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Fine-Grained Generic Aspects

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FOAL Workshop

Overview

- Motivation
- LogicAJ 2
- Examples
- Related Work
- Conclusion

Limitations of Common Aspect Languages

- Restricted set of join points
  - ⇨ pointcuts just on the interface level (classes, methods, fields)
    - → **`call, execution, set, get …`**
  - ⇨ fine-grained ?
    - → e.g. loops ?

call

```
class Foo{
private int myField;
public void foo(){
  myField = 42;
  if(Bar.A < 4711){
     myField = 1;
  }
  else{
     myField = 0;
  }
}
public int bar(){
  foo();
  return myField;
}
public void m(int[] a, int[] b) {
  for(int i = 0;i< a.length;i++) {
    a[i] = 2*i;
    b[i] = i*i;
  } }
 }
```

parallizable!

statement

aspect

```
...
final Vector v = new Vector();
List list = new ArrayList();
final int range= (a.length-0)/THREADS;
for(int i = 0; i< THREADS; i++){
  final int finalThreads = i;
  Thread thread = new Thread(){
    public void run(){
      int newLb = lb+range*finalThreads;
      int newUB = newLB + range;
      if(newUB >= ub) newUB = ub;

      for(int i = newLB;i< newUB;i++) {
         a[i] = 2*i;
         b[i] = i*i;
      }
   }.run();
   list.add(thread);
   ...
```

Limitations of Common Aspect Languages

- Restricted set of join points

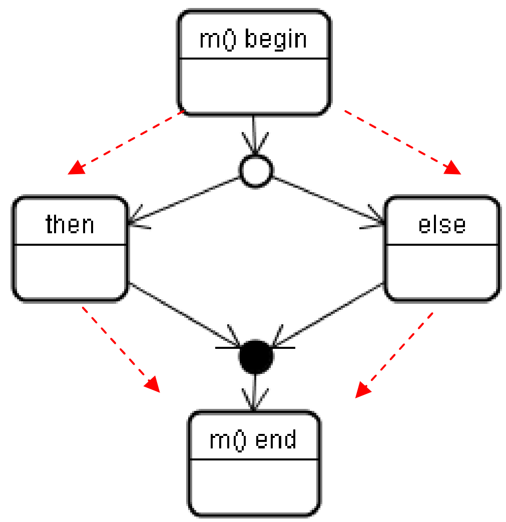
  ⇨ pointcuts just on the interface level (classes, methods, fields)

  → **`call, execution, set, get …`**

  ⇨ fine-grained ?

AOP Test Coverage?

```
class Foo{
private int myField;
public void foo(){
  myField = 42;
  if(Bar.A < 4711){
     myField = 1;
  }
  else{
     myField = 0;
}
public int bar(){
  foo();
  return myField;
}
public void (int[] a, int[] b) {
  for(int i = 0;i< a.length;i++) {
    a[i] = 2*i;
    b[i] = i*i;
  }
 }
```



Find Bad Smells

- Compile-time check for bad smells

```
class Foo{
 public int getValue(){
  if(this instanceof A) return 42;
  if(this instanceof B) return 4711;
  else return 0;
}…
```

Bad Smell!

?

aspect

Compile-time warning :
„Use Polymorphism!“

```
myField.methFromKnownClass().
                methFromUnknownClass();
```

Bad Smell!

?

aspect

Compile-time warning :
„Violates the Law of Demeter!“

LogicAJ 2

A fine-grained generic aspect language

Fine-grained pointcuts

- Fine-grained pointcuts
  - ⇨ select all syntactically distinguishable join points
    - → statements, expressions, declarations

```
    stmt(code)
    expr(code)
    decl(code)
```

- Minimal language core
  - ⇨ minimal number of pointcuts
  - ⇨ simple, easy to learn language based on code patterns

```
pointcut fooBarCalls():
    expr(foo() )
 || expr(bar() );
```

Extensible

- Extensible
  - ⇨ build high-level pointcuts by composition
    - → logic operations and recursion
  - ⇨ e.g. static *AspectJ* pointcut semantics
  - ⇨ loops, condition pointcuts

- Patterns?
  - ⇨ Placeholders necessary!
  - ⇨ Example task: Select all getter methods
    - → First try: use wildcards

```
pointcut getter():
    decl( public int get*() {
        *
        return *;
    });
```

Use Logic Meta-Variables instead of Wildcards

- Transition from wildcards to meta-variables

```
pointcut getter():
    decl( public int get*() {
          *
          return *;
    });
```

```
pointcut getter(?fname) :
    decl( public int ?getter() {
          ??stmts
          return ?fname;
    }) &&
    concat("get", ?fname, ?getter);
```

Logic Meta-Variables

- ⇨ Syntax: **?lmv**
- ⇨ Here: used to bind syntactically complete syntax elements
  - → statements, expressions, declarations, (type) identifier
- ⇨ Special meta-variables for lists: **??llmv**

```
pointcut getter(?fname) :
    decl( public int ?getter() {
        ??stmts
         return ?fname;
    }) &&
    concat("get", ?fname, ?getter);
```

identifier

arbitrary number of statements

auxiliary predicates for string and list operations

Relations between pointcuts

- Additional pointcut: setter

```
pointcut setter(?fname):
    decl( public void ?setter(int ?param) {
          ??stmtbefore
           this.?fname = ?param;
          ??stmtafter
    }) &&
    concat("set", ?fname, ?setter);
```

- New contract: For every setter there is a getter method in the *same* class

How do we express a relationship between selected join points?

```
pointcut inconsistentGetterSetter():
   setter(?fname) &&
  !getter(?fname);
```

INSUFFICIENT

Explicit join point variables

- Primitive pointcuts bind join points to meta-variables

```
stmt(?jp, code)
expr(?jp, code)
decl(?jp, code)
```

Explicit join point variables

- Primitive pointcuts bind the join points to a meta-variable

```
pointcut getter(?jp, ?fname):
    decl(?jp, public int ?getter() {
        ??stmts
         return ?fname;
    }) &&
    concat("get", ?fname, ?getter);

pointcut setter(?jp):  …
```

How do we express a relationship between **meta-variables**?

```
pointcut inconsistentGetterSetter():
   setter(?setter, ?fname) &&
  !getter(?getter ,?fname);
```

STILL INSUFFICIENT

How do we ensure they are defined in the same class?

Finally …

- Use attributes to relate to meta-variable context

```
pointcut getter(?jp):
    decl(?jp public int ?getter() {
        ??stmts
         return ?fname;
    }) &&
    concat(get, ?fname, ?getter);

pointcut setter(?jp):  …
```

```
pointcut inconsistentGetterSetter():
    setter(?setter, ?fname) &&
    !(getter(?getter, ?fname) &&
      equals(?getter::parent,
            ?setter::parent));
```

Logic Meta-Variable Attributes

- Meta-variable attributes provide context information
  - ⇨ Syntax: ?lmv::<attr>
- **parent**
  - ⇨ The enclosing element
- **ref**
  - ⇨ Resolved referenced declaration
- **type**
  - ⇨ Resolved Java type of an element bound to a LMV
    (syntactic sugar, inferable via the ref attribute)

Generalized Aspect Construct

- Syntax

explicit join point meta-variable

```
(  introduce | before | after | around )
               <name>(<jp id>, <optional parameters>) :
        <pointcut description>
{
        ( <class template> |
          <method introduction> |
          <field introduction> |
          <advice body> )
}
```

LogicAJ 2 Summary

- Fine-grained aspect language
- Minimal set of basic pointcuts as a language core
- Uniform genericity
- Extensible
  - ⇨ build high-level pointcuts by composition
    - → logic operations and recursion
  - ⇨ e.g. static *AspectJ* pointcut semantics
  - ⇨ loops, condition pointcuts

Constructing higher-level pointcuts

Named Pointcut Examples

- AspectJ call pointcut

```
pointcut call(?jp,??mods,?declType,?returnType,?name,??parTypes):
  expr(?jp, ?name(??args) )
  && decl(?jp::ref, ??mods ?returnType ?name(??par){??stmts} )
  && equals(?declType, ?jp::ref::parent::type)
  && parameterTypes(??parTypes,??par);
```

select call expression and bind **`?name`** to the method name and the LMV list variable **`??args`** to the arguments list

Named Pointcut Examples

- AspectJ call pointcut

```
pointcut call(?jp,??mods,?declType,?returnType,?name,??parTypes):
  expr(?jp, ?name(??args) )
  && decl(?jp::ref, ??mods ?returnType ?name(??par){??stmts} )
  && equals(?declType, ?jp::ref::parent::type)
  && parameterTypes(??parTypes,??par);
```

select the syntax elements of the referenced method **?jp**::ref

Using named pointcuts: Free Code Patterns

- Free Code patterns

```
pointcut call(?jp,??mods,?declType,?returnType,?name,??parTypes):
  …
```

```
after log(?jp):
   call(?jp, [public], ?ret, ClassX, ?m, [int] )
{
   System.out.println("called method" + ?m);
}
```

The call pointcut can easily be extended to support patterns.

For-loop pointcut

- For-loop

```
pointcut forLoop(?jp,index, ?lb, ?ub, ?incr, ?statements):
   stmt(
     for(?jp, type ?index = ?lb; ?index < ?ub; ?incr) {
       ??statements
     }
);
```

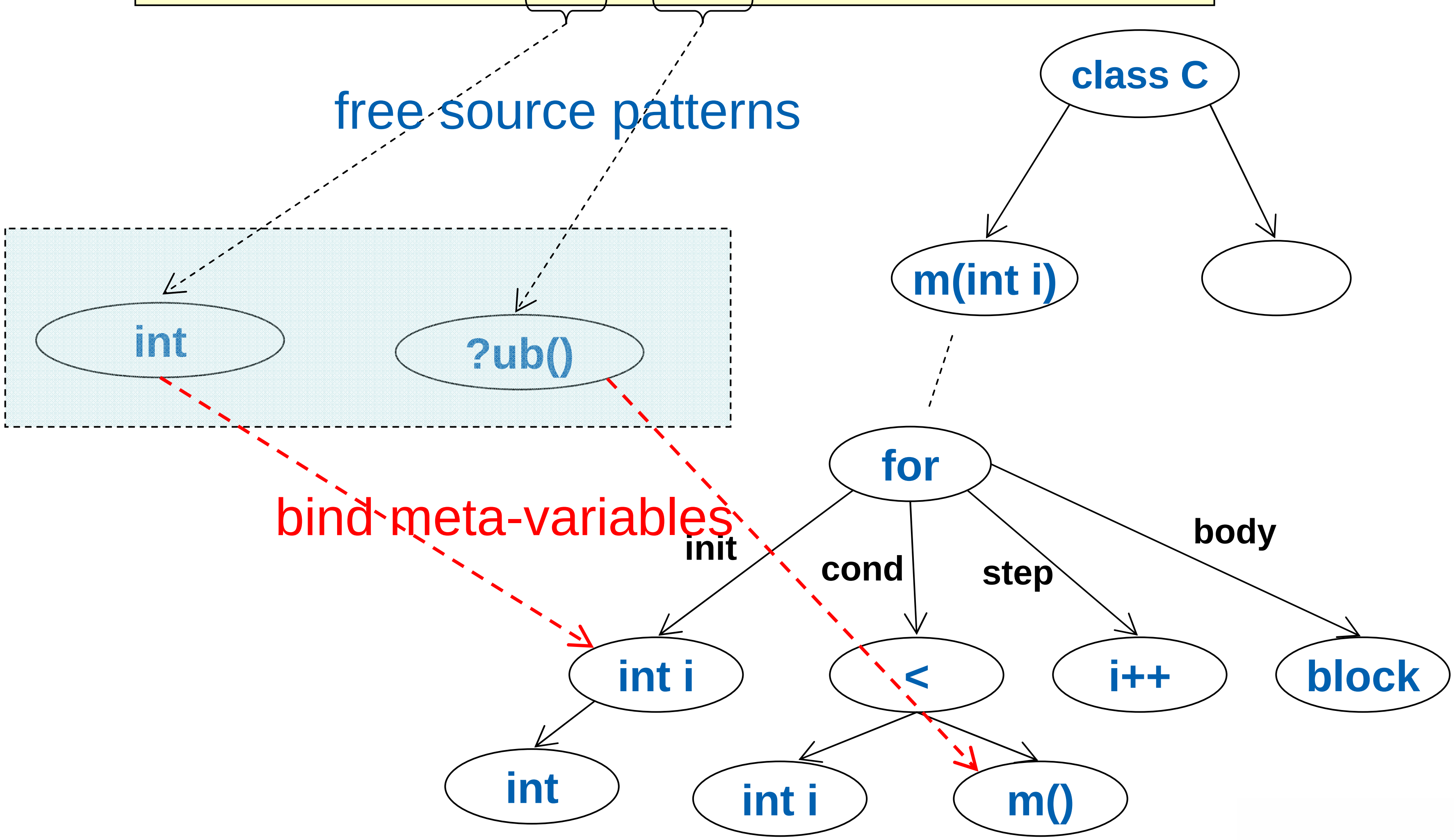
For-loop pointcut

- Using the For-loop pointcut

```
?range::type around():
   forLoop(?range, ?lb , ?ub, ?incr, ??statements)
{
   < .. >
   int newLb = < .. >
   int newUb = < .. >
   for(?range::type ?range = newLb;?range < newUb; ?incr) {
       ??statements
   }
   < .. >
}
```

Free Code Patterns

```
forLoop(?index, int, ?ub(), 0, ??statements)
```



Related Work

- concrete solutions to a subset of join points
  - ⇨ EOS (Hridesh Rajan et al.)
    - → conditionals and loop pointcuts
  - ⇨ LoopsAJ (B. Harbulot et al.)
    - → loop pointcut, byte code analysis
- Extensible Compiler
  - ⇨ abc Compiler (de Moor et al.)
    - → aspect compiler framework
    - → every part of the compiler is open to extension
    - → still, for all extensions compiler knowledge is necessary
- JaTS
  - ⇨ language for pattern based transformations of Java programs
  - ⇨ code patterns describe program parts on which transformations should take place
  - ⇨ transformation specification is described with another pattern
  - ⇨ both parts can be linked by the use of meta-variables, which substitute syntactic elements at the interface level of a base-program

Conclusion

- fine-grained genericity for aspect languages
- base-language code patterns with meta-variables
- minimal set of fine-grained pointcuts
- express dependencies between multiple join points
- define arbitrary kinds of pointcuts that previously required specific language extensions

Questions?

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