The quark Tool

The **quark** tool was designed to illustrate the different ways in which module expressions are composed in different program synthesis paradigms. Four paradigms are considered: Ahead, AspectJ, Aspectual Mixin Layers++ (a generalization of Aspectual Mixin Layers that has pointcuts advising multiple pieces of advice), and General (a generalization of the previous three). The capabilities -- supporting, **introductions**, **local** (bounded) advice, **global** (unbounded) advice, and higher-order advice (**hoa**) -- of each of these models is tabulated below.

	introductions	local	global	hoa
Ahead	x	x		
AspectJ	x		x	
Aspectual Mixin Layers++	x		x	x
General	x	x	x	x

An ultimate goal of this work is to show a general theory of program synthesis that unifies aspects, ahead refinements, and aspect refinements. It is based on a staged meta-programming approach: the changes a feature makes to a program will be defined by a quark, an n-tuple of terms. The theory tells us how to weave (transform) each term of a quark into a program. The **quark** tool illustrates a two-level algebra: at the top level one defines feature expressions. These expressions are then transformed into module expressions, which implement introductions, advice, and higher-order advice. Once the feature expression of a program is defined, a module expression for it is synthesized. This expression is then evaluated to produce a module expression for the generated program. This is an example of staged meta-programming: a feature expression generates a module expression, which then is evaluated to generate a program.

In principle, a compiler implementing the theory will "inhale" a code base, as specified by a feature expression. The compiler will then generate a module expression (much like the one in the quark tool), and then it will evaluate this expression. Both evaluation steps involve program transformations.

- Invoking Quark
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Invoking Quark

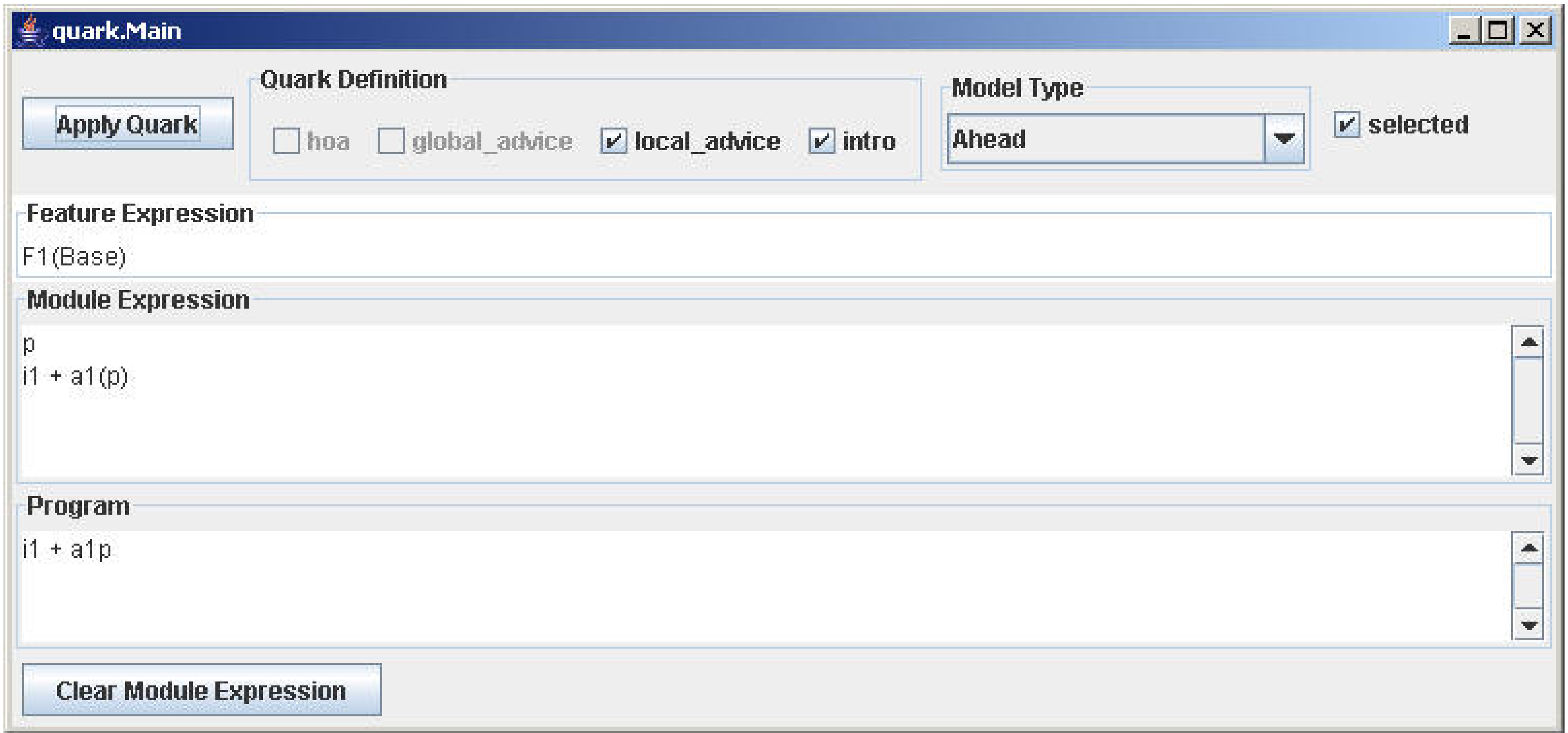
quark has no parameters. It is invoked from the command line by:

. > java quark.Main

The **quark.jar** file should be on your classpath.

A Tour

The **quark** tool screen is shown below, along with a labeling of its key panels.



A feature is defined by a quark. A **quark** is a 4-tuple, that may consist of an introduction, local advice, global advice, and a higher order advice (**hoa**). Different model types offer a subset of these terms. You can select the model that you want to use in the **Model Type** drop-down menu.

To the right of the **Model Type**, you can select which terms will be in a particular quark. In the above figure, a quark has both local advice and introductions. By clicking on term checkboxes, you can customize the contents of a quark.

The selected checkbox to the right of the **Model Type** sets whether any or all terms are selected in a quark by default.

Whe you click the **Apply Quark** button, the quark you specified is woven into a program. Initially, you have a program called Base which is modeled by the module expression 'p'. The figure above shows what happens after the **Apply Quark** has been clicked: a local advice is woven into p and an introduction is added. The **Feature Expression** field show the feature expression -- in this case, it is feature F1 (which consists of local advice and an introduction) has been woven into Base. Each time you click **Apply Quark**, you are applying a new feature to the expression in the **Feature Expression** field. The corresponding module expression is shown below in the **Module Expression** panel, and a 'pseudo' evaluation of the module expression is shown in the **Program** panel. Note that the **Module Expression** panel actually shows a list of expressions, where the bottom-most expression is the most recent module expression produced. (This allows you to see the sequence of transformations that have been applied). You can start a new computation by clicking the **Clear Module Expression** button.

Note that the order of quark term weaving is:

1. apply higher-order advice
2. apply local advice
3. apply introductions
4. apply global advice

Notation:

- introductions are added by +
- advice is composed by a() or a1.a2
- higher order advice is modeled by a function h[ ] using square brackets

- higher order advice is function composition, denoted by * (just so that you can visually detect where argument boundaries lie).

Have fun!

Implementation Notes

The quark tool generates module expressions in the following grammar:

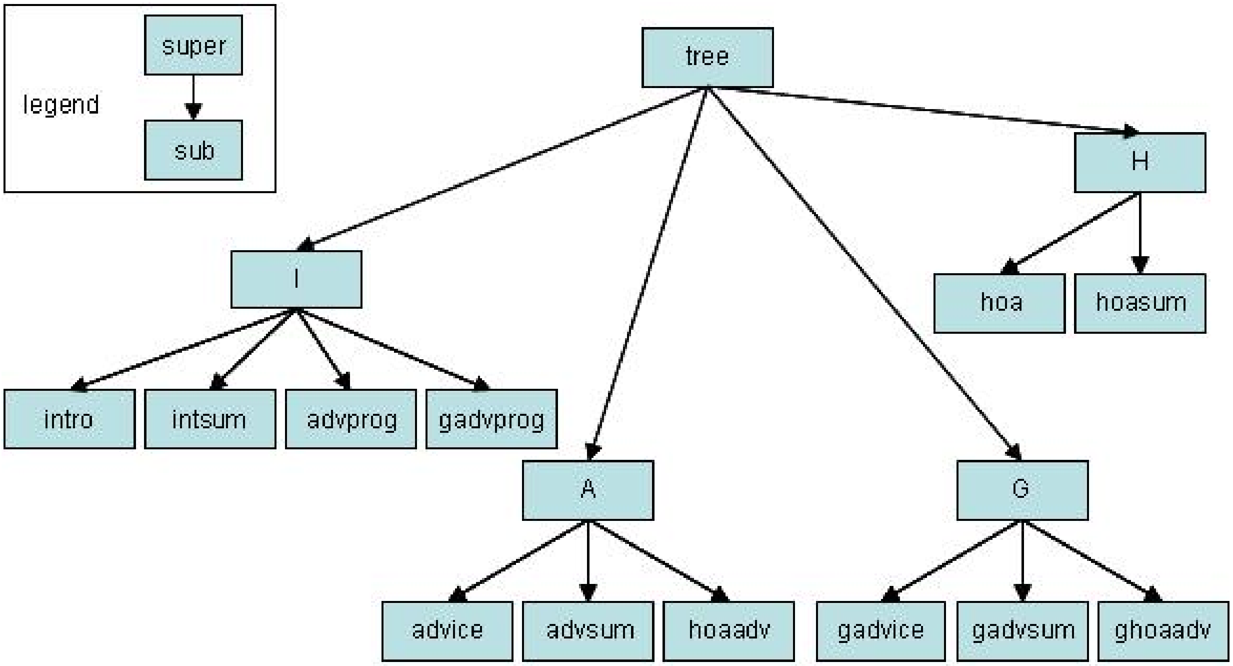
```
I  :  intro         :: intro
   |  intro + I     :: intsum
   |  A(I)          :: advprog
   |  G(I)          :: gavprog
   ;

A  : advice         :: advice
   | advice . A     :: advsum
   | H[A]           :: hoaadv
   ;

G  : gadvice        :: gadvice
   | gadvice . G    :: gadvsum
   | H[G]           :: ghoaadv
   ;

H  : hoa            :: hoa
   | hoa * H        :: hoasum
   ;
```

Each pattern (right-hand side of a production) has a name, indicated by the **::name** tag. When a production is recognized, an instance of a class with the pattern's name is instantiated. So an expression (intro + intro) is a tree rooted by an intsum object, whose left and right arguments are intro objects. All productions are instances of the class tree. An class diagram, which is derived from the above grammar, is shown below:



There are 4 different transformations that can be applied to a tree:

- apply(intro i) -- weave in an introduction
- apply(advice a) -- weave in a local advice
- apply(gadvice g) -- weave in a global advice
- apply(hoa h) -- weave in a higher-order advice

Notice that i, a, g, and h are names of terms. In reality, an introduction can be replaced with a sum of introductions, an advice can be replaced with a composition of advice, etc. In addition to the above methods that transform (weave) module expressions, there are two additional functions:

- toString( ) -- convert an expression into a pretty-printed string
- eval( ) -- do a pseudo-evaluation of an expression

Notation for expressions is simple. Here are some examples:

- i1+a1(p) means weave advice a1 into program p and add introduction i1
- g1(i1+p) means add introduction i1 to p and weave global advice g1
- h2[g1](i1+p) means apply higher-order advice h2 to global advice g1 to produce some refined advice g'; weave g' into the program that is the sum of i1 and p

The programs that are produced by the above expressions are trivially evaluated:

- i1+a1p means a1p is the introduction that results from a1(p)
- g1i1 + g1p means g1i1 is the introduction that results from g1(i1) and g1p is the introduction that results from g1(p)
- h1g1i1 + h2g1p means h1g1i is the introduction that results from h1[g1](i1) and h1g1p is the introduction that results from h1[g1](p)

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Last modified:02/04/2006