

コード生成 + Shift0/Reset0 の型システム

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answer type は考えていない.
後で, answer type を加えたやつを考える.
answer type modification については考えない

1 Syntax

$$v ::= x \mid \lambda x.e \mid \langle e \rangle$$

$$\begin{aligned} e ::= & x \mid \lambda x.e \mid e \ e \\ & \mid \lambda x.e \mid \text{reset0 } e \mid \text{shift0 } k \rightarrow e \mid \text{throw } k \ e \\ & \mid \text{clet } x = e \text{ in } e \mid \langle e_1 \rangle @ \langle e_2 \rangle \mid \dots \end{aligned}$$

2 Semantics

2.1 Evaluation Context

$$E ::= [] \mid E \ e \mid v \ E \mid \text{reset0 } E \mid \underline{\lambda x}.E$$

2.2 Operation Semantics

$$\begin{aligned} E[(\lambda x.e) \ v] &\rightsquigarrow E[e\{x := v\}] \\ E[\text{reset0 } \langle e \rangle] &\rightsquigarrow E[\langle e \rangle] \\ E[(\lambda x.e)v] &\rightsquigarrow E[\underline{\lambda y}.e\{x := \langle y \rangle\}] \\ E[\underline{\lambda y}.\langle e \rangle] &\rightsquigarrow E[\langle \lambda y.e \rangle] \\ E[\text{reset0}(E'[\text{shift0 } k \rightarrow E''[\text{throw } k \ e]])] &\rightsquigarrow E[E''[e\{k := \underline{\lambda x}.\text{reset0 } (E'[x])\}]] \\ E[\langle e_1 \rangle @ \langle e_2 \rangle] &\rightsquigarrow E[\langle e_1 \ e_2 \rangle] \\ E[\text{clet } x = e_1 \text{ in } e_2] &\rightsquigarrow E[\underline{\lambda x}.e_2 @ e_1] \end{aligned}$$

3 Type System

$$t ::= \text{BasicType} \mid t \rightarrow t \mid \langle t \rangle^\gamma$$

Typing rule for code-level lambda:

$$\frac{\Gamma, \gamma_1 \geq \gamma, x : \langle t_1 \rangle^{\gamma_1} \vdash e : \langle t_2 \rangle^{\gamma_1}}{\Gamma \vdash \underline{\lambda}x.e : \langle t_1 \rightarrow t_2 \rangle^\gamma} \quad (\gamma_1 \text{ is eigen var})$$

Typing rule for code-level let (derived rule):

$$\frac{\Gamma \vdash e_1 : \langle t_1 \rangle^\gamma \quad \Gamma, \gamma_1 \geq \gamma, x : \langle t_1 \rangle^{\gamma_1} \vdash e_2 : \langle t_2 \rangle^{\gamma_1}}{\Gamma \vdash \underline{\text{clet}} x = e_1 \underline{\text{in}} e_2 : \langle t_2 \rangle^\gamma} \quad (\gamma_1 \text{ is eigen var})$$

Typing rule for code-level reset0:

$$\frac{\Gamma \vdash e : \langle t \rangle^\gamma}{\Gamma \vdash \underline{\text{reset0}} e : \langle t \rangle^\gamma}$$

Typing rule for code-level shift0:

$$\frac{\Gamma, k : (\langle t_1 \rangle^{\gamma_1} \Rightarrow \langle t_0 \rangle^{\gamma_0}) \vdash e : \langle t_0 \rangle^{\gamma_0} \quad \Gamma \models \gamma_1 \geq \gamma_0}{\Gamma \vdash \underline{\text{shift0}} k \rightarrow e : \langle t_1 \rangle^{\gamma_1}}$$

Typing rule for code-level throw:

$$\frac{\Gamma, \gamma_3 \geq \gamma_1, \gamma_3 \geq \gamma_2 \vdash e : \langle t_1 \rangle^{\gamma_3} \quad \Gamma \models \gamma_2 \geq \gamma_0}{\Gamma, k : (\langle t_1 \rangle^{\gamma_1} \Rightarrow \langle t_0 \rangle^{\gamma_0}) \vdash \underline{\text{throw}} k e : \langle t_0 \rangle^{\gamma_2}} \quad (\gamma_3 \text{ is eigen var})$$

4 Example

$$\begin{aligned} e_1 = & \underline{\text{reset0}} \quad \underline{\text{clet}} x_1 = \%3 \underline{\text{in}} \\ & \underline{\text{reset0}} \quad \underline{\text{clet}} x_2 = \%5 \underline{\text{in}} \\ & \underline{\text{shift0}} k \rightarrow \underline{\text{clet}} y = t \underline{\text{in}} \\ & \underline{\text{throw}} k (x_1 \pm x_2 \pm y) \end{aligned}$$

If $t = \%7$ or $t = x_1$, then e_1 is typable.

If $t = x_2$, then e_1 is not typable.

$$\begin{aligned} e_2 = & \underline{\text{reset0}} \quad \underline{\text{clet}} x_1 = \%3 \underline{\text{in}} \\ & \underline{\text{reset0}} \quad \underline{\text{clet}} x_2 = \%5 \underline{\text{in}} \\ & \underline{\text{shift0}} k_2 \rightarrow \underline{\text{shift0}} k_1 \rightarrow \underline{\text{clet}} y = t \underline{\text{in}} \\ & \underline{\text{throw}} k_1 (\underline{\text{throw}} k_2 (x_1 \pm x_2 \pm y)) \end{aligned}$$

If $t = \%7$, then e_1 is typable.

If $t = x_2$ or $t = x_1$, then e_1 is not typable.