A Compositional Approach to Bidirectional Model Transformation

ICSE’09 New Ideas and Emerging Results

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Introduction

In bidirectional model transformation, modifications propagate from source models to target models as well as from target to source. Although bidirectional model transformation plays an important role in model-driven software development, lack of clear semantics of composition is one of open problems.

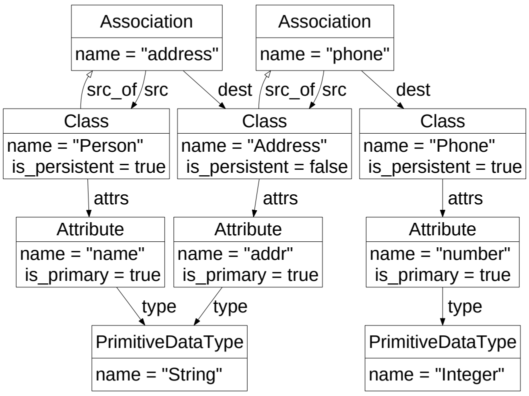
Proposed Approach and Results

Compositional graph transformation language UnQL is extended for bidirectional model transformation by

- Editing primitives (replace, delete, extend) [1]
- Bidirectional interpretation of each graph constructors and combinators [2]

Models as Edge-labeled Graphs

Models are internally represented by edge-labeled graphs.



Association
name = "address"

Association
name = "phone"

src_of / src   dest   src_of / src   dest

Class
name = "Person"
is_persistent = true

Class
name = "Address"
is_persistent = false

Class
name = "Phone"
is_persistent = true

attrs   attrs   attrs

Attribute
name = "name"
is_primary = true

Attribute
name = "addr"
is_primary = true

Attribute
name = "number"
is_primary = true

type   type   type

PrimitiveDataType
name = "String"

PrimitiveDataType
name = "Integer"

Class diagram: an example of models to be transformed

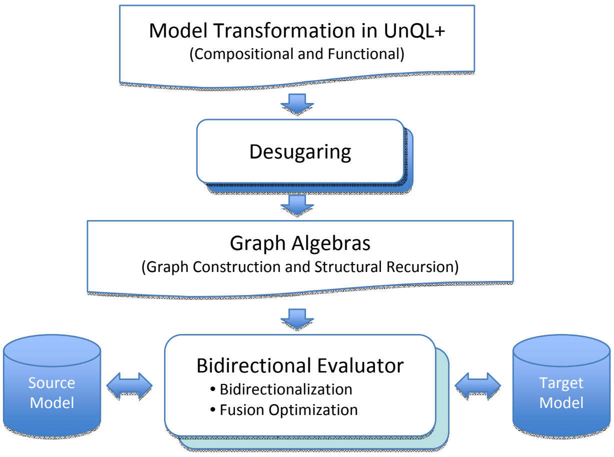
Model Transformations in UnQL+

Transformation to prefix every name of the class by “class_” can be expressed in UnQL+ as

replace {$*name* : {}} by {("*class_*"^$*name*):{}} where
{_*.*Class.name.String*:{$*name*:{}}} in $*classDB*

Bidirectional Evaluator and its property

Every UnQL+ program is translated[1] into UnCAL in which fixed number of constructors and combinators are combined to form a bigger transformation.



Model Transformation in UnQL+
(Compositional and Functional)

Desugaring

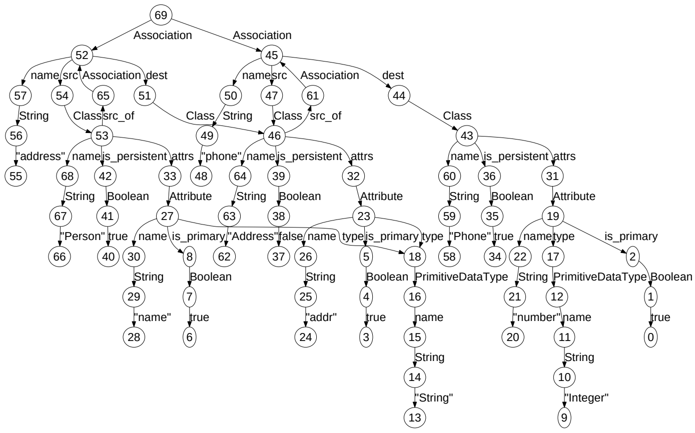
Graph Algebras
(Graph Construction and Structural Recursion)

Source Model

Bidirectional Evaluator
- Bidirectionalization
- Fusion Optimization

Target Model

A compositional Framework for Bidirectional Model Transformation



Internal representation of the class diagram that is transformed by our system

$E ::= \{\} \mid \{L : E\} \mid E \cup E$	(* tree constructors *)
$\mid \&x := E \mid \&y \mid () \mid E \oplus E \mid E \mathbin{@} E$	(* graph constructors *)
$\mid cycle(E)$	(* graph with cycles *)
$\mid Var$	(* variables *)
$\mid \text{let } Var = E \text{ in } E$	(* sequential composition *)
$\mid \text{if } B \text{ then } E \text{ else } E$	(* conditional *)
$\mid rec(\lambda(LabelVar, Var).E)(E)$	(* structural recursion *)

Syntax of UnCAL graph algebra

Formal semantics: union (∪) example

Two transformations are executed componentwise and combined.

$$\frac{\rho \xrightarrow{e_1} g_1 \quad \rho \xrightarrow{e_2} g_2 \quad g_1 \cup g_2 \Rightarrow g}{\rho \xrightarrow{e_1 \cup e_2} g}\,(\mathrm{FWD})$$

Modified target (g’) are decomposed and the resultant components are fed to backward transformation.

$$\frac{g' \Rightarrow_\rho (g'_1, g'_2) \quad \rho'_1 \xleftarrow[\rho]{e_1} g'_1 \quad \rho'_2 \xleftarrow[\rho]{e_2} g'_2}{\rho'_1 \uplus_\rho \rho'_2 \xleftarrow[\rho]{e_1 \cup e_2} g'}\,(\mathrm{BWD})$$

Well behavedness

No change on the target g should give no change on the source (environment) ρ.

$$\frac{\rho \xrightarrow{e} g}{\rho \xleftarrow[\rho]{e} g}\;[\mathrm{GetPut}]$$

Another forward transformation from the modified source ρ’ produces g’ again.

$$\frac{\rho' \xleftarrow[\rho]{e} g'}{\rho' \xrightarrow{e} g'}\;[\mathrm{PutGet}]$$

Impact and Future Work

- Demonstrate that functional approach is helpful to give bidirectional semantics in a formal and concise way
  - Demonstration available at http://www.biglab.org/
- Compare/combine with rule based approach

[1] S. Hidaka, Z. Hu, H. Kato, K. Nakano, Towards Compositional Approach to Model Transformation for Software Development, SAC 2009: 468-475, Mar. 2009.
[2] S. Hidaka, Z. Hu, H. Kato, and K. Nakano. An Algebraic approach to bidirectional model transformations. Technical Report GRACE-TR08-02, GRACE Center, National Institute of Informatics, Sept. 2008.

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