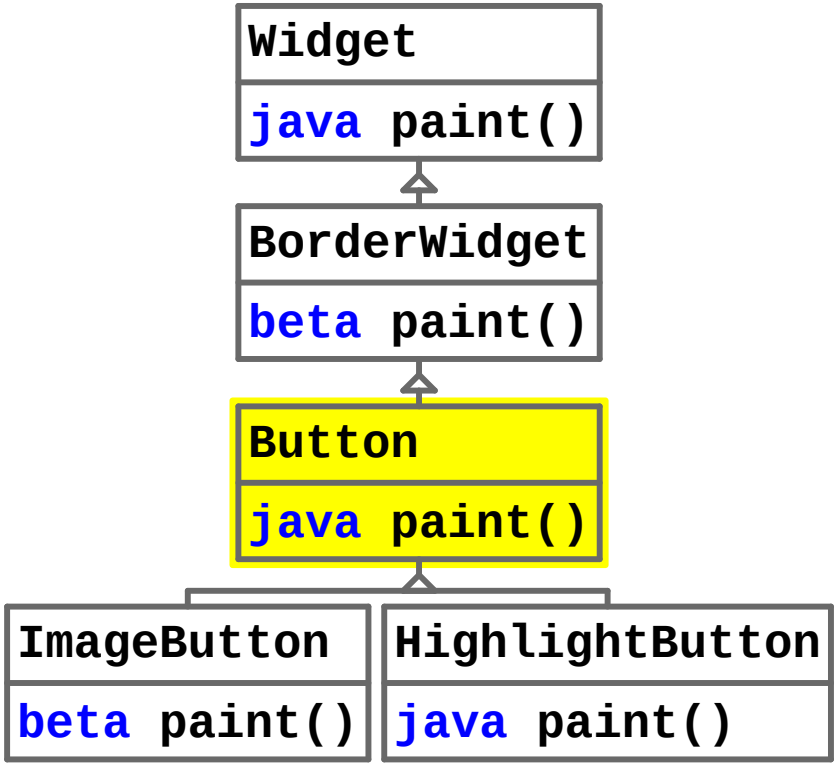

```
class Widget ...
  java void paint() {
    // paint the background:
    ...;
  }
```

Code for Beta/Java Combination



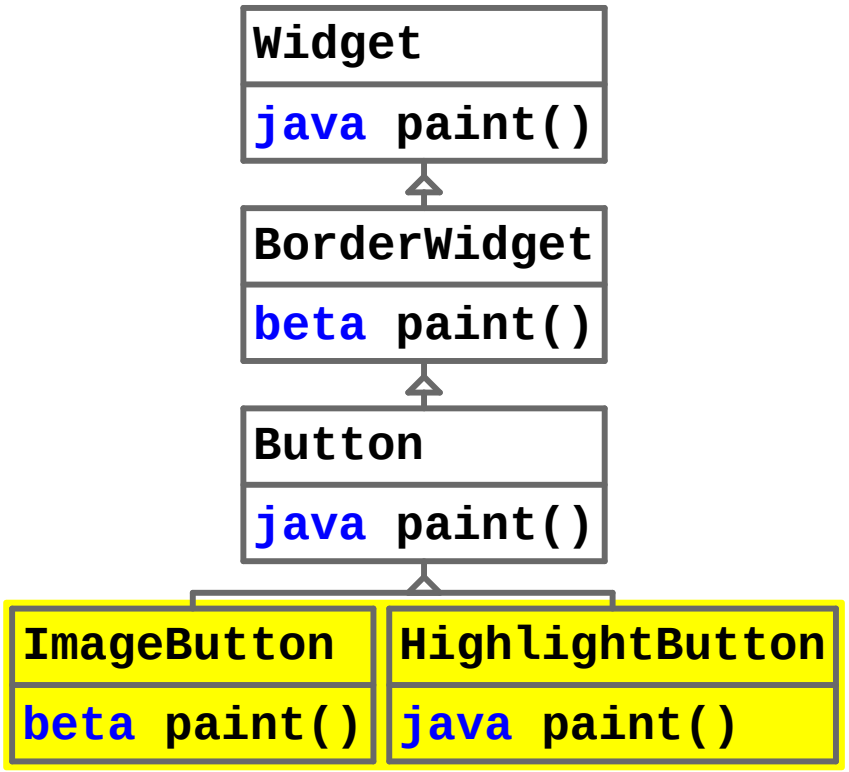

```
class BorderWidget ...
  beta void paint() {
    // paint background:
    super.paint();
    // draw a border:
    ...;
    inner.paint();
  }
```

Code for Beta/Java Combination




```
class Button ...
  java void paint() {
    // draw a button label:
    ...;
  }
```

Code for Beta/Java Combination




```
class ImageButton ...
  beta void paint() {
    // draw image,
    // don't call super
    // for label:
    ...;
    inner.paint();
  }
```

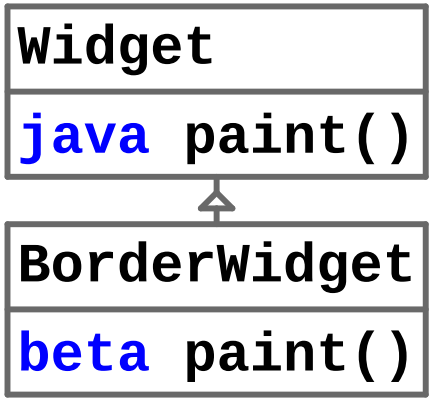
```
class HighlightButton ...
  java void paint() {
    // replace background with
    // blue gradient:
    ...;
    // draw label
    super.paint();
  }
```

Summary: Java to Beta/Java Combination

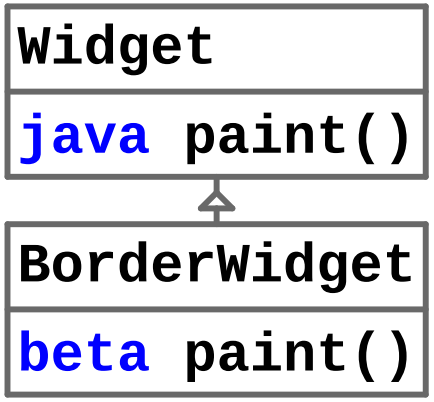
- Add **`java`** and **`beta`** keywords for methods
- Add **`inner`** statement:

  `inner``.`*Identifier* (*Expression, ... Expression*) **`else`** *Statement*

Operational Semantics: Calling paint on BorderWidget



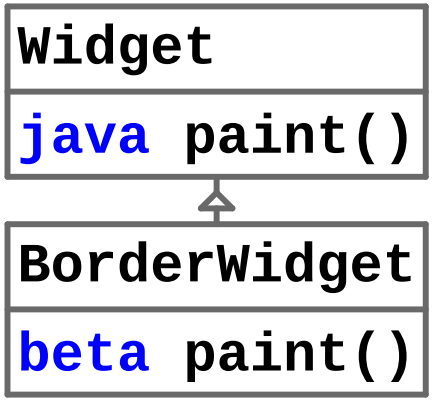
Calling paint on BorderWidget: Method Dispatch




```
new BorderWidget().paint();
```

Calling paint on BorderWidget: Method Dispatch

- Highest method declared **`beta`** or lowest method, if none

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Calling paint on BorderWidget: Method Dispatch

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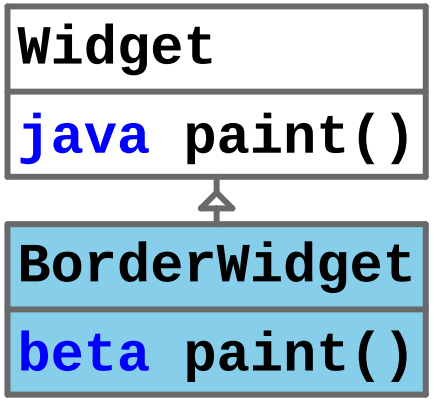
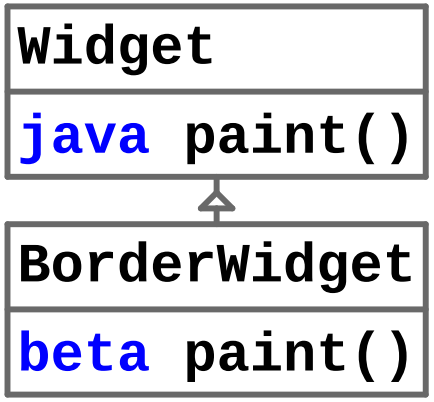


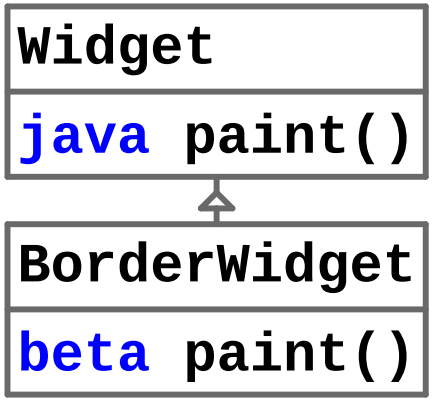

```
new BorderWidget().paint();
```

Calling paint on BorderWidget: Method Dispatch




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

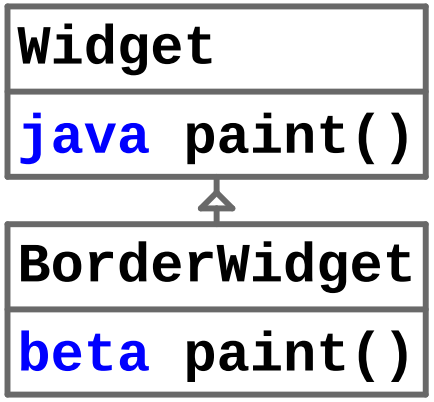
Calling paint on BorderWidget: super Dispatch




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

Calling paint on BorderWidget: super Dispatch

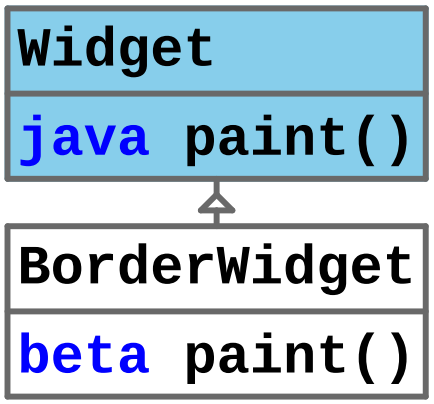
- Next method above in hierarchy




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

Calling paint on BorderWidget: super Dispatch

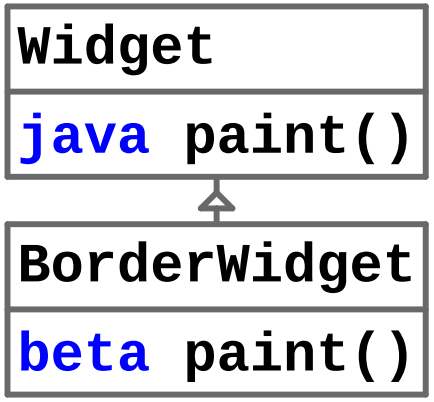
- Next method above in hierarchy




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

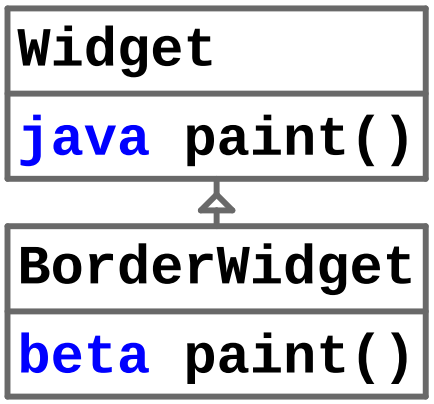
Calling paint on BorderWidget: super Dispatch

- Next method above in hierarchy




```
class Widget ...
  java void paint() {
    // paint the background:
    ...;
  }
```

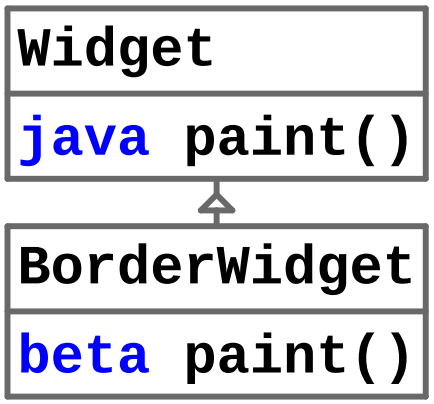
Calling paint on BorderWidget: inner Dispatch




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

Calling paint on BorderWidget: inner Dispatch

- Next method below declared **`beta`** or lowest method, if none




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

Calling paint on BorderWidget: inner Dispatch

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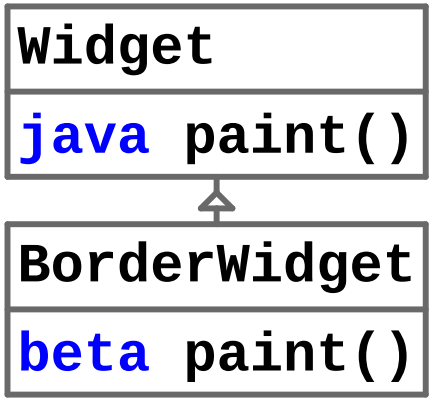
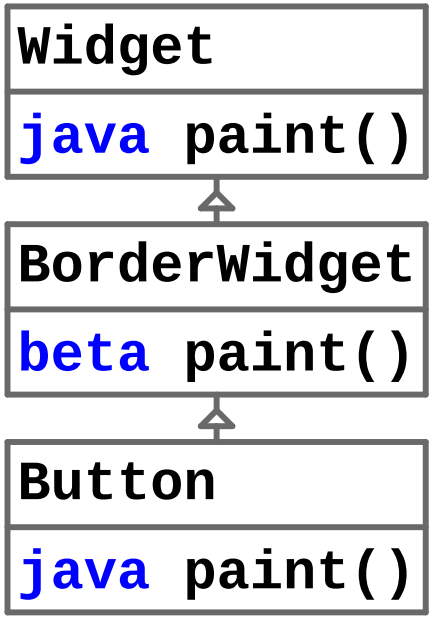
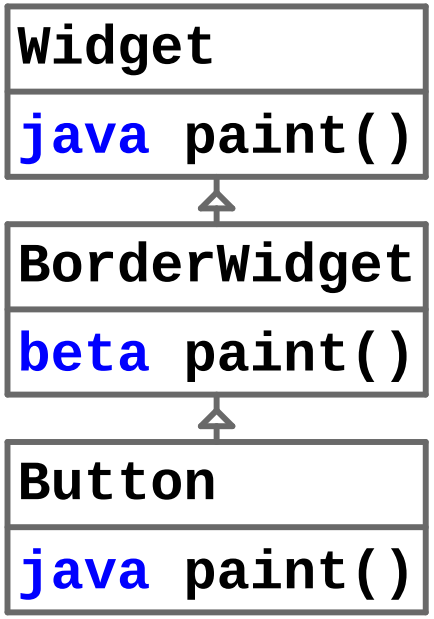



```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

Operational Semantics: Calling paint on Button



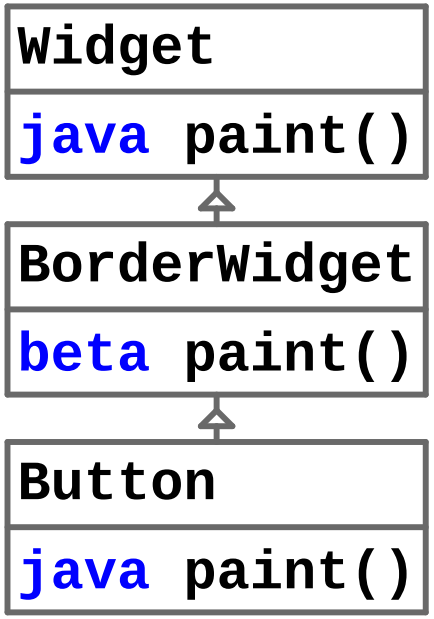
Calling paint on Button: Method Dispatch




```
new Button().paint();
```

Calling paint on Button: Method Dispatch

- Highest method declared **`beta`** or lowest method, if none

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Calling paint on Button: Method Dispatch

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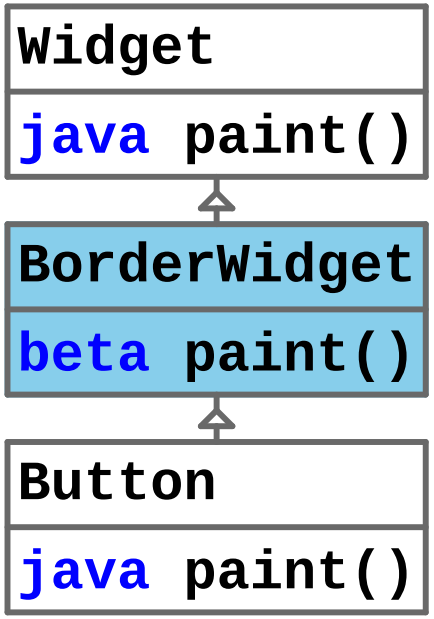


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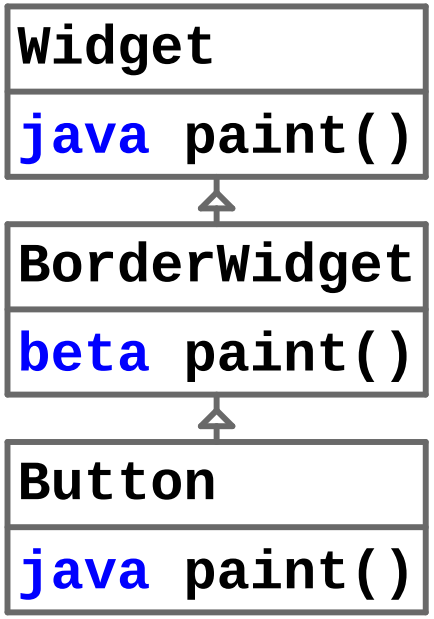
Calling paint on Button: Method Dispatch




```
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  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```
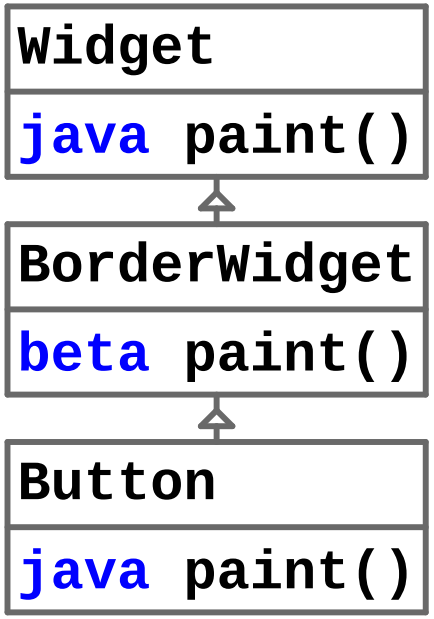
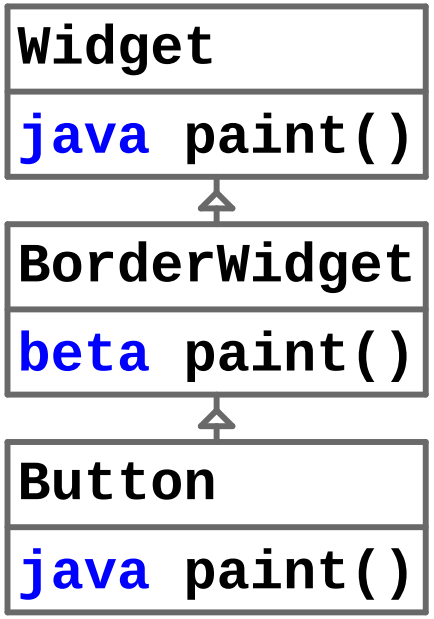

Calling paint on Button: inner Dispatch




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

Calling paint on Button: inner Dispatch

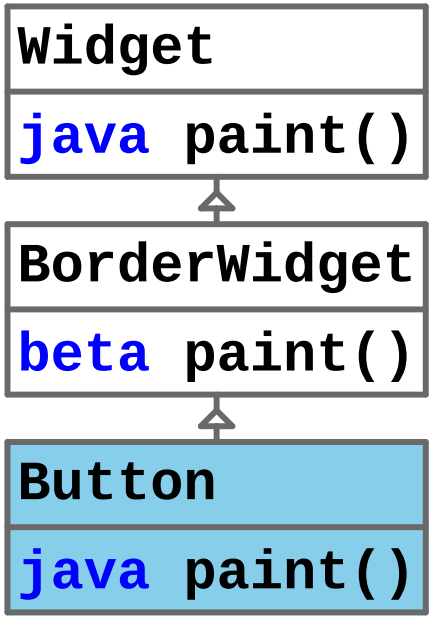
- Next method below declared **beta** or lowest method, if none




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

Calling paint on Button: inner Dispatch

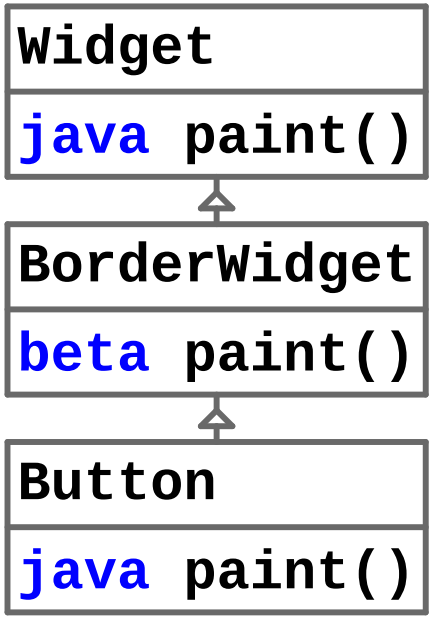
- Next method below declared **`beta`** or lowest method, if none




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

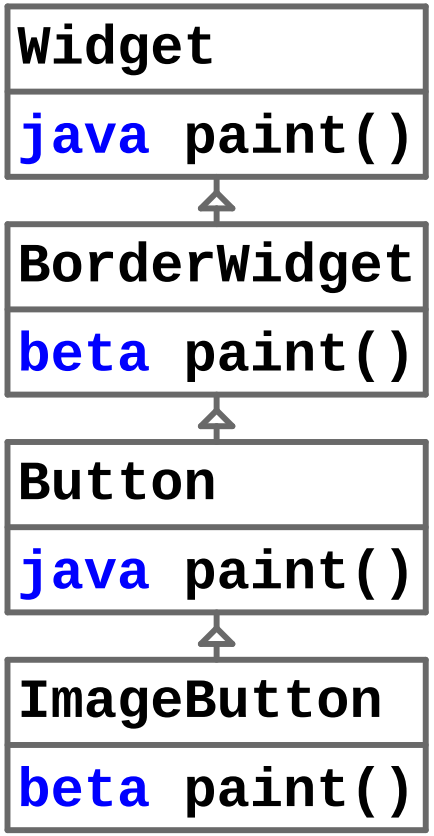
Calling paint on Button: inner Dispatch

- Next method below declared **`beta`** or lowest method, if none

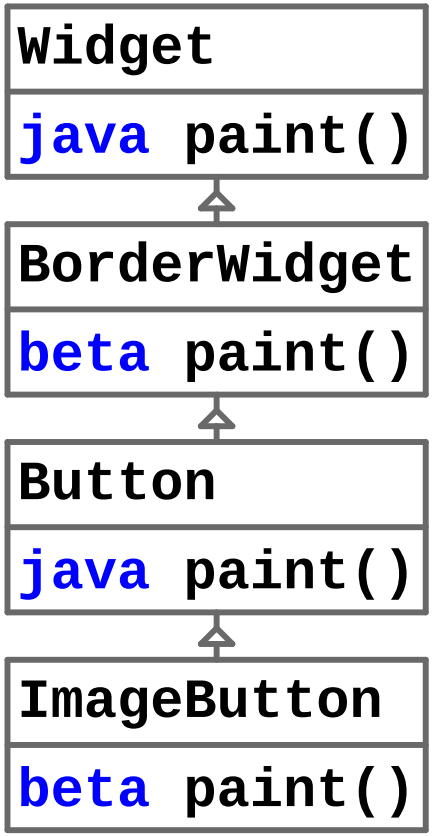



```
class Button ...
  java void paint() {
    // draw a button label:
    ...;
  }
```

Operational Semantics: Calling paint on ImageButton



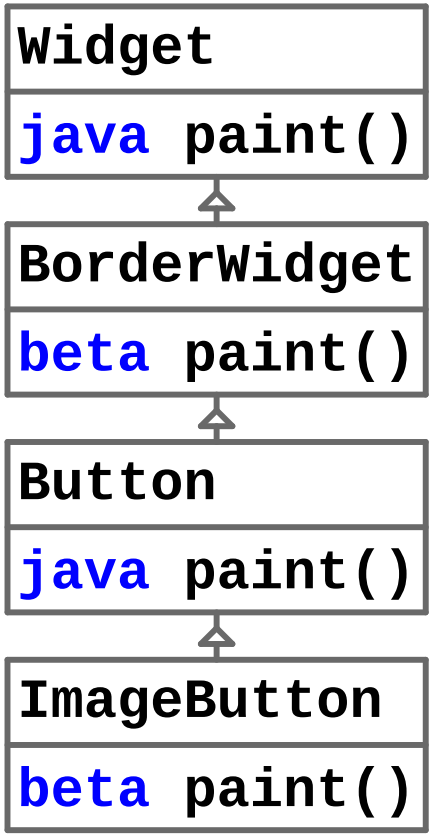
Calling paint on ImageButton: Method Dispatch




```
new ImageButton().paint();
```

Calling paint on ImageButton: Method Dispatch

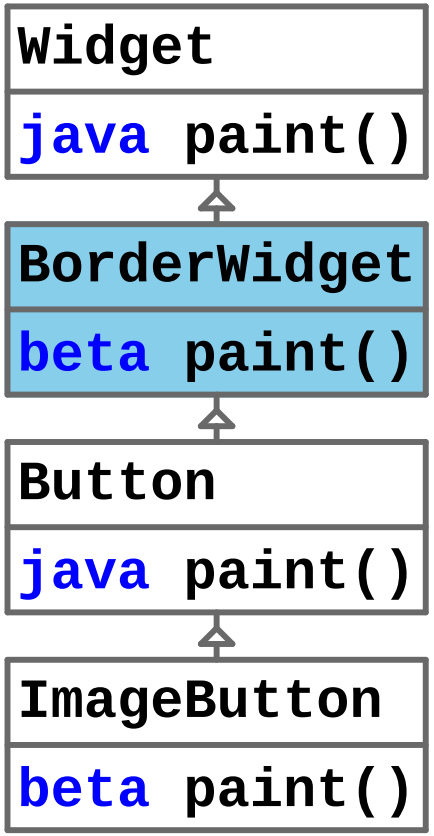
- Highest method declared **`beta`** or lowest method, if none




```
new ImageButton().paint();
```

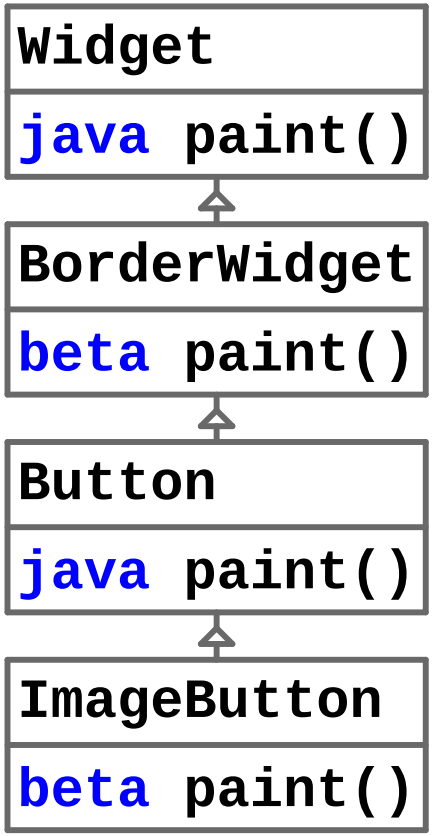
Calling paint on ImageButton: Method Dispatch

- Highest method declared **`beta`** or lowest method, if none



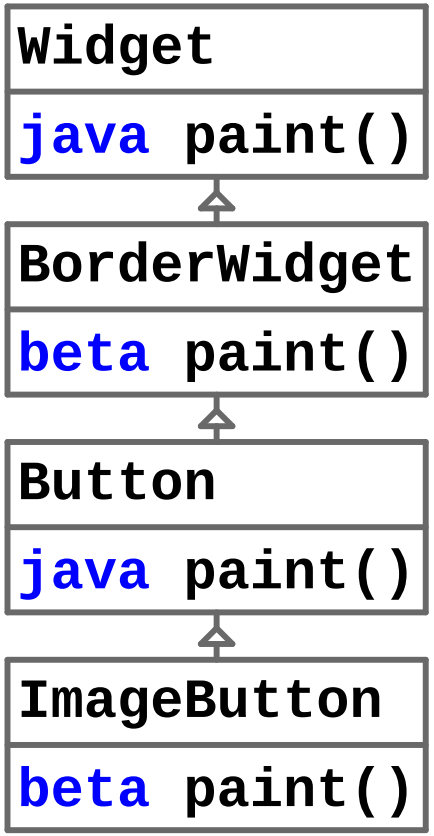

```
new ImageButton().paint();
```

Calling paint on ImageButton: Method Dispatch




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

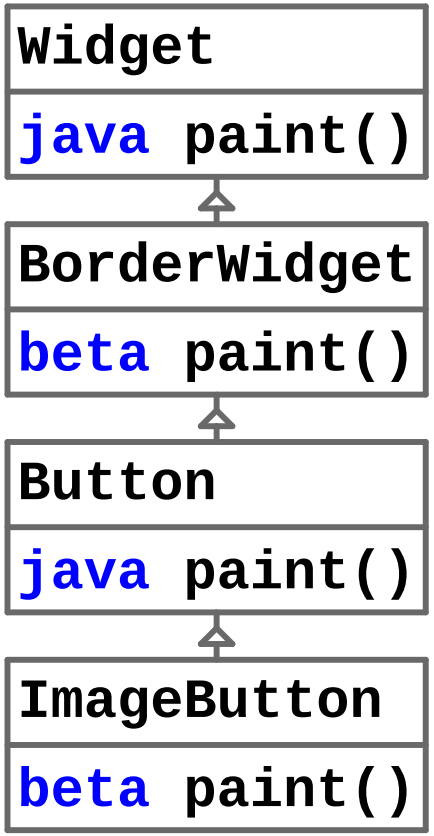
Calling paint on ImageButton: inner Dispatch




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

Calling paint on ImageButton: inner Dispatch

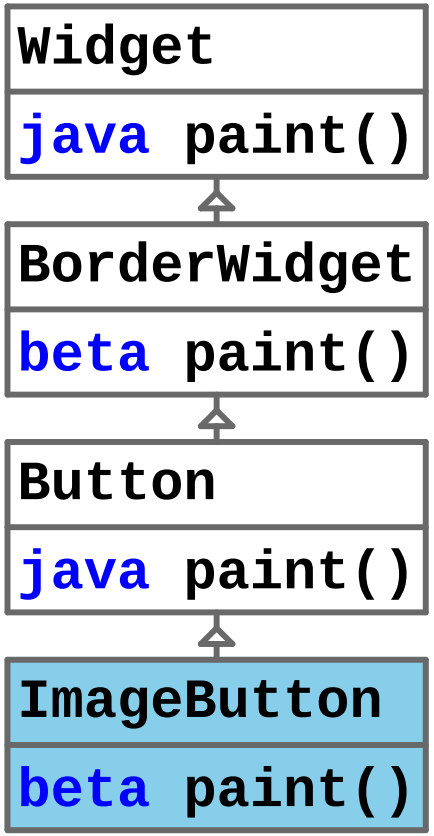
- Next method below declared **beta** or lowest method, if none




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

Calling paint on ImageButton: inner Dispatch

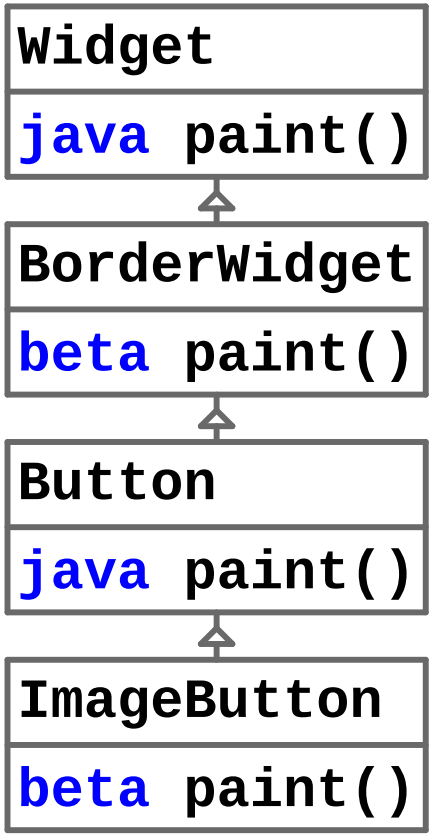
- Next method below declared **`beta`** or lowest method, if none




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

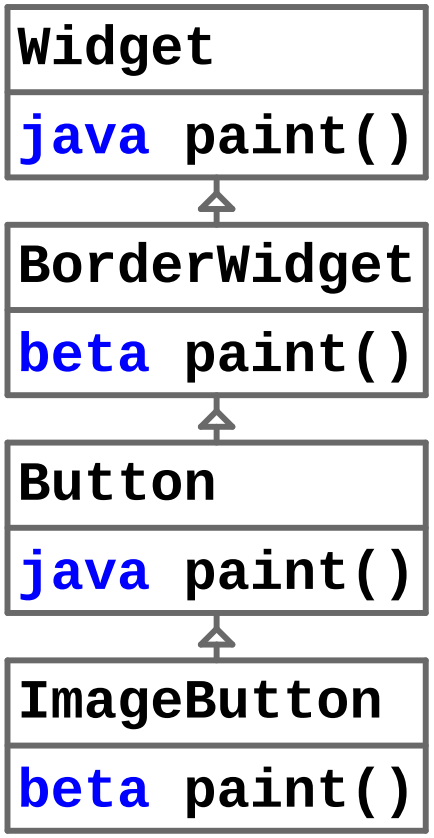
Calling paint on ImageButton: inner Dispatch

- Next method below declared **`beta`** or lowest method, if none

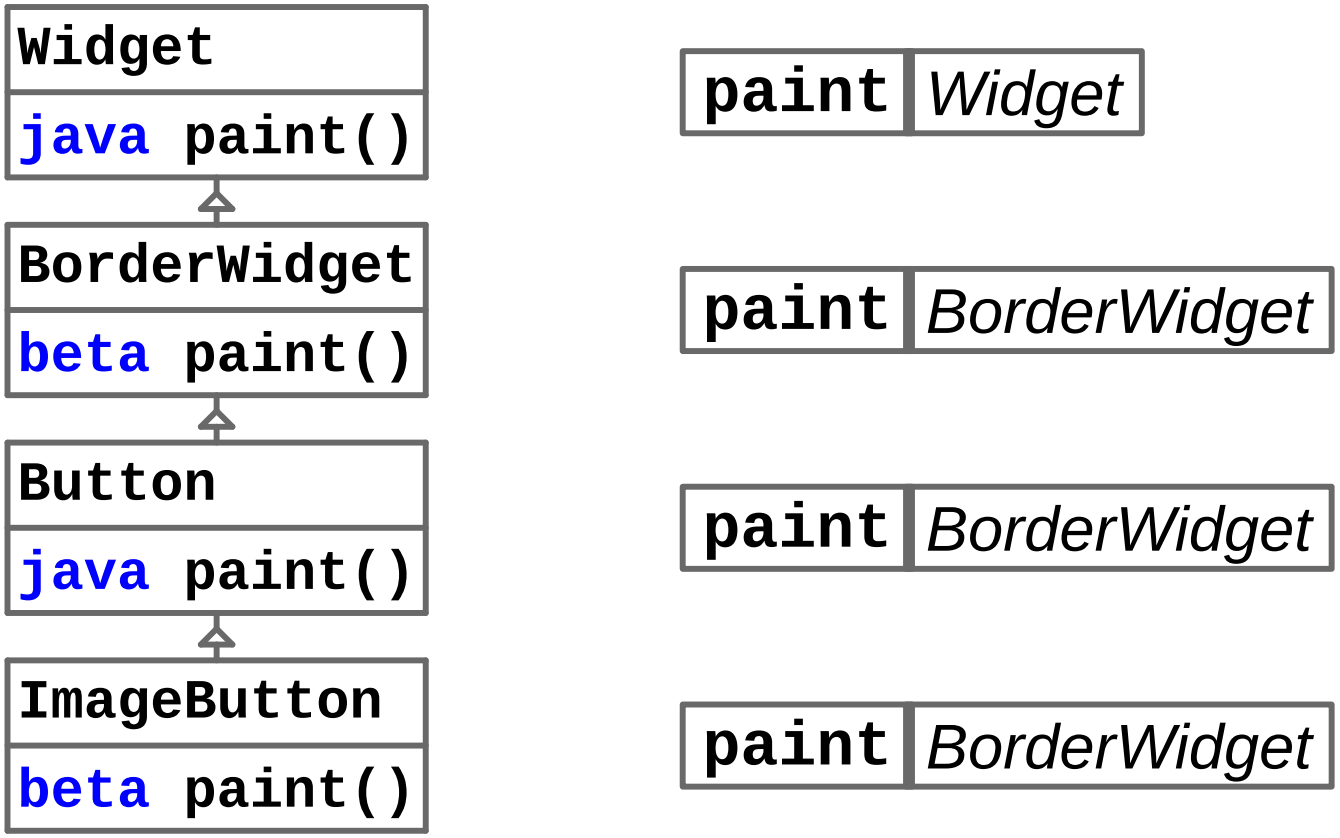



```
class ImageButton ...
  beta void paint() {
    // draw image,
    // don't call super
    // for label:
    ...;
    inner.paint();
  }
```

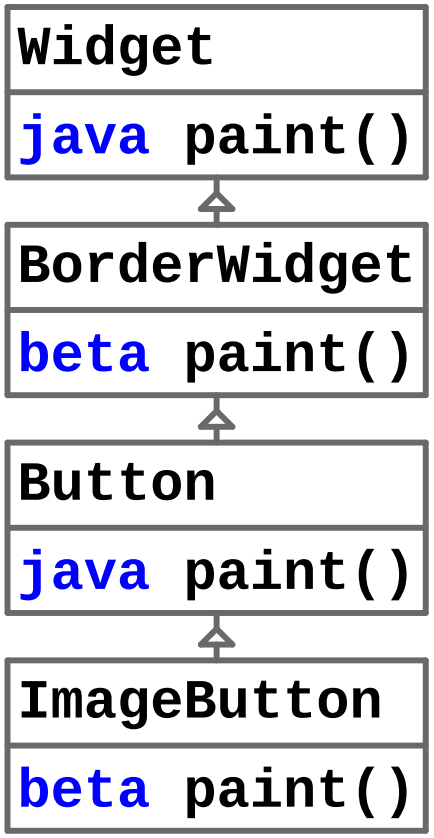
Compiling Method Dispatch



Compiling Method Dispatch

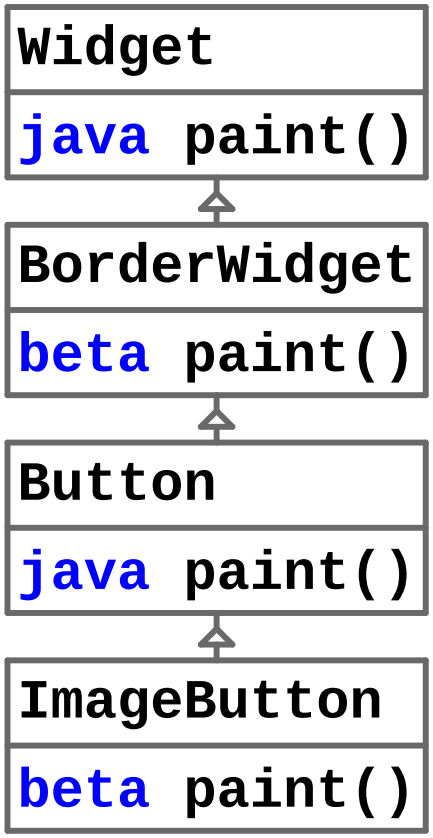


Compiling super Calls



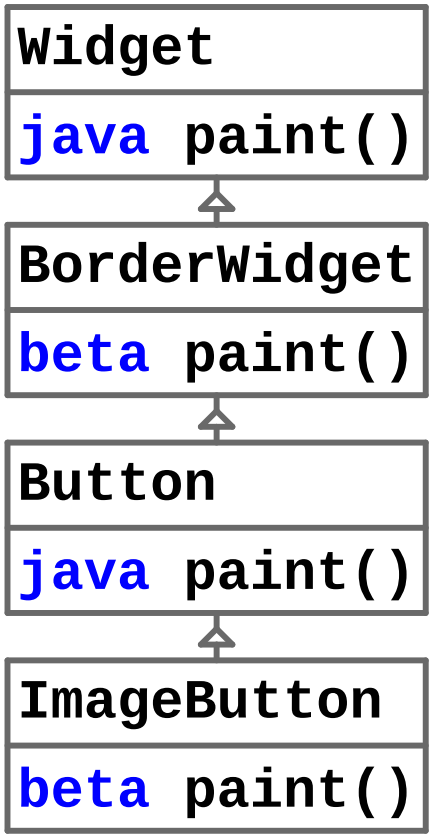

```
class BorderWidget ...
  beta void paint() {
     super.paint();
     ...
     inner.paint() else ...;
  }
```

Compiling super Calls

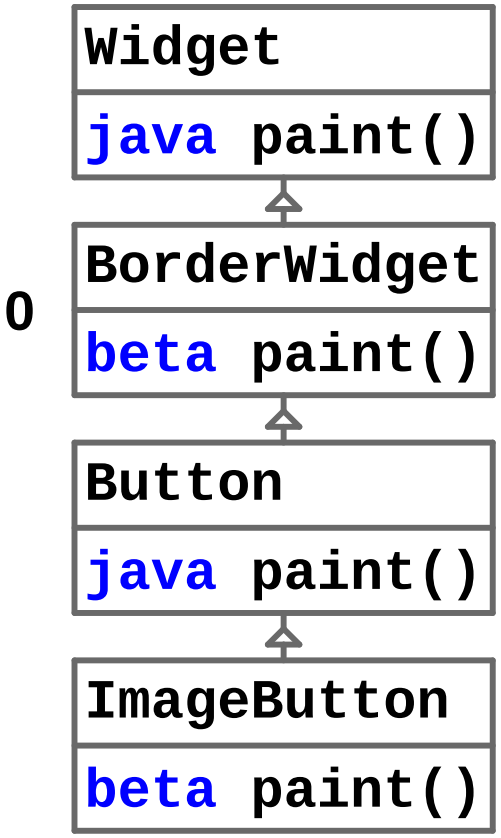



```
class BorderWidget ...
  beta void paint() {
     paint() in class Widget
     ...
     inner.paint() else ...;
  }
```

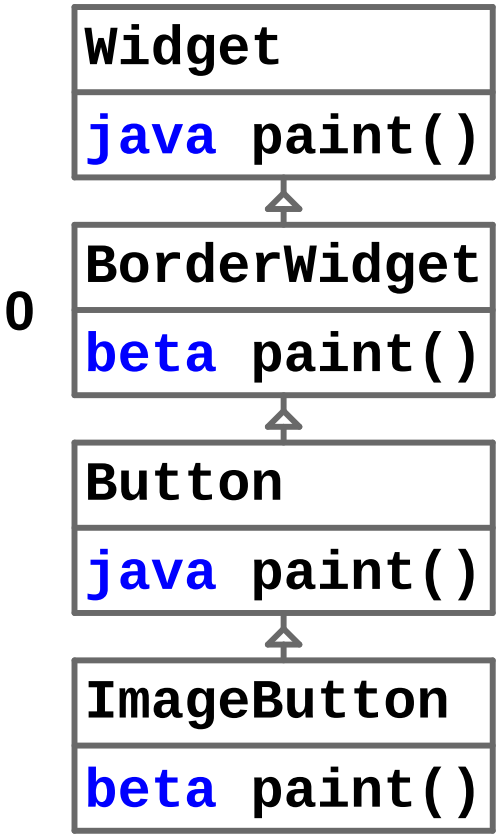
Compiling inner Calls



Compiling inner Calls

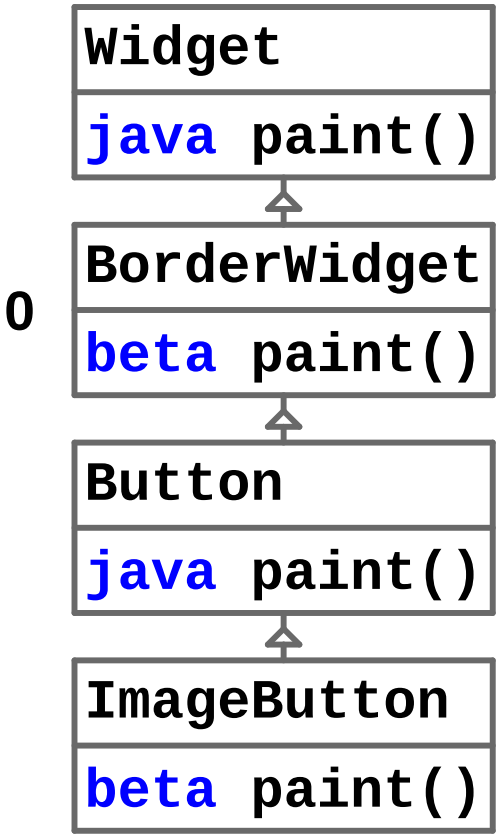


Compiling inner Calls



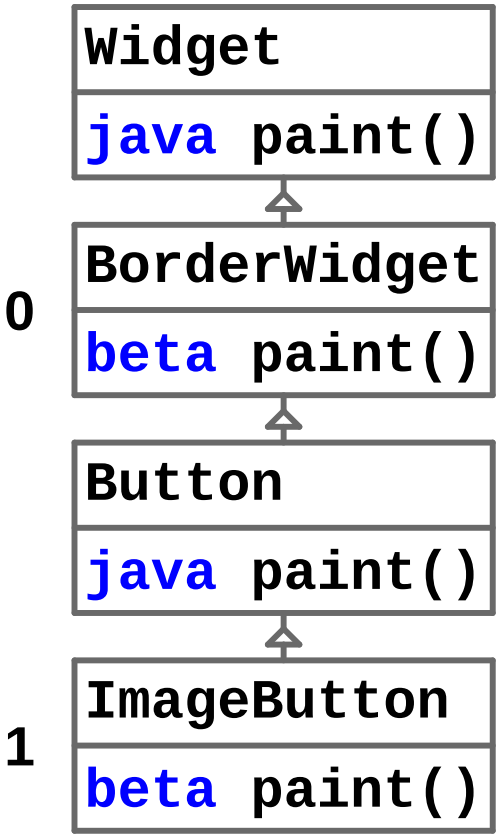

```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    inner.paint() else ...;
  }
```

Compiling inner Calls



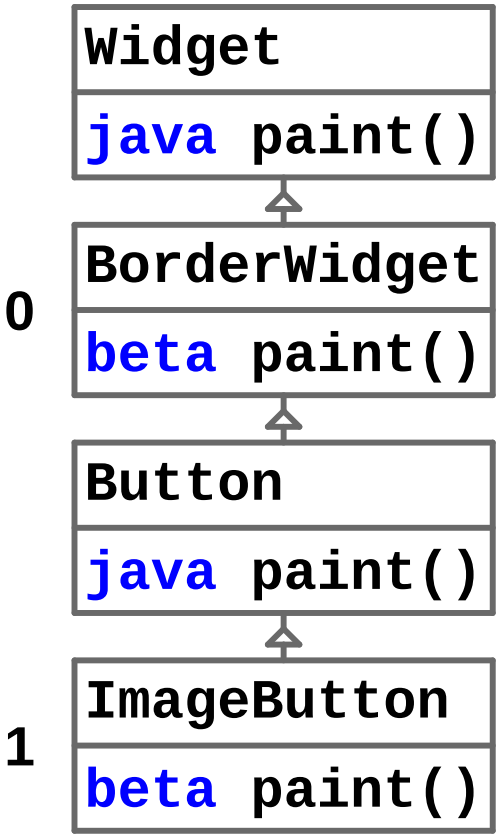

```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    paint() at index 1
  }
```

Compiling inner Calls




```
class BorderWidget ...
  beta void paint() {
    super.paint();
    ...
    paint() at index 1
  }
```

Compiling inner Calls



paint	0
	Widget

paint	0	1
	BorderWidget	*null*

paint	0	1
	BorderWidget	*Button*

paint	0	1	2
	BorderWidget	*ImageButton*	*null*

Performance

- Performance unchanged with these modifications
  - All **`java`** methods behave exactly like normal Java
- Additional 250 lines of code to 2800-line object system

Model and Implementation

- Model based on CLASSICJAVA [Flatt, Krishnamurthi, Felleisen '98]
  - Soundness proof in paper
- Implemented in v299 of PLT Scheme

Use in Practice: on-close and render-value Methods

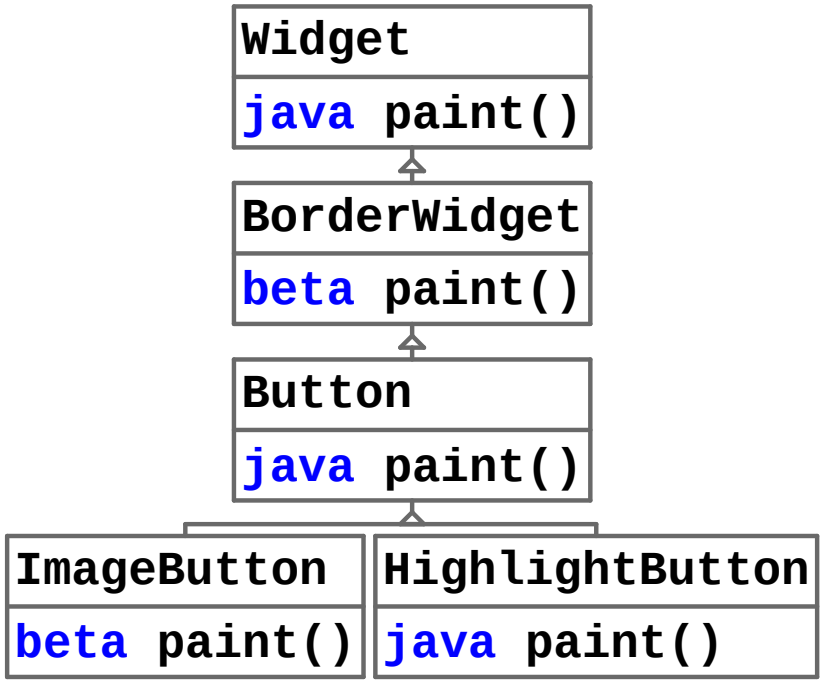
- **`on-close`** method of editor called when window closed
  - Includes important code to be executed
  - Must be in control
- **`render-value`** method of language converts values to strings
  - Sometimes language wants control — certain values always displayed the same
  - Sometimes gives up control to subclasses

Related Work

- CLOS [Keene, 1988],
- gbeta [Ernst, Ph.D. Thesis, 1999]
- Cook [Ph.D. Thesis, 1989],
  Clark [GEC Journal of Research, 1994]
  Bracha and Cook [OOPSLA 1990],
  Ancona and Zucca [PLILP 1997, MSCS 1998],
  Duggan [ECOOP 2000],
  Bettini, et al. [WOOD 2003],
  GNU EDMA [Oliveira]

Conclusions

- Programmers need **super** and **inner** in same language
  - Method can maintain control or give control as desired
- Developed simple system of determining control
  - Easy to implement



- Implementations:
  http://drscheme.plt-scheme.org/
  http://www.cs.utah.edu/plt/super+inner/