1 Object encoding

Solution:

$\texttt{Object} = \{\}$

$\texttt{A} = \{foo : \texttt{Object} \to \texttt{Object},\ bar : \texttt{Object} \to \texttt{Object}\ \ get : \texttt{Unit} \to \texttt{Object}\}$
$\texttt{ARep} = \{x : \texttt{Ref Object}\}$

$\texttt{classA} =$
$\quad \lambda rep : \texttt{ARep}.$
$\quad\quad \lambda this : \texttt{Unit} \to \texttt{A}.$
$\quad\quad\quad \lambda\_ : \texttt{Unit}.\{$
$\quad\quad\quad\quad foo = \lambda a : \texttt{Object}.\ (this\ unit).bar\ a,$
$\quad\quad\quad\quad bar = \lambda b : \texttt{Object}.\ b$
$\quad\quad\quad\quad get = \lambda\_ : \texttt{Unit}.\ !(rep.x)$
$\quad\quad\quad \}$
$\texttt{newA} =$
$\quad \lambda x' : \texttt{Object}.$
$\quad\quad \texttt{let}\ r = \{x = \texttt{ref}\ x'\}\ \texttt{in fix}\ (\texttt{classA}\ r)\ unit$

$\texttt{B} = \texttt{A} = \{foo : \texttt{Object} \to \texttt{Object},\ bar : \texttt{Object} \to \texttt{Object}\ \ get : \texttt{Unit} \to \texttt{Object}\}$
$\texttt{BRep} = \{x : \texttt{Ref Object}, y : \texttt{Ref Object}\}$

$\texttt{classB} =$
$\quad \lambda rep : \texttt{BRep}.$
$\quad\quad \lambda this : \texttt{Unit} \to \texttt{A}.$
$\quad\quad\quad \lambda\_ : \texttt{Unit}.$
$\quad\quad\quad\quad \texttt{let}\ super = \texttt{classA}\ rep\ this\ unit\ \texttt{in}$
$\quad\quad\quad\quad \{$
$\quad\quad\quad\quad\quad foo = \lambda a : \texttt{Object}.\ !(rep.y),$
$\quad\quad\quad\quad\quad bar = \lambda b : \texttt{Object}.\ super.foo\ ((this\ unit).get\ unit)$
$\quad\quad\quad\quad\quad get = \lambda\_ : \texttt{Unit}.\ super.get\texttt{unit}$
$\quad\quad\quad\quad \}$
$\texttt{newB} =$
$\quad \lambda x' : \texttt{Object}.$
$\quad\quad \lambda y' : \texttt{Object}.$
$\quad\quad\quad \texttt{let}\ r = \{x = \texttt{ref}\ x',\ y = \texttt{ref}\ y'\}\ \texttt{in fix}\ (\texttt{classB}\ r)\ unit$

Results of evaluation:

- `new B(v, w).foo(z)` → w
- `new B(v, w).bar(z)` → diverge

Reduction steps:

$(\texttt{newB}\ v\ w\ unit).foo\ z$
$\longrightarrow ((\texttt{let}\ r\ =\ \{x = \texttt{ref}\ v,\ y = \texttt{ref}\ w\}\ \texttt{in fix}\ (\texttt{classB}\ r)\ unit)\ unit).foo\ z$

$\longrightarrow$ ($\texttt{fix}$ ($\texttt{classB}$ $\{x = \texttt{ref}\ v,\ y = \texttt{ref}\ w\}$) $unit$).foo z

$\longrightarrow$ ($\texttt{fix}$ $\lambda this : \texttt{Unit} \to \texttt{B}.\ \ \lambda\_ : \texttt{Unit}.$

$\texttt{let}$ $super\ =\ \texttt{classA}$ $\{x = \texttt{ref}\ v,\ y = \texttt{ref}\ w\}$ $this$ $unit$ $\texttt{in}$ $\{$

$foo\ =\ \lambda a : \texttt{Object}. \ldots$

$bar\ =\ \lambda b : \texttt{Object}. \ldots$

$get\ =\ \lambda\_ : \texttt{Unit}. \ldots$

$\}$ $unit$).foo z

2 Equivalences

Solution:

1. $\equiv$
2. NONE
3. $\cong$
4. NONE
5. $\cong_\beta$
6. $\cong_\beta$

3 Checked Error Handling

Solution:

(T-Error) $\Gamma\ ;\ \mathit{true} \vdash \texttt{error} : T$

(T-Try) $$\frac{\Gamma\ ;\ \mathit{true} \vdash t_1 : T \quad \Gamma\ ;\ E \vdash t_2 : T}{\Gamma\ ;\ E \vdash \texttt{try}\ t_1\ \texttt{with}\ t_2 : T}$$

All other typing rules do not modify the permission context.

(T-App) $$\frac{\Gamma\ ;\ E \vdash t_1 : T_1 \to T_2 \quad \Gamma\ ;\ E \vdash t_2 : T_1}{\Gamma\ ;\ E \vdash t_1\ t_2 : T_2}$$