ENHANCING BASE-CODE PROTECTION IN ASPECT-ORIENTED PROGRAMS

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Outline

- Introduction - Motivation
- Our AOP Modularity Focus
- Interface Image (I2) Approach
- I2 implementation
- I2 Evaluation
- Related Work
- Conclusion

Introduction - Motivation

- Separation of crosscutting concerns
- Roadblocks to AOP adoption
  - Not just education
  - Reality of coding standards for small companies
  - Lack of invasiveness regulation
  - Pure obliviousness
- Support for AOP adoption has to come at the language level.

Introduction - Motivation

- Interfaces Role Overlap:
  - Base code sees: Service Access Points
  - Aspect code sees: Event Hooks
- Protection (invasiveness control) is easier when roles are separated

Our AOP Modularity Focus

- Independent evolution of components
- Expanding parallel development
- Enhancing module protection
- Supporting modular reasoning

Classical AOP Limitations

- In our context, Classical AOP means: Pure Obliviousness
- Tight coupling between aspects and base code
- Base code cannot regulate any advising activity on itself
- Impossible to reason about a base code component solely by examining its interface (Tool support can help with this)

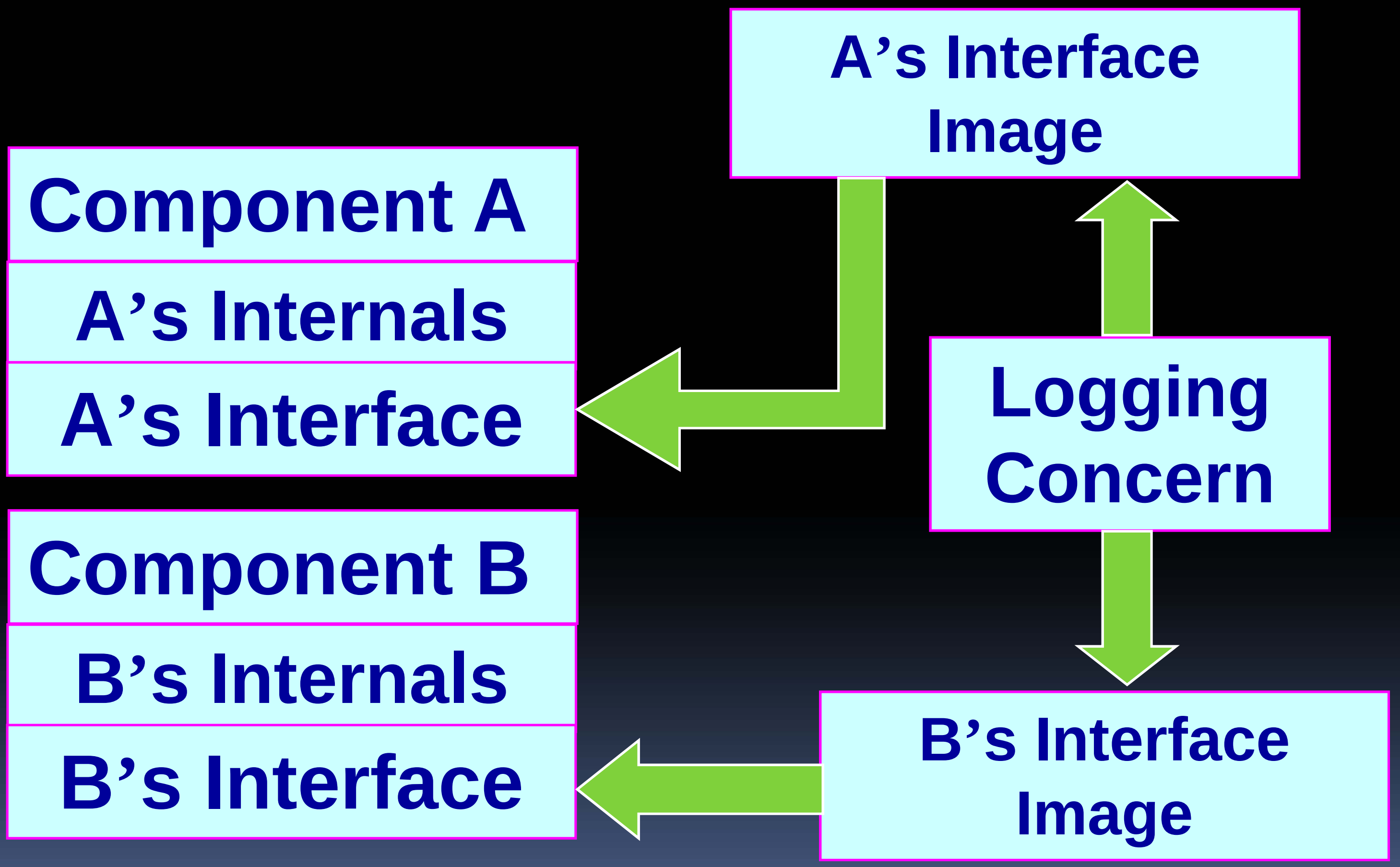
Interface Image (I2) Approach

- What is an Interface Image?
- “image” construct syntax
- “image” construct semantics
- What does I2 offer?

What is an interface image?

- A language mechanism for exporting views of a component's advisable interface
- A middleware through which all advising is carried out
- A language mechanism for base code to express advising constraints

Separation of XCC – I2 Style



The “image” construct

image {

[opento: {aspects allowed ITD’s}]

[alias definitions]

}

- An empty image scope reduces I2 to AspectJ-style AOP

Alias Definitions - Syntax

- [modifiers] RT method-name(P) = [modifiers] RT alias(P) { Constraints }
- modifiers: Java-style method modifiers
- RT: return type
- method-name, alias: Java-style method identifier
- P: Java-style method parameter list
- Constraints: A list of advising constraints

Constraints: kind clause

- Kind: {Advice_Kind*}
- Advice_Kind: before | after| after_returning | after_throwing | around

Constraints: (origin, boundary)

- (origin=ORIGIN, boundary=BOUNDARY);
- ORIGIN: internal | external
- BOUNDARY: method | class | package

Constraints: exceptions clause

- Exceptions: {Exception_Type*}
- Exception_Type: Java-style type identifier

“image” Construct Semantics

- Only classes declaring images are advisable
- Omitting a clause implies no constraint
- Empty “kind” list implies no advice allowed
- Empty “exceptions” list implies no checked exceptions can be softened

“image” Construct Semantics

- “opento” semantics
- “kind” semantics
- “(origin, boundary)” semantics
- “exceptions” semantics

Alias Definition Rules

- A class can only alias methods it declares
- Multiple (distinct) aliases for the same aliased method allowed
- Alias definitions in a base class are advisable in derived class unless method private in base

Example: Point class

```
Class Point extends Shape {
    protected int x, y;
    public void moveby(int dx, int dy){
        x += dx; y += dy;
    }
    // image goes here (next slide)
}
```

Example: Point class

```
Image {
    opento: {CheckScence};
    public void moveby(int dx, int dy) =
    public void translate(int dx, int dy) {
        kind: {after};
        (origin=external, boundary=class);
        exceptions: {SceneInvariantViolation};
    }
}
```

Example: Rectangle class

```
class Rectangle extends Shape {
    void moveby(int dx, int dy){
        p1x += dx; p1y += dy; p2x += dx; p2y += dy;
    }
    image {
        void moveby(int, int) = void translate(int, int){}
    }
}
```

Example: CheckSceneInvariants aspect

```
aspect CheckSceneInvariants {
pointcut moves(): call (void Shape+.translate(..));
    after(): moves() {
        scene.checkInvariants();
    }
}
```

Example: modifying moveby()

```
class Rectangle extends Shape {
    void moveby(int dx, int dy){
        p1x += dx; p1y += dy; p2x += dx; p2y += dy;
    }
    image {
        void moveby(int, int) = void translate(int, int){}
    }
}
```

P2.moveby(dx,dy);

P1.moveby(dx,dy);

Example: Updating Point

```
class Point extends Shape {
    …
image { …
    void moveby(int, int) = void translate(int, int){
        (origin=external, boundary=class);
    }
}
}
```

What does I2 offer?

- A level of indirection through which all advising requests are carried out
- Provides base code qualification of classes: advisable and unadvisable
- A mechanism for base code to expose views of joinpoints along with advising constraints

What does I2 offer?

- Control over aspect invasiveness (traded for less obliviousness)
- I2 affords better parallel development and reduces aspect brittleness
- I2 advising control does not limit AOP capabilities

I2 Implementation

- JastAdd
  - Error Checking
  - AST Rewrite
- abc
  - Compilation Sequence

I2 Implementation

- Image checking and collecting information:
  - “opento” clause
  - “kind” clause
  - “exceptions” clause

I2 Implementation

- "image" rewrite
  - Wrapper methods introduction
  - (origin, boundary) to pointcuts
  - "around" advice
- Sample translation
- Precedence ordering aspect

Sample Translation

```
Priviliged static imageAspect {
  public void Point.translate(int dx, int dy) {
    moveby(dx, dy);
  }
  void around(Point p):
    target(p) && !within(imageAspect) &&
    !within(Point) &&
    call(public void Point.moveby(int dx, int dy)){
         p.translate(dx, dy);
    }
}
```

Precedence Ordering Aspect

```
public aspect _internalOrderingAspect{
declare precedence: *..*imageAspect*. *;
}
```

Compilation Sequence

- Image checking happens after computing intertype declarations
- Image rewrite and precedence ordering aspect
- Computing advice lists
- Filtering advice
- Weaving

Evaluation: Quantitative

- What are we measuring?
- How are we measuring it?
- Evaluation examples
- Results

What are we measuring?

- We measure coupling between aspects and base code classes
- Coupling is measured in terms of crosscutting relationships
- Crosscutting relationships result from advice and intertype declarations

How are we measuring it?

- Simulating effects of I2 syntax for AJDT
- Input to AJDT

Evaluation Examples

- Subject/Observer Protocol (1p, 6c, 2a)
- A Simple Telecom Simulation (1p, 10c, 2 a)
- Ants Simulation (11p, 33c, 11a)

Results

- I2 induces 26.3% more coupling for Subject/Observer Protocol
- I2 reduces coupling by 20% for Telecom Simulation
- I2 reduces coupling by 6.6% for Ants Simulation

Results

- Subject/Observer has only one advice, not much room for decoupling with aliases
- The use of “opento” introduces crosscutting relationships that were not existing in the original implementation

Results

- The more aspects use advice, the more the payoff (more room for aliasing)
- Ants Simulation is closer to real AOP programs in terms of the feature-mix. So it's result is a better representative of effects of aliasing

Related Work

- Open Modules(2004)
- AAI (2005)
- XPI (2006)
- EJP (2007)
- MAO (2007)
- Ptolemy (2007, 2008, 2009?)
- Key distinction

Differences from Open Modules

- Loose coupling without restricting advising
- I2 exposes an explicit set of joinpoints versus compact OM pointcuts
- Flexible joinpoint aliasing and advising constraints

Differences from AAI

- In I2, class is oblivious to which aspect will be extending its interface (except with opento)
- Improved readability
- Loose coupling between base code and aspect code

Differences from XPI

- In I2, joinpoints and constraints are the responsibility of the base code while pointcuts and advice are of the aspect code
- In I2, all advice is channeled through images
- Documentation of entry points into the class interface

Differences from EJP

- EJP can advise arbitrary blocks of code, I2 cannot
- EJP requires advising markers to be placed manually in the source code, I2 does not
- EJP does not incorporate advising constraints on the base code side

Differences from MAO

- MAO supports better modular reasoning in exchange for less feature-obliviousness
- Control effects and heap effects
- I2 engages the base code while MAO engages the aspect code for protection

Ptolemy

- Solves the fragile pointcut problem using typed events that pointcuts can be written in terms of
- I2 still relies on aliases so pointcuts are as stable as the aliases
- I2 relies on the predefined possible events of AspectJ

Key Distinction

- I2 recognize that interface specifications (e.g. method signatures) are intended to play two different roles in one breath:
  - Service Access Points
  - Joinpoints for use by aspects
- I2 reassigns these responsibilities by introducing the image construct and removes the role overlap

Conclusion

- It is possible to realize a design that loosely couples the evolution of base code interfaces from the AO code advising those components.
- It is possible to afford better parallel development and maintainability in exchange for less obliviousness.

Conclusion

- It is possible to provide a level of protection to the base code without restricting AO capabilities.
- Aid to modular reasoning in the presence of aspects.
- Achievable while maintaining a practical level that facilitates AOP adoption.

Thank You!