Using Attribute-Oriented Programming to Leverage Fractal-Based Developments

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INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

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5th International ECOOP Workshop on the Fractal Component Model

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Motivations

Component-Oriented Programming is expensive!

- Several files per component: Interfaces, implementation, meta-data files

Business and technical code weaving

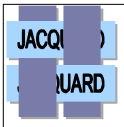
- Component lifecycle, bindings, attributes handled in program code

Component meta-information redundancy

- Some meta-data duplicated in both program code and ADL

These drawbacks impact

- Development time (technical code cost, which is error prone)
- Coherency maintenance cost (architecture description ⇔ program code)
- Evolution support (application, component model)



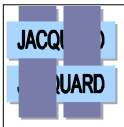
Fractal Component Model

An interesting component model :-)

- Various implementations: Julia, AOKell, ProActive, etc.
- Various extensions: FAC, Confract, etc.
- Various tools: Fractal ADL, Fractal GUI, Fractal Explorer, SAFRAN, etc.
- Various applications: Dream, CLIF, Speedo, GoTM, etc.

BUT, it may quickly become boring :-(

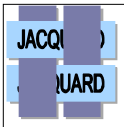
- Implementation of the component business code
- Definition of an AttributeController interface
- Implementation of Fractal controller callbacks
  - *BindingController: to support client interfaces*
  - *LifeCycleController: to be notified of start/stop transitions*
  - *XXXAttributeController: to support attribute (re)configuration*
- Definition of the primitive component ADL description
- Definition of the composite component ADL description



Example: Binding Controller Overhead

```
public class ClientImpl implements Main, BindingController {
    private Service service;
    public void main (final String[] args) {
        service.print("hello world");
    }
    public String[] listFc () { return new String[] { "s" }; }
    public Object lookupFc (final String cItf) {
        if (cItf.equals("s")) { return service; }
        return null;
    }
    public void bindFc (final String cItf, final Object sItf) {
        if (cItf.equals("s")) { service = (Service)sItf; }
    }
    public void unbindFc (final String cItf) {
        if (cItf.equals("s")) { service = null;    }
    }
}
```

BEST OVERHEAD (lines) = 5 + 3 * NB-BINDINGS



Fraclet: @OP for Fractal

Application of Attribute-Oriented Programming principles

- Annotate the program code with common component concerns
- Generate the technical code for the Fractal component model

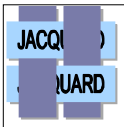
Annotations define only the component semantics

- No assumption on the technical stuff
- Extensible to additional concerns

Generators complete the component program code

- Component glue (programming model)
- Architecture descriptions (Fractal ADL)

```
@Interface(name="r",signature=Runnable)
public class MyComponent
implements Runnable {

  @Binding
  protected Runnable delegate;
  @Attribute
  protected int repeat;

  @Lifecycle(on="stop")
  protected void onStop() {
    System.out.println("Stopping…");
  }

  public void run() {
    for (int i=0;i<this.repeat;i++)
      this.delegate.run();
} }
```

Overview of Fraclet Annotations

Fraclet defines 7 annotations

- 4 structural annotations
  - **@interface** *<CLASS>: describes an interface provided by the component*
  - **@binding** *<FIELD>: describes an interface required by the component*
  - **@attribute** *<FIELD>: describes a component attribute*
  - **@component** *<CLASS>: describes the component membrane*
- 3 behavioral annotations
  - **@lifecycle** *<METHOD>: handles lifecycle transitions*
  - **@controller** *<FIELD>: accesses the controller part of the component*
  - **@logger** *<FIELD>: defines a component logger*

Fraclet supports 2 types of annotations

- XDoc annotations (Javadoc comments) for Java <= 1.5
- Java5 annotations for Java >= 1.5

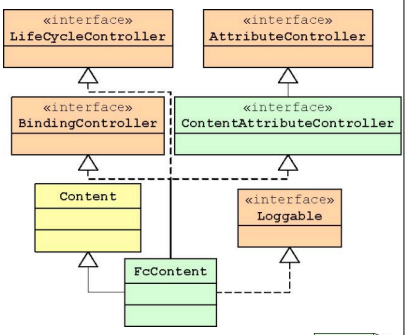
Overview of Fraclet Generators

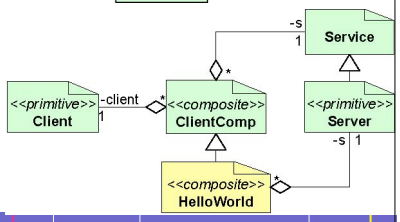
Fraclet provides 5 generators

- 2 Java generators
  - *AttributeController interface*
  - *Component glue*
- 2 Fractal ADL generators
  - *Primitive definition*
  - *Abstract composite definition*
- 1 Monolog generator
  - *Monolog configuration*

Fraclet supports 2 generation engines

- XDoclet: uses XDoc annotations to extend the content class
- Spoon: uses Java5 annotations to modify the content class





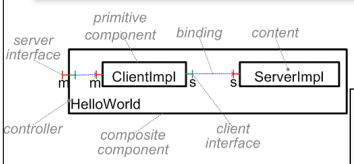
Revisiting HelloWorld…

```
/** @interface name=m */
public interface Main {
    void main (String[] args);
}
```

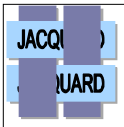
```
/** @interface name=s */
public interface Service {
    void print (String msg);
}
```

```
public class ClientImpl implements Main {
    /** @binding name=s */
    protected Service service;

    public void main (final String[] args) {
        service.print("hello world");
}   }
```

```
public class ServerImpl implements Service {
    /** @attribute */
    protected String header ;
    /** @attribute */
    protected int count ;

    public void print (final String msg) {
        for (int i = 0; i < count; ++i)
            System.err.println(header + msg);
}   }
```




```
<definition name="HelloWorld" extends="ClientImplComp">
    <component name="s" definition="ServerImpl('->',3)"/>
</definition>
```



Fraclet Benefits

Reduction of the program code size

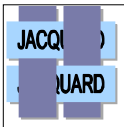
- Between 40% and 70% of the original code size
- Binding controller overhead: from 5+3*NB-BINDINGS to NB-BINDINGS
- But this is not the only benefit …

Simplification of component-oriented programming

- Hiding technical details
- Ensuring coherency between program code and artifacts

Evolution support

- Software evolution
  - *evolution of the program code (e.g., adding an attribute)*
- Component model evolution
  - *evolution of the component specification (e.g., modification of the API)*



Related Work

Generative Programming

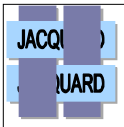
- Generating technical code from ADL descriptions
- Generating technical code & ADL from model descriptions (*e.g.,* FractalGUI)
  - *+ Enforces separation of concerns (architect ⇔ developer)*
  - *-- Increases the size of handwritten code (ADL + business code)*
  - *-- No support for code instrumentation (controllers, logging, etc.)*

Aspect-Oriented Programming

- Limited to code advising and injection (*e.g.,* AOKell)
- No support for external artifacts generation

Complementary approaches

- Providing reverse engineering support for generative programming approaches (UML => ADL => code => ADL => UML)



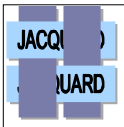
Fraclet Perspectives

Program code validation
- Component model specification
- Hidden communication path detection

Reverse engineering support: *e.g.,* Fractal GUI
- Annotated program code generation using Fractal GUI
- Fractal GUI description file generation using Fraclet

Component model independency
- Developing the application only once (PIC - Platform Independent Code)
- Executing on various component models (PSC: Fractal, OpenCOMJ, etc.)

Fractal Explorer support
- *E.g.,* defining annotations to mark invokable methods
- *E.g.,* generating Fractal Explorer configuration file



Conclusion

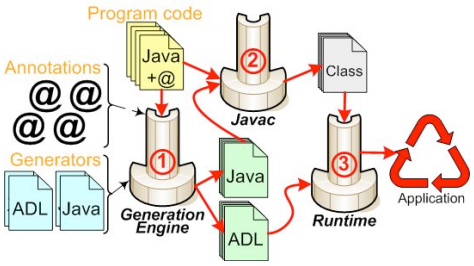
Fraclet addresses the problem of business and technical code tangling
- Non-functional code merged with business code
- Redundancy of some meta-data between program code and ADL

Fraclet proposes to apply Attribute-Oriented Programming to Fractal
- 7 annotations (structural, behavioral) using Java5 or Xdoc annotations
- 5 generators (Java, Fractal ADL, Monolog) using Spoon or Xdoclet engines

Fraclet provides added values to Fractal-Based developments
- Continuous integration of the technical code
- Reduction of the program code size (~50%)
- Support for application and component model evolution

Fraclet implementations are available at http://fractal.objectweb.org/

Questions ?



Fraclet is already applied in

- **GoTM**: a *framework for the construction of transaction services*
- **ProActive**: *a platform for Grid Computing*
- **COSMOS**: a *framework for the composition of system resources*
- **Deployment Framework**: *a generic deployment tool*
- **DACAR**: an *autonomous deployment framework*
- **FAC**: an *extension to support AOP at component level*
- …