Funcons-beta: Storing

The PLanCompS Project

`Funcons-beta/Computations/Normal/Storing/Storing.cbs`*

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Issues: `https://github.com/plancomps/CBS-beta/issues`.

Storing

[*Datatype* locations
Alias locs
Type stores
Entity store
Funcon initialise-storing
Funcon store-clear
Datatype variables
Alias vars
Funcon variable
Alias var
Funcon allocate-variable
Alias alloc
Funcon recycle-variables
Alias recycle
Funcon initialise-variable
Alias init
Funcon allocate-initialised-variable
Alias alloc-init
Funcon assign
Funcon assigned
Funcon current-value
Funcon un-assign
Funcon structural-assign
Funcon structural-assigned]

Meta-variables $T, T' <:$ values

Stores

Type locations $\rightsquigarrow$ atoms

Alias locs = locations

A storage location is represented by an atom.

Type stores $\rightsquigarrow$ maps(locations, values ?)

The domain of a store is the set of currently allocated locations. Mapping a location to $(\,)$ models the absence of its stored value; removing it from the store allows it to be re-allocated.

$$\textit{Entity}\ \langle \_, \mathsf{store}(\_ : \mathsf{stores})\rangle \longrightarrow \langle \_, \mathsf{store}(\_ : \mathsf{stores})\rangle$$

The current store is a mutable entity. A transition $\langle X, \mathsf{store}(\sigma)\rangle \longrightarrow \langle X', \mathsf{store}(\sigma')\rangle$ models a step from X to X' where the difference between σ and σ' (if any) corresponds to storage effects.

$$\textit{Funcon}\ \mathsf{store\text{-}clear} : \Rightarrow \mathsf{null\text{-}type}$$
$$\textit{Rule}\ \langle \mathsf{store\text{-}clear}, \mathsf{store}(\_)\rangle \longrightarrow \langle \mathsf{null\text{-}value}, \mathsf{store}(\mathsf{map}(\,))\rangle$$

store-clear ensures the store is empty.

$$\begin{aligned}&\textit{Funcon}\ \mathsf{initialise\text{-}storing}(X : \Rightarrow T) : \Rightarrow T\\ &\quad \rightsquigarrow \mathsf{sequential}(\mathsf{store\text{-}clear},\\ &\qquad\quad \mathsf{initialise\text{-}giving}(\mathsf{initialise\text{-}generating}(X)))\end{aligned}$$
$$\textit{Alias}\ \mathsf{init\text{-}storing} = \mathsf{initialise\text{-}storing}$$

$\mathsf{initialise\text{-}storing}(X)$ ensures that the entities used by the funcons for storing are properly initialised.

Simple variables Simple variables may store primitive or structured values. The type of values stored by a variable is fixed when it is allocated. For instance, allocate-variable(integers) allocates a simple integer variable, and allocate-variable(vectors(integers)) allocates a structured variable for storing vectors of integers, which can be updated only monolithically.

$$\textit{Datatype}\ \mathsf{variables}\ ::=\ \mathsf{variable}(\_ : \mathsf{locations}, \_ : \mathsf{value\text{-}types})$$

$$\textit{Alias}\ \mathsf{vars} = \mathsf{variables}$$

$$\textit{Alias}\ \mathsf{var} = \mathsf{variable}$$

variables is the type of simple variables that can store values of a particular type.

$\mathsf{variable}(L, T)$ constructs a simple variable for storing values of type T at location L. Variables at different locations are independent.

Note that variables is a subtype of datatype-values.

Funcon $\mathsf{allocate\text{-}variable}(T : \mathsf{types}) : \Rightarrow \mathsf{variables}$

Alias $\mathsf{alloc} = \mathsf{allocate\text{-}variable}$

$\mathsf{allocate\text{-}variable}(T)$ gives a simple variable whose location is not in the current store. Subsequent uses of $\mathsf{allocate\text{-}variable}(T')$ give independent variables, except after $\mathsf{recycle\text{-}variables}(V, \cdots)$ or store-clear.

$$\textit{Rule}\ \frac{\begin{array}{c}\langle \mathsf{use\text{-}atom\text{-}not\text{-}in}(\mathsf{dom}(\sigma)), \mathsf{store}(\sigma)\rangle \longrightarrow \langle L, \mathsf{store}(\sigma')\rangle \\ \mathsf{map\text{-}override}(\{L \mapsto (\ )\}, \sigma') \rightsquigarrow \sigma''\end{array}}{\langle \mathsf{allocate\text{-}variable}(T : \mathsf{types}), \mathsf{store}(\sigma)\rangle \longrightarrow \langle \mathsf{variable}(L, T), \mathsf{store}(\sigma'')\rangle}$$

Funcon $\mathsf{recycle\text{-}variables}(\_ : \mathsf{variables}^{+}) : \Rightarrow \mathsf{null\text{-}type}$

Alias $\mathsf{recycle} = \mathsf{recycle\text{-}variables}$

$\mathsf{recycle\text{-}variables}(Var, \cdots)$ removes the locations of Var, ..., from the current store, so that they may subsequently be re-allocated.

$$\textit{Rule}\ \frac{\mathsf{is\text{-}in\text{-}set}(L, \mathsf{dom}(\sigma)) == \mathsf{true}}{\langle \mathsf{recycle\text{-}variables}(\mathsf{variable}(L : \mathsf{locations}, T : \mathsf{types})), \mathsf{store}(\sigma)\rangle \longrightarrow \langle \mathsf{null\text{-}value}, \mathsf{store}(\mathsf{map\text{-}delete}(\sigma, \{L\}))}$$

$$\textit{Rule}\ \frac{\mathsf{is\text{-}in\text{-}set}(L, \mathsf{dom}(\sigma)) == \mathsf{false}}{\langle \mathsf{recycle\text{-}variables}(\mathsf{variable}(L : \mathsf{locations}, T : \mathsf{types})), \mathsf{store}(\sigma)\rangle \longrightarrow \langle \mathsf{fail}, \mathsf{store}(\sigma)\rangle}$$

Rule $\mathsf{recycle\text{-}variables}(Var : \mathsf{variables}, Var^{+} : \mathsf{variables}^{+}) \rightsquigarrow \mathsf{sequential}(\mathsf{recycle\text{-}variables}(Var), \mathsf{recycle\text{-}variable}$

Funcon $\mathsf{initialise\text{-}variable}(\_ : \mathsf{variables}, \_ : \mathsf{values}) : \Rightarrow \mathsf{null\text{-}type}$

Alias $\mathsf{init} = \mathsf{initialise\text{-}variable}$

$\mathsf{initialise\text{-}variable}(Var, Val)$ assigns Val as the initial value of Var, and gives null-value. If Var already has an assigned value, it fails.

$$\textit{Rule}\ \frac{\mathsf{and}(\mathsf{is\text{-}in\text{-}set}(L, \mathsf{dom}(\sigma)), \mathsf{not}\ \ \mathsf{is\text{-}value}(\mathsf{map\text{-}lookup}(\sigma, L)), \mathsf{is\text{-}in\text{-}type}(Val, T)) == \mathsf{t}}{\langle \mathsf{initialise\text{-}variable}(\mathsf{variable}(L : \mathsf{locations}, T : \mathsf{types}), Val : \mathsf{values}), \mathsf{store}(\sigma)\rangle \longrightarrow \langle \mathsf{null\text{-}value}, \mathsf{store}(\mathsf{map\text{-}ov}}$$

$$\textit{Rule}\ \frac{\mathsf{and}(\mathsf{is\text{-}in\text{-}set}(L, \mathsf{dom}(\sigma)), \mathsf{not}\ \ \mathsf{is\text{-}value}(\mathsf{map\text{-}lookup}(\sigma, L)), \mathsf{is\text{-}in\text{-}type}(Val, T)) == \mathsf{false}}{\langle \mathsf{initialise\text{-}variable}(\mathsf{variable}(L : \mathsf{locations}, T : \mathsf{types}), Val : \mathsf{values}), \mathsf{store}(\sigma)\rangle \longrightarrow \langle \mathsf{fail}, \mathsf{store}(\sigma)\rangle}$$

Funcon allocate-initialised-variable(T, Val : T) : ⇒ variables
⇝ give(allocate-variable(T),
sequential(initialise-variable(given,
Val),
given))

Alias alloc-init = allocate-initialised-variable

allocate-initialised-variable(T, Val) allocates a simple variable for storing values of type T, initialises its value to Val, and returns the variable.

Funcon assign(_ : variables, _ : values) : ⇒ null-type

assign(Var, Val) assigns the value Val to the variable Var, provided that Var was allocated with a type that contains Val.

$$\textit{Rule}\ \frac{\text{and}(\text{is-in-set}(L, \text{dom}(\sigma)), \text{is-in-type}(Val, T)) == \text{true}}{\langle \text{assign}(\text{variable}(L : \text{locations}, T : \text{types}), Val : \text{values}), \text{store}(\sigma)\rangle \longrightarrow \langle \text{null-value}, \text{store}(\text{map-override}(\{L \mapsto}$$

$$\textit{Rule}\ \frac{\text{and}(\text{is-in-set}(L, \text{dom}(\sigma)), \text{is-in-type}(Val, T)) == \text{false}}{\langle \text{assign}(\text{variable}(L : \text{locations}, T : \text{types}), Val : \text{values}), \text{store}(\sigma)\rangle \longrightarrow \langle \text{fail}, \text{store}(\sigma)\rangle}$$

Funcon assigned(_ : variables) : ⇒ values

assigned(Var) gives the value assigned to the variable Var, failing if no value is currently assigned.

$$\textit{Rule}\ \frac{\text{map-lookup}(\sigma, L) \rightsquigarrow (Val : \text{values})}{\langle \text{assigned}(\text{variable}(L : \text{locations}, T : \text{types})), \text{store}(\sigma)\rangle \longrightarrow \langle Val, \text{store}(\sigma)\rangle}$$

$$\textit{Rule}\ \frac{\text{map-lookup}(\sigma, L) == (\ )}{\langle \text{assigned}(\text{variable}(L : \text{locations}, T : \text{types})), \text{store}(\sigma)\rangle \longrightarrow \langle \text{fail}, \text{store}(\sigma)\rangle}$$

Funcon current-value(_ : values) : ⇒ values

current-value(V) gives the same result as assigned(V) when V is a simple variable, and otherwise gives V.

It represents implicit dereferencing of a value that might be a variable.

Rule current-value(Var : variables) ⇝ assigned(Var)

Rule current-value(U : ∼variables) ⇝ U

Funcon $\textsf{un-assign}(\_ : \textsf{variables}) : \Rightarrow \textsf{null-type}$

$\textsf{un-assign}(\mathit{Var})$ remove the value assigned to the variable Var.

$$\textit{Rule}\ \frac{\textsf{is-in-set}(L, \textsf{dom}(\sigma)) == \textsf{true}}{\langle \textsf{un-assign}(\textsf{variable}(L : \textsf{locations}, T : \textsf{types})), \textsf{store}(\sigma)\rangle \longrightarrow \langle \textsf{null-value}, \textsf{store}(\textsf{map-override}(\{L \mapsto (\ )\}, \sigma)}$$

$$\textit{Rule}\ \frac{\textsf{is-in-set}(L, \textsf{dom}(\sigma)) == \textsf{false}}{\langle \textsf{un-assign}(\textsf{variable}(L : \textsf{locations}, T : \textsf{types})), \textsf{store}(\sigma)\rangle \longrightarrow \langle \textsf{fail}, \textsf{store}(\sigma)\rangle}$$

Structured variables Structured variables are structured values where some components are simple variables. Such component variables can be selected using the same funcons as for selecting components of structured values.

Structured variables containing both simple variables and values correspond to hybrid structures where particular components are mutable.

All datatypes (except for abstractions) can be used to form structured variables. So can maps, but not sets or multisets.

Structural generalisations of $\textsf{assign}(\mathit{Var}, \mathit{Val})$ and $\textsf{assigned}(\mathit{Var})$ access all the simple variables contained in a structured variable. Assignment requires each component value of a hybrid structured variable to be equal to the corresponding component of the structured value.

Funcon $\textsf{structural-assign}(\_ : \textsf{values}, \_ : \textsf{values}) : \Rightarrow \textsf{null-type}$

$\textsf{structural-assign}(V_1, V_2)$ takes a (potentially) structured variable $V_1$and a (potentially) structured value V_2. Provided that the structure and all non-variable values in V_1 match the structure and corresponding values of V_2, all the simple variables in V_1 are assigned the corresponding values of V_2; otherwise the assignment fails.

$$\textit{Rule}\ \textsf{structural-assign}(V_1 : \textsf{variables}, V_2 : \textsf{values}) \rightsquigarrow \textsf{assign}(V_1, V_2)$$

$$\textit{Rule}\ \frac{\begin{array}{c} V \\ V_1 \rightsquigarrow \textsf{datatype-va} \\ V_2 \rightsquigarrow \textsf{datatype-va} \end{array}}{\textsf{structural-assign}(V_1 : \textsf{datatype-values}, V_2 : \textsf{datatype-values}) \rightsquigarrow \textsf{sequential}(\textsf{check-true}(\textsf{is-equal}(I_1, I_2)), \textsf{e}}$$

Note that simple variables are datatype values.

$$\textit{Rule}\ \frac{\mathsf{dom}(M_1) == \{\ \}}{\mathsf{structural\text{-}assign}(M_1 : \mathsf{maps}(\_,\_), M_2 : \mathsf{maps}(\_,\_)) \rightsquigarrow \mathsf{check\text{-}true}(\mathsf{is\text{-}equal}(\mathsf{dom}(M_2), \{\ \}))}$$

$$\textit{Rule}\ \frac{\mathsf{some\text{-}}}{\mathsf{structural\text{-}assign}(M_1 : \mathsf{maps}(\_,\_), M_2 : \mathsf{maps}(\_,\_)) \rightsquigarrow \mathsf{sequential}(\mathsf{check\text{-}true}(\mathsf{is\text{-}in\text{-}set}(K, \mathsf{dom}(M_2))), \mathsf{stru}}$$

$$\textit{Rule}\ \frac{V_1 : \sim(\mathsf{datatype\text{-}values} \mid \mathsf{maps}(\_,\_))}{\mathsf{structural\text{-}assign}(V_1 : \mathsf{values}, V_2 : \mathsf{values}) \rightsquigarrow \mathsf{check\text{-}true}(\mathsf{is\text{-}equal}(V_1, V_2))}$$

Funcon $\mathsf{structural\text{-}assigned}(\_ : \mathsf{values}) : \Rightarrow \mathsf{values}$

$\mathsf{structural\text{-}assigned}(V)$ takes a (potentially) structured variable V, and computes the value of V with all simple variables in V replaced by their assigned values, failing if any of them do not have assigned values.

When V is just a simple variable or a (possibly structured) value with no component variables, $\mathsf{structural\text{-}assigned}(V)$ gives the same result as $\mathsf{current\text{-}value}(V)$.

Rule $\mathsf{structural\text{-}assigned}(Var : \mathsf{variables}) \rightsquigarrow \mathsf{assigned}(Var)$

$$\textit{Rule}\ \frac{V : \sim(\mathsf{variables}) \qquad V \rightsquigarrow \mathsf{datatype\text{-}value}(I : \mathsf{identifiers}, V^* : \mathsf{values}^*)}{\mathsf{structural\text{-}assigned}(V : \mathsf{datatype\text{-}values}) \rightsquigarrow \mathsf{datatype\text{-}value}(I, \mathsf{interleave\text{-}map}(\mathsf{structural\text{-}assigned}(\mathsf{given}),}$$

Note that simple variables are datatype values.

Rule $\mathsf{structural\text{-}assigned}(M : \mathsf{maps}(\_,\_)) \rightsquigarrow \mathsf{map}(\mathsf{interleave\text{-}map}(\mathsf{structural\text{-}assigned}(\mathsf{given}), \mathsf{map\text{-}elements}(M)$

$$\textit{Rule}\ \frac{U : \sim(\mathsf{datatype\text{-}values} \mid \mathsf{maps}(\_,\_))}{\mathsf{structural\text{-}assigned}(U : \mathsf{values}) \rightsquigarrow U}$$