**StrongRelaxAJ: integrating adaptability of RelaxAJ and expressiveness of StrongAspectJ**

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**ABSTRACT**

A sketch of StrongRelaxAJ is presented. StrongRelaxAJ is an extension to AspectJ with a type system for around advice that integrates the ones in RelaxAJ and StrongAspectJ. In other words, StrongRelaxAJ employs the type-relaxed weaving mechanism in RelaxAJ for better adaptability of around advice, and supports type variables and explicit signatures of proceed for better expressiveness without relying on dangerous and annoying dynamic casting on the return values from proceed.

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1. INTRODUCTION

Around advice is one of the unique and powerful features of the pointcut and advice mechanism. It allows programmers not only to replace the operations with others without directly modifying the source code but also to change parameters and return values of operations by using proceed.

Defining a good type system for around advice is one of the challenges in statically typed aspect-oriented programming (AOP) languages that employ the pointcut and advice mechanism. Because a type system conservatively accepts “safe” programs, it constrains the adaptability of around advice.

Recent studies revealed and solved problems of type-safety and expressiveness in AspectJ [3, 5], which is one of the widely used statically typed AOP languages.

RelaxAJ [6], which is an extension to AspectJ, improves the adaptability of AspectJ’s around advice by relaxing the restriction on its return type. While a piece of around advice and its target join point on which the advice is executed must have the same return type for type safety in AspectJ, this is not required any more in RelaxAJ. Instead, it guarantees type safety by ensuring that the return values of around advice are safely used within the program.

StrongAspectJ [2] is another extension to AspectJ, which supports type-safe generic around advice. A piece of around advice in StrongAspectJ is safely evaluated on each target join point. Intuitively, it is achieved by ensuring that a piece of around advice always returns the return values of proceed.

This position paper points out the problems of expressiveness in RelaxAJ as well as the problems of adaptability in StrongAspectJ, and proposes StrongRelaxAJ as our solution. StrongRelaxAJ integrates the adaptability of RelaxAJ and genericity of StrongAspectJ. In other words, it solves the problems of expressiveness in RelaxAJ as well as solves the problems of adaptability in StrongAspectJ. In the position paper, we roughly explain its syntax and type checking rules by using a concrete example. Its formalization and implementation are left for future work.

The rest of the paper is organized as follows. Section 2 gives a brief overview of RelaxAJ and StrongAspectJ. Section 3 presents examples that cannot be achieved by either RelaxAJ or StrongAspectJ, and Section 4 shows a sketch of StrongRelaxAJ. After discussing related work in Section 5, Section 6 concludes the position paper and lists our future work.

2. BACKGROUND: RELAXAJ AND STRON-GASPECTJ

This section presents brief overviews of RelaxAJ and StrongAspectJ along with a code fragment that implements a popup window.

2.1 Base code: creating a popup window

Suppose we have an image editor in which one can manipulate images by applying various filters (e.g., Gaussian blur filters) and see a preview of the filter’s effect in a popup window. Listing 1 shows the method showPreview that creates a popup window for previewing.
It takes two parameters, namely mainWin, which is the main window of the application, and image, which is the processed image the user will see. MyCanvas, which is a subclass of JPanel, draws the processed image. The popup window popup, which is an instance of JWindow, contains a canvas and button. If the button is clicked then the popup window is closed.

### 2.2 RelaxAJ

RelaxAJ is an extension to AspectJ, which has a novel type-checking rule for the return types of around advice. A piece of around advice in RelaxAJ can have a return type that is not a subtype of the target join points' on which the advice is executed. In AspectJ, the return type instead must be a subtype of the target join points'.

Of course the return type cannot be any type in RelaxAJ. It must be consistent with the values as which the return values are used in the program.

Assume we want to create a modal dialog instead of a simple popup window in the above example so as not to leave previews outdated. One of the easiest ways to achieve it is to use JDialog with the modal flag, instead of JWindow.

Listing 2 shows a piece of around advice that implements the idea. It simply creates a new modal JDialog object and returns it when a JWindow object is to be created.

```java
Listing 2: Around advice that replaces JWindow with JDialog

RootPaneContainer around(Frame frame)
+call(JDialog||JWindow).new(Frame))&&args(frame){
  JDialog popup = proceed(frame);
  popup.setLocation(DEFAULT_LOC);
  popup.getContentPane().add(closeButton);
  popup.getContentPane().add(canvas);
  popup = new JDialog(mainWin, true);
  popup.setLocation(p); // here its return type
  popup = proceed(frame); //T proceed(Frame){
    popup = proceed(frame);
    popup.setLocation(DEFAULT_LOC);
    return popup;
  }
}
```

Note that the return type, which is RootPaneContainer, is a supertype of the target join point's return type, which is JWindow. It is not valid in AspectJ because it requires the return type is a subtype of the return types of its target join points.

RelaxAJ accepts the advice when it is applied only to the line 2 in Listing 1 because its return value is used only as RootPaneContainer within the program and thus the replacement is safe.

### 2.3 StrongAspectJ

StrongAspectJ is another extension to AspectJ, which supports type-safe generic around advice. The genericity and type-safety are achieved by using (bounded) type variables to declare the return types of around advice and also proceed. Although AspectJ implicitly decides the return type of proceed, StrongAspectJ does not. It is given by the programmer through a dual advice signature.

Assume a popup window is an instance of either JDialog or JWindow, and we want to specify the location where the window appears. This can be achieved by calling setLocation that is defined in Component.

Listing 3 is a piece of the around advice in StrongAspectJ that catches the popup window object and calls setLocation on it. Line 1 declares the type variable T whose upper bound is Component. It is used as the return type of the advice. Line 4 is the dual advice signature that declares the return and argument types of proceed: here its return type is T and its argument type is Frame.

If the base program is type safe, the woven program is also type safe. This is because (1) the return type of each target join points (JDialog or JWindow) is always a subtype of Component (see Figure 1) so that no type error occurs within the advice, and (2) the return types of the advice and proceed are always the same so that the values returned by the advice can be used safely as the original values.

### 3. EXAMPLES THAT NEED AN INTEGRATED LANGUAGE

By integrating RelaxAJ and StrongAspectJ, we can implement more adaptive and interesting aspects. This section presents two examples that cannot be achieved in either RelaxAJ or StrongAspectJ alone but can be achieved in the integrated language.

#### 3.1 Specifying return type of proceed in type-relaxing advice

![Figure 1: Relationship between Component, Window, JDialog, JWindow and RootPaneContainer](image-url)
Suppose that we want to make the popup window modal only if POPUP_MODAL is true. Otherwise, we show a message dialog that warns danger of out-of-date previews along with the original popup window. It can be achieved in RelaxAJ by defining a piece of around advice shown in Listing 4.

The problem here is the use of a cast operator at line 5. It is necessary because RelaxAJ simply adapts AspectJ's typing rule for proceed. The return type of proceed is the same to the one of the around advice, that is, RootPaneContainer. On the other hand, to set popup as the parent window of the message dialog (JOptionPane) through showMessageDialog1, its static type must be a subtype of Component, which is incompatible with RootPaneContainer.

We should be able to omit dynamic casting because it is obvious that proceed always returns a JWindow object. One way to achieve it is to add StrongAspectJ's dual advice signature and the typing rules to RelaxAJ. StrongAspectJ allows programmers to declare the return type of the advice in Line 2 instead of RootPaneContainer.

Of course StrongAspectJ does not accept such advice because its return type is invalid: it must be a subtype of the return types of the target join points (JWindow itself) and also (2) a subtype of the return type of the advice (RootPaneContainer).

We can define a piece of around advice whose return values are used as two or more incompatible types shown in Section 3.1. Type variables are used to define a piece of around advice whose return values are used as two or more incompatible types shown in Section 3.2.

### 3.2 Abstracting the return type of around advice by using type variables

RelaxAJ provides no way to write a piece of around advice whose return value of is used as two or more types incompatible with each other. In other words, the return type of a piece of around advice must be one type in RelaxAJ.

It is natural to control orders of windows in GUI programs. Listing 5 extends the base program (Listing 1) so that the popup window stays above all other windows. Line 7 is added where popup is used as a Window because setAlwaysOnTop, which is an instance method defined in Window, is called on it.

The around advice declaration in Listings 2 and 4 cannot be compiled with the above extended program. This is because the return type cannot be relaxed to RootPaneContainer. As mentioned before, the return value is used as:

1. showMessage(Component, Object) is a static method in JOptionPane

### 4. STRONGRELAXAJ

We propose StrongRelaxAJ, which is a hybrid of RelaxAJ and StrongAspectJ. StrongRelaxAJ has two additional language features, namely explicit signature of proceed and type variables to the type-relaxed weaving mechanism in RelaxAJ. An explicit signature of proceed helps us to omit dynamic casts shown in Section 3.1. Type variables are used to define a piece of around advice whose return values are used as two or more incompatible types shown in Section 3.2.

This section first explains how the StrongRelaxAJ around advice looks by showing an example. Then it explains about explicit signature of proceed and type variables.

#### 4.1 Around advice in StrongRelaxAJ

The syntax of around advice in StrongRelaxAJ is similar to StrongAspectJ. A piece of around advice in StrongRelaxAJ has declarations of type variables and the signature of proceed.

Listing 6 is a piece of around advice in StrongRelaxAJ. It is a modified version of the advice in Listing 3.1 that works with the extended base code shown in Listing 5.

Line 1 declares the type variable T whose upper bounds are RootPaneContainer and Window. It is used as the return type of the advice in Line 2 instead of RootPaneContainer. Line 4 declares the signature of proceed.

Note that we do not use dynamic casting at line 7. Because the return type of proceed is JWindow, we can use its
return value as a JWindow object.

4.2 Explicit signature of proceed

The return type of proceed in a piece of around advice must be (1) a supertype of the return types of the target join points and also (2) a supertype of the return types of around advice that may be called by proceed. In other words, StrongRelaxAJ does not need any relationships between the return type of a piece of around advice and its proceed unlike AspectJ, StrongAspectJ and RelaxAJ. This does not break type-safety because proceed never calls the around advice that encloses it.

Let’s look at the example in Section 4.1. The explicit signature of proceed on Line 4 in Listing 6 satisfies the condition. The return type JWindow is not a type variable, and it is clearly a supertype of JWindow, which is the return type of the target join points. Because there is no other pieces of advice, the second condition for non variable return types holds too.

4.3 Type variables

Type variables in StrongRelaxAJ are more expressive than the ones in StrongAspectJ. StrongAspectJ uses type variables to ensure that the return value of proceed is the return value of the advice. For instance, if the return type of proceed is T, which is a type variable, then the enclosing around advice must be T.

In addition to the usage, StrongRelaxAJ uses them to declare that the advice returns a value of some type that satisfies the upper bounds. Listing 6 is an example. It uses the type variable T to return JDialog and JWindow. Because each of them is a subtype of Window and RootPaneContainer, StrongRelaxAJ’s type system accepts the return statements.

Note that the return value is used as only a Window and a RootPaneContainer within the target program, that is, Listing 5. Therefore, type safety is preserved.

5. RELATED WORK

Adding union types to Java [4] gives another solution for the situation in Section 3.2. If it is allowed to use union types, we can declare the return type of the advice as JWindow ∨ JDialog instead of using a type variable as in Listing 6. Then RelaxAJ with union types successfully accepts the advice because JWindow and JDialog are subtypes of JWindow ∨ JDialog and RootPaneContainer and Window are supertypes of JWindow ∨ JDialog.

6. CONCLUSIONS AND FUTURE WORK

The position paper presented a sketch of StrongRelaxAJ, which is a hybrid of RelaxAJ and StrongAspectJ. By using explicit signature of proceed, programmers can omit dynamic casting on the return values of proceed. Type variables are used not only to write generic advice but also to declare the return type of a piece of around advice whose return type cannot be described by using only one type.

Dealing with parameter types of proceed is one of our future work as RelaxAJ. Formalization and implementation are also our future work. Formalization could be done by extending Featherweight Java for Relaxation (FJR) [6] and StrongAspectJ [2]. Implementation would be done on top of StrongAJ compiler or the AspectBench compiler (abc) [1].