Software product lines

Paulo Borba
Informatics Center
Federal University of Pernambuco

Variability implementation mechanisms

Paulo Borba

Informatics Center

Federal University of Pernambuco

Conditional compilation

```
//#if canvas_midp2 || canvas_siemens
      this.mainCanvas.paint();
      this.mainCanvas.flushGraphics();
//#else
//#   this.mainCanvas.repaint();
//#   this.mainCanvas.serviceRepaints();
//#endif
```

From Meantime Mobile Creations

Pre-processing followed by

Antenna file

```
//#if canvas_midp2 || canvas_siemens
//#   this.mainCanvas.paint();
//#   this.mainCanvas.flushGraphics();
//#else
//#   this.mainCanvas.repaint();
//#   this.mainCanvas.serviceRepaints();
//#endif
```

Tags file

```
canvas_midp2,
device_screen_128x128,
...
```

product

```
this.mainCanvas.paint();
this.mainCanvas.flushGraphics();
```

CC Core assets

Antenna file

```
//#if canvas_midp2 || canvas_siemens
//#   this.mainCanvas.paint();
//#   this.mainCanvas.flushGraphics();
//#else
//#   this.mainCanvas.repaint();
//#   this.mainCanvas.serviceRepaints();
//#endif
```

Makefiles

Tags files

canvas_midp2,	**canvas_siemens,**
device_screen_128x128,	**device_screen_128x128,**
...	**...**

Inside commands…

```
if (display.getCurrent()==this.mainCanvas)
{
//#if canvas_midp2 || canvas_siemens
//#  this.mainCanvas.paint();
//#  this.mainCanvas.flushGraphics();
//#else
//#  this.mainCanvas.repaint();
//#  this.mainCanvas.serviceRepaints();
//#endif
}
```

From Meantime Mobile Creations

and everywhere

```
//#if canvas_nokiaui
//# public class MainCanvas extends FullCanvas {
//#elif canvas_midp2 || canvas_siemens
//# public class MainCanvas extends GameCanvas {
//#else
//# public class MainCanvas extends Canvas {
//#endif
private static int keyStatesNotRepeatable;
//#if device_screen_128x128
//# public static final int SCREEN_WIDTH  = 128;
//# public static final int SCREEN_HEIGHT = 128;
//#elif device_screen_128x117
//# public static final int SCREEN_WIDTH  = 128;
...
```

Analyzing conditional compilation

- Variation point
  - any point in the program text
- Variation
  - any program element
- Binding time
  - precompilation time
- Mechanism
  - decision based on tags file, specified by makefile

Parametrization via property files (PFP)

```
Properties p = new Properties();
p.load(new
    FileInputStream("device_screen.prop"));
...
    p.getProperty("SCREEN_WIDTH")
...
```

device_screen.prop

```
SCREEN_WIDTH=128
SCREEN_HEIGHT=128
```

PFP core assets

Java file

```
Properties p = new Properties();
p.load(new
    FileInputStream("device_screen.prop"));
...
     p.getProperty("SCREEN_WIDTH")
...
```

Makefiles

Property files

device_screen.prop

```
SCREEN_WIDTH=128
SCREEN_HEIGHT=128
```

device_screen.prop

```
SCREEN_WIDTH=128
SCREEN_HEIGHT=117
```

Properties provide data and behavior too

```
Properties p = new Properties();
p.load(new
    FileInputStream("device_screen.prop"));
...
    if (p.getProperty("SCREEN_WIDTH")==128) {
        ...
    } else {...}
...
```

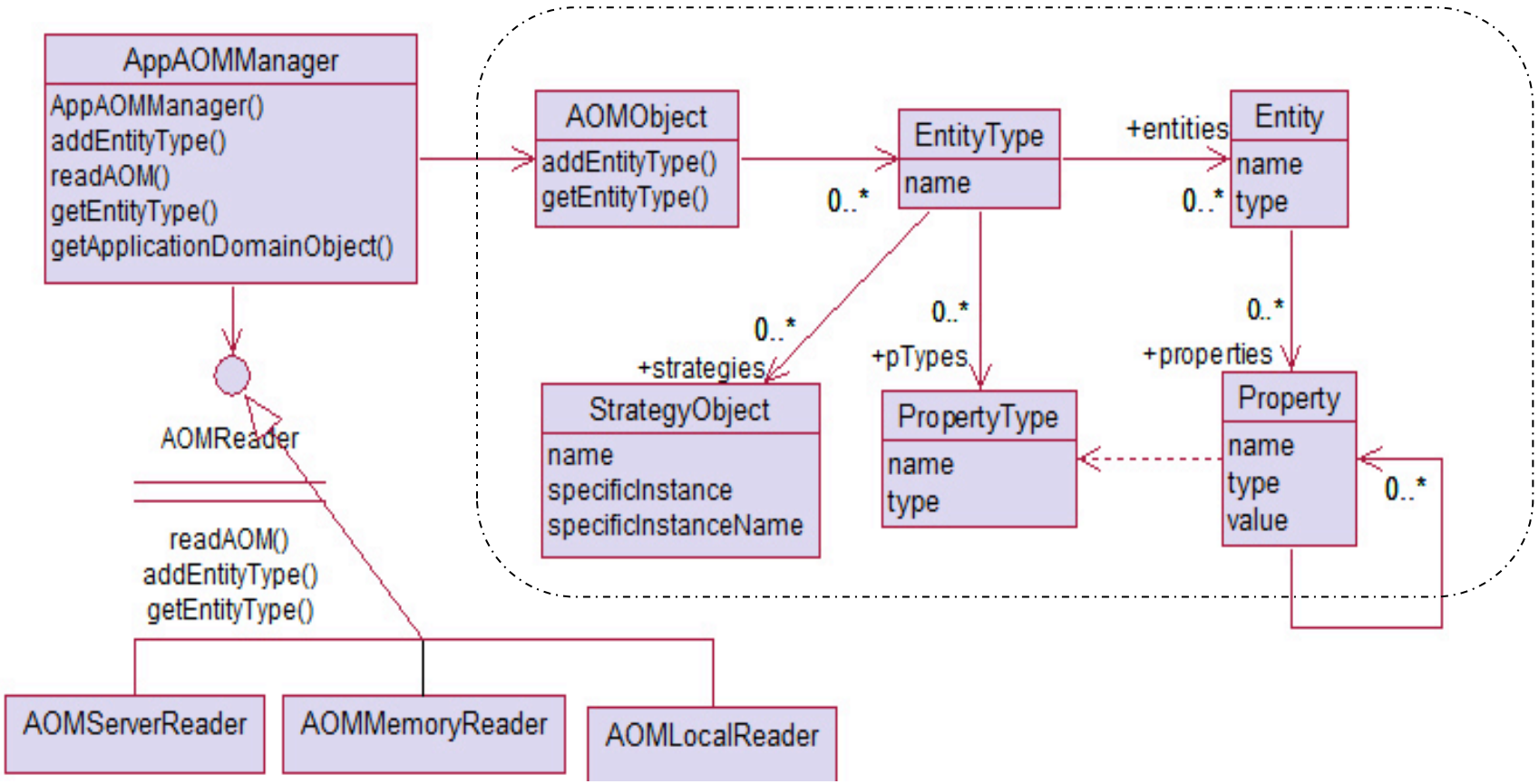
Analyzing PFP

- Variation point
  - expressions in the program text, and commands too (with conditionals)
- Variation
  - constants and values, commands
- Binding time
  - execution time, based on makefile choice
- Mechanism
  - value instantiation, decision

Adaptive object models

- Several OO patterns
- But not only subtype polymorphism
- Metadata plays an essential role
  - Supports flexible dynamic adaptations
  - Represents business rules and entities as data
  - POS performs a sequence of actions; the actions and sequence are represented as objects

Adaptive object-model



Parametrization via parametric polymorphism (PPP)

```
public class Record<ComplaintType> {
    ...
    public void insert(ComplaintType o) {
       ...
    }
}
```

```
...
Record<HealthComplaint>
...
```

PPP core assets

Java file, generic

```
public class Record<
   ComplaintType extends CodeIdentifiable> {
   ...
   public ComplaintType search(int code){
      ...
   }
   public void insert(ComplaintType o) {
      ...
   }
}
```

Makefiles

Java files, specific

```
...
Record<HealthComplaint>
...
```

```
...
Record<SafetyComplaint>
...
```

Parametrizing data + operations

```
public class Record<
    ComplaintType extends CodeIdentifiable> {
    ...
    public ComplaintType search(int code){
       ...
    }
    public void insert(ComplaintType o) {
       ...
    }
}
```

```
interface CodeIdentifiable {
   int getCode();
}
```

Analyzing PPP

- Variation point
  - class parameters (types and methods) in the program text
- Variation
  - types (including methods)
- Binding time
  - compilation time, based on makefile choice
- Mechanism
  - type instantiation, variation modularization

Mixing mechanisms: PPP, but instantiation with PFP and conditional

- Variation point
  - class parameters (types and methods) in the program text
- Variation
  - types (including methods)
- Binding time
  - execution time, based on makefile choice

Mixing mechanisms: PPP, with conditional and input parameter

- Variation point
  - class parameters (types and methods) in the program text
- Variation
  - types (including methods)
- Binding time
  - execution time, based on user choice

Same modularization mechanism, 3 decision mechanisms:

- Makefiles
- Makefiles + property_files + conditionals
- Input + conditionals

Variability implementation mechanisms

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