Lifting Definition Option*

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Abstract

We implemented a command, **lift-definition-option**, which can be used to easily generate elements of a restricted type $\{x :: 'a.\ P\ x\}$, provided the definition is of the form $\lambda\ y_1 \ldots y_n.\ \mathit{if}\ \mathit{check}\ y_1 \ldots y_n\ \mathit{then}\ \mathit{Some}\ (\mathit{generate}\ y_1 \ldots y_n :: 'a)\ \mathit{else}\ \mathit{None}$ and $\mathit{check}\ y_1 \ldots y_n \Longrightarrow P\ (\mathit{generate}\ y_1 \ldots y_n)$ can be proven.

In principle, such a definition is also directly possible using one invocation of **lift-definition**. However, then this definition will not be suitable for code-generation. To this end, we automated a more complex construction of Joachim Breitner which is amenable for code-generation, and where the test $\mathit{check}\ y_1 \ldots y_n$ will only be performed once. In the automation, one auxiliary type is created, and Isabelle's lifting- and transfer-package is invoked several times.

This entry is outdated as in the meantime the lifting- and transfer-package has the desired functionality in an even more general way. Therefore, only the examples are kept.

Contents

theory *Lifting-Definition-Option-Examples*
imports
  Main
begin

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1 Examples

1.1 A simple restricted type without type-parameters

typedef *restricted* = { *i* :: *int*. *i mod 2* = *0*} **morphisms** *base restricted*
by (*intro exI*[*of* - *4*]) *auto*
setup-lifting *type-definition-restricted*

Let us start with just using a sufficient criterion for testing for even numbers, without actually generating them, i.e., where the generator is just the identity function.

lift-definition(*code-dt*) *restricted-of-simple* :: *int* ⇒ *restricted option* **is**
λ *x* :: *int*. *if x* ∈ {*0*, *2*, *4*, *6*} *then Some x else None* **by** *auto*

We can also take several input arguments for the test, and generate a more complex value.

lift-definition(*code-dt*) *restricted-of-many-args* :: *nat* ⇒ *int* ⇒ *bool* ⇒ *restricted option* **is**
λ *x y* (*b* :: *bool*). *if int x* + *y* = *5 then Some* ((*int x* + *1*) ∗ (*y* + *1*)) *else None*
by *clarsimp presburger*

No problem to use type parameters.

lift-definition(*code-dt*) *restricted-of-poly* :: *'b list* ⇒ *restricted option* **is**
λ *xs* :: *'b list*. *if length xs* = *2 then Some* (*int* (*length* (*xs*))) *else None* **by** *auto*

1.2 Examples with type-parameters in the restricted type.

typedef *'f restrictedf* = { *xs* :: *'f list*. *length xs* < *3*} **morphisms** *basef restrictedf*

by (*intro exI*[*of* - *Nil*]) *auto*
setup-lifting *type-definition-restrictedf*

It does not matter, if we take the same or different type-parameters in the lift-definition.

lift-definition(*code-dt*) *test1* :: *'g* ⇒ *nat* ⇒ *'g restrictedf option* **is**
λ (*e* :: *'g*) *x*. *if x* < *2 then Some* (*replicate x e*) *else None* **by** *auto*

lift-definition(*code-dt*) *test2* :: *'f* ⇒ *nat* ⇒ *'f restrictedf option* **is**
λ (*e* :: *'f*) *x*. *if x* < *2 then Some* (*replicate x e*) *else None* **by** *auto*

Tests with multiple type-parameters.

typedef (*'a*,*'f*) *restr* = { (*xs* :: *'a list*,*ys* :: *'f list*) . *length xs* = *length ys*}
morphisms *base' restr*
by (*rule exI*[*of* - ([], [])], *auto*)
setup-lifting *type-definition-restr*

lift-definition(*code-dt*) *restr-of-pair* :: *'g* ⇒ *'e list* ⇒ *nat* ⇒ *nat* ⇒ (*'e*,*nat*) *restr option* **is**
λ (*z* :: *'g*) (*xs* :: *'e list*) (*y* :: *nat*) *n*. *if length xs* = *n then Some* (*xs*,*replicate n y*) *else None*

by *auto*

1.3 Example from IsaFoR/CeTA

An argument filter is a mapping π from n-ary function symbols into lists of positions, i.e., where each position is between 0 and n-1. In IsaFoR, (Isabelle's Formalization of Rewriting) and CeTA [1], the corresponding certifier for term rewriting related properties, this is modelled as follows, where a partial argument filter in a map is extended to a full one by means of an default filter.

typedef $'f\ af = \{\ (\pi :: 'f \times nat \Rightarrow nat\ list).\ (\forall\ f\ n.\ set\ (\pi\ (f,n)) \subseteq \{0\ ..< n\})\}$
morphisms *af Abs-af* **by** (*rule exI*[*of* - λ -. []], *auto*)

setup-lifting *type-definition-af*

type-synonym $'f\ af\text{-}impl = (('f \times nat) \times nat\ list)list$

fun *fun-of-map-fun* :: $('a \Rightarrow 'b\ option) \Rightarrow ('a \Rightarrow 'b) \Rightarrow ('a \Rightarrow 'b)$ **where**
fun-of-map-fun m f a = (*case m a of Some b* $\Rightarrow$ *b* | *None* $\Rightarrow$ *f a*)

lift-definition(*code-dt*) *af-of* :: $'f\ af\text{-}impl \Rightarrow 'f\ af\ option$ **is**
$\lambda\ s :: 'f\ af\text{-}impl.\ if\ (\forall\ fidx \in set\ s.\ (\forall\ i \in set\ (snd\ fidx).\ i < snd\ (fst\ fidx)))$
then Some (*fun-of-map-fun* (*map-of s*) (λ (*f*,*n*). [*0* ..< *n*])) *else None*
using *map-of-SomeD* **by** (*fastforce split*: *option.splits*)

1.4 Code generation tests and derived theorems

export-code
restricted-of-many-args
restricted-of-simple
restricted-of-poly
test1
test2
restr-of-pair
af-of
in *Haskell*

lemma *restricted-of-simple-Some*:
restricted-of-simple x = *Some r* $\Longrightarrow$ *base r* = *x*
using *restricted-of-simple.rep-eq*[*of x*]
apply (*split if-splits*)
apply (*simp-all only*: *option.map option.inject option.simps*(*3*))
done

end

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References

[1] R. Thiemann and C. Sternagel. Certification of termination proofs using CeTA. In S. Berghofer, T. Nipkow, C. Urban, and M. Wenzel, editors, *Theorem Proving in Higher Order Logics, 22nd International Conference, TPHOLs 2009, Munich, Germany, August 17-20, 2009. Proceedings*, volume 5674 of *Lecture Notes in Computer Science*, pages 452–468. Springer, 2009.