VALIDATOR FOR FLAMBDA2 SIMPLIFIER

1. Reduction strategy

Let-β
$$\mathsf{let}\ x\ =\ v\ \mathsf{in}\ e_2 \longrightarrow e_2\ [x \setminus v]$$

LetL
$$\frac{e_1 \longrightarrow e_1'}{\mathsf{let}\ x\ =\ e_1\ \mathsf{in}\ e_2 \longrightarrow \mathsf{let}\ x\ =\ e_1'\ \mathsf{in}\ e_2}$$

LetR
$$\frac{e_2 \longrightarrow e_2'}{\mathsf{let}\ x\ =\ N\ \mathsf{in}\ e_2 \longrightarrow \mathsf{let}\ x\ =\ N\ \mathsf{in}\ e_2'}$$

LetCodeDeleted
$$\mathsf{let}\ (\mathsf{code}\ x)\ =\ \mathsf{Deleted}\ \mathsf{in}\ e \longrightarrow e$$

LetCodeNewer
$$\mathsf{let}\ (\mathsf{code}\ (\mathsf{newer\_of}\ x)\ x')\ =\ e_1\ \mathsf{in}\ e_2 \longrightarrow \mathsf{let}\ (\mathsf{code}\ x)\ =\ e_1\ [x' \setminus x]\ \mathsf{in}\ e_2\ [x' \setminus x]$$

LetCode
$$\frac{e_2 \longrightarrow e_2'}{\mathsf{let}\ (\mathsf{code}\ x)\ =\ N\ \mathsf{in}\ e_2 \longrightarrow \mathsf{let}\ (\mathsf{code}\ x)\ =\ N\ \mathsf{in}\ e_2'}$$

LetCont-β
$$e_1\ \mathsf{where}\ k\ \overrightarrow{args}\ =\ e_2 \longrightarrow e_1\ [k \setminus \lambda\ \overrightarrow{args}.\, e_2]$$

ApplyContR
$$\frac{\overrightarrow{args} \longrightarrow \overrightarrow{args}'}{v\ \overrightarrow{args} \longrightarrow v\ \overrightarrow{args}'}$$

ApplyContL
$$\frac{k \longrightarrow k'}{k\ \overrightarrow{args} \longrightarrow k'\ \overrightarrow{args}}$$

ApplyCont-β
$$(\lambda\ x.\, e)\ v \longrightarrow e\ [x \setminus v]$$

ApplyR
$$\frac{\overrightarrow{args} \longrightarrow \overrightarrow{args}'}{e\ \ res_k\ \ exn_k\ \ \overrightarrow{args} \longrightarrow e\ \ res_k\ \ exn_k\ \ \overrightarrow{args}'}$$

ApplyL
$$\frac{e \longrightarrow e'}{e\ \ res_k\ \ exn_k\ \ \overrightarrow{args} \longrightarrow e'\ \ res_k\ \ exn_k\ \ \overrightarrow{args}}$$

Apply-β
$$(\lambda\ \overrightarrow{x}.\, e)\ \ res_k\ \ exn_k\ \ \overrightarrow{v} \longrightarrow e\ [x \setminus \overrightarrow{v}] \hookrightarrow res_k/exn_k$$

Switch
$$\frac{e \longrightarrow e'}{\mathsf{switch}\ (e)\ arms \longrightarrow \mathsf{switch}\ (e')\ arms}$$

Switch-β
$$\mathsf{switch}\ (v)\ [x \mapsto e] \longrightarrow e\ [x \setminus v]$$

$$\overrightarrow{args} \longrightarrow \overrightarrow{args}' := \forall a, a \in \overrightarrow{args}. \exists a', a \longrightarrow^{*} a' \wedge a \in \overrightarrow{args}'$$

LetR

This language has a call-by-value style reduction strategy. Notice the unusual [LetR] rule—the expression N refers to an expression in the normal form, which may refer to a normalized effectful expression. This rule is *not* analogous to the [ApplyContR] rule, since the lambda abstraction is always implicit in let expressions, ensuring that the "lefthand-side" of the application is always a value. This is necessary because for the case of several effectful expressions (such as a print statement), inlining the occurence of the expression multiple times will be behaviorally different from the original expression.

The [Apply-β] rule describes the case when the callee is a lambda expression, and the argument is fully evaluated. The expression is beta-reduced, then the resulting value get passed on as an argument to either the return or exception continuation, depending on whether or not the expression throws an exception.

The let-bindings that bind static code does not get inlined, as shown in [LetCode]. Here, N denotes any code that is not a $\mathsf{Deleted}$ snippet. Any let-bound code with a deleted code block gets erased, as in [LetCodeDeleted], and in place, every code binding that is a newer version of a code gets assigned the code id of the original code (note that this assumes a unique generation of newer versions of code, which is assumed for simplicity for now).

2. Rewrite Rules

FlattenMatch

$$\mathsf{switch}\ (\mathsf{switch}\ (e_1)\ [A \mapsto e_2 : B|..])\ [B \mapsto e_2'|..] \longrightarrow \mathsf{switch}\ (e_1)\ [A \mapsto e_2'\ [B \setminus e_2]|..]$$

3. Features

A wishlist of desirable inlining/semantic features to support for the validator.

3.1. Inlining.

- function calls
- recursive functions
- inlining (direct calls, within same function)
- cross-module inlining
- low-priority: locals

3.2. Semantics.

- mutable state
- exceptions
- effects (printing, etc.)
- external calls

3.3. **Primitives evaluation.**

- arithmetic evaluation: commutative and associative laws for arithmetic? It is likely that the commutative/associative laws are not necessary for the simplifier
- block-based primitives (makeblock, loading from block) The blocks have a tag, corresponding to the constructors (i.e. tag0 is the first constructor) values either are immediate tags or blocks Mutability corresponds to reference cells

  Being able to treat the block-related primitives will resolve supporting the structures below (except for arrays, which have a tricky case involving storing floating-point values. See floating-point valued array optimization)

TODO: Refactor [simplify_primitive].

3.4. **Supported structures.**

- structs
- tuples
- lists
- arrays