

# Type system for Code Generation plus Shift0/Reset0

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Assumption: we ignore answer types. (Later we will consider them.)

## 1 Syntax and Operational Semantics

$$e ::= x \mid \lambda x.e \mid e \ e \mid \underline{\lambda}x.e \mid \mathbf{reset0} \ e \mid \mathbf{shift0} \ k \rightarrow e \mid \mathbf{throw} \ k \ e \mid \mathbf{clet} \ x = e \ \mathbf{in} \ e \mid \dots$$

## 2 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):

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

Typing rule for code-level reset0:

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

Typing rule for code-level shift0:

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

Typing rule for code-level throw:

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

### 3 Example

$e_1 = \underline{\text{reset0}} \quad \underline{\text{clet}} \ x_1 = \%3 \ \underline{\text{in}}$

$\underline{\text{reset0}} \quad \underline{\text{clet}} \ x_2 = \%5 \ \underline{\text{in}}$

$\underline{\text{shift0}} \ k \rightarrow \underline{\text{clet}} \ y = t \ \underline{\text{in}}$

$\underline{\text{throw}} \ k \ (x_1 \ \underline{+} \ x_2 \ \underline{+} \ y)$

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

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

$e_2 = \underline{\text{reset0}} \quad \underline{\text{clet}} \ x_1 = \%3 \ \underline{\text{in}}$

$\underline{\text{reset0}} \quad \underline{\text{clet}} \ x_2 = \%5 \ \underline{\text{in}}$

$\underline{\text{shift0}} \ k_2 \rightarrow \underline{\text{shift0}} \ k_1 \rightarrow \underline{\text{clet}} \ y = t \ \underline{\text{in}}$

$\underline{\text{throw}} \ k_1 \ (\underline{\text{throw}} \ k_2 \ (x_1 \ \underline{+} \ x_2 \ \underline{+} \ y))$

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

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