

Syntax

Literals	lit	$::= None \mid True \mid False \mid "a" \mid \dots \mid 1 \mid \dots$
Expression	Exp	$::= lit @ (\overline{A}) \mid Exp.id \mid f(\overline{Exp}) \mid Exp.f(\overline{Exp}) \mid C[\overline{A}](\overline{Exp})$
Typed Expression	$TExp$	$::= lit @ (\overline{A}) : \tau \mid \dots$
Assign Op.	$AsgOp$	$\in \{=, +=, -=, *=, /=, \%=, //=\}$
Binary Op.	$BinOp$	$\in \{ , \&\&, , \&, ==, !=, <, >, <=, >=, +, -, *, /, \%, **\}$
Statement	Stm	$::= \mathbf{pass} \mid \mathbf{return} \ Exp \mid Exp ; Stm \mid id = Exp ; Stm$ $\mid Exp_1 \ AsgOp \ Exp_2 ; Stm \mid \mathbf{if} \ Exp : Stm_1 ; \mathbf{else} : Stm_2 ; Stm$ $\mid \mathbf{try} : Stm \ \mathbf{except} : Exp ; Stm \mid \mathbf{raise} \ Exp$

Projection To Python

$$\begin{aligned}
(Exp) \quad \langle lit @ (\overline{B}) : \tau \rangle^A &= \begin{cases} lit & \text{if } A \in \overline{B} \\ \text{Unit.id} & \text{otherwise} \end{cases} \\
\langle Exp.id : \tau \rangle^A &= \begin{cases} \langle Exp \rangle^A.id & \text{if } A \in \text{rolesOf}(Exp.id) \\ \text{absent} & \text{otherwise} \end{cases} \\
\langle f(\overline{Exp}) : \tau \rangle^A &= \begin{cases} f(\langle \overline{Exp} \rangle^A) & \text{if } A \in \text{rolesOf}(f(\overline{Exp})) \\ \text{Unit.id}(f(\langle \overline{Exp} \rangle^A)) & \text{if } A \in \text{rolesOf}(\overline{Exp}) \wedge A \notin \text{rolesOf}(f(\overline{Exp})) \\ \text{Unit.id}(\langle \overline{Exp} \rangle^A) & \text{otherwise} \end{cases} \\
\langle Exp.f(\overline{Exp}) : \tau \rangle^A &= \begin{cases} \langle Exp \rangle^A.f(\langle \overline{Exp} \rangle^A) & \text{if } A \in \text{rolesOf}(Exp) \wedge A \in \text{rolesOf}(\overline{Exp}) \\ & \wedge A \in \text{rolesOf}(Exp.f(\overline{Exp})) \\ \text{Unit.id}(\langle Exp \rangle^A.f(\langle \overline{Exp} \rangle^A)) & \text{if } A \in \text{rolesOf}(Exp) \wedge A \notin \text{rolesOf}(Exp.f(\overline{Exp})) \\ \text{Unit.id}(\langle Exp \rangle^A, \langle \overline{Exp} \rangle^A) & \text{otherwise} \end{cases} \\
\langle C[\overline{B}](\overline{Exp}) : \tau \rangle^A &= \begin{cases} \langle C[\overline{B}] \rangle^A(\langle \overline{Exp} \rangle^A) & A \in \overline{B} \\ \text{Unit.id}(\langle \overline{Exp} \rangle^A) & \text{otherwise} \end{cases} \\
\text{rolesOf}(_ : \tau @ (\overline{B})) &= \overline{B} \\
\text{rolesOf}(\overline{Exp}) &= \bigcup_i \text{rolesOf}(Exp_i) \\
\langle \overline{Exp} \rangle^A &= Exp'_1, Exp'_2, \dots, Exp'_n \text{ where } Exp'_i = \langle Exp_i \rangle^A
\end{aligned}$$

$$\begin{aligned}
(Stm) \quad & \llbracket \text{pass} \rrbracket^A = \text{pass} \\
& \llbracket \text{return } Exp; \rrbracket^A = \text{return } \llbracket Exp \rrbracket^A \\
& \llbracket Exp; Stm \rrbracket^A = \begin{cases} \text{match } \llbracket Exp \rrbracket^A : & \text{if } Exp = Exp.f(\overline{Exp}) : \text{Enum} @ A \text{ and} \\ \quad \text{case } id : \llbracket Stm' \rrbracket^A; & @\text{SelectionMethod} \in \text{annotationOf}(f) \\ \quad \text{case } _ : \llbracket Stm'' \rrbracket^A; & \\ \llbracket Stm \rrbracket^A & \\ \llbracket Exp \rrbracket^A; \llbracket Stm \rrbracket^A & \text{otherwise} \end{cases} \\
& \llbracket id : TE = Exp ; Stm \rrbracket^A = \begin{cases} id = \llbracket Exp \rrbracket^A; \llbracket Stm \rrbracket^A & \text{if } A \in \text{rolesOf}(TE) \\ \llbracket Exp \rrbracket^A; \llbracket Stm \rrbracket^A & \text{otherwise} \end{cases} \\
& \llbracket Exp_1 \text{ AsgOp } Exp_2 ; Stm \rrbracket^A = \llbracket Exp_1 \rrbracket^A \text{ AsgOp } \llbracket Exp_2 \rrbracket^A ; \llbracket Stm \rrbracket^A \\
& \llbracket \text{if } Exp : Stm_1 ; \text{else} : Stm_2 ; Stm \rrbracket^A = \\
& \quad \begin{cases} \text{if } \llbracket Exp \rrbracket^A : \llbracket Stm_1 \rrbracket^A ; \text{else} : \llbracket Stm_2 \rrbracket^A ; \llbracket Stm \rrbracket^A & \text{if } \text{rolesOf}(Exp) = A \\ \llbracket Exp \rrbracket^A ; \llbracket \llbracket Stm_1 \rrbracket^A \rrbracket \sqcup \llbracket \llbracket Stm_2 \rrbracket^A \rrbracket ; \llbracket Stm \rrbracket^A & \text{otherwise} \end{cases} \\
& \llbracket \text{try} : Stm ; \text{except } Exp : Stm ; Stm \rrbracket^A = \\
& \quad \left\{ \text{try} : \llbracket Stm \rrbracket^A ; \overline{\llbracket Exp \rrbracket^A : \llbracket Stm \rrbracket^A} ; \llbracket Stm \rrbracket^A \quad \text{if } A \in \text{rolesOf}(Exp) \right.
\end{aligned}$$

Merging

Statement

$$\begin{aligned}
& \mathbf{return} \ Exp \sqcup \mathbf{return} \ Exp' = \mathbf{return} \ Exp \sqcup \mathbf{return} \ Exp' \\
& (Exp_1 \ \mathbf{AsgOp} \ Exp_2; Stm) \sqcup (Exp'_1 \ \mathbf{AsgOp} \ Exp'_2; Stm') \\
& \quad = (Exp_1 \sqcup Exp'_1) \ \mathbf{AsgOp} \ (Exp_2 \sqcup Exp'_2); (Stm \sqcup Stm') \\
& (Exp; Stm) \sqcup (Exp'; Stm') = (Exp \sqcup Exp'); (Stm \sqcup Stm') \\
& (\mathbf{if} \ Exp : Stm_1 ; \mathbf{else} : Stm_2 ; Stm) \sqcup (\mathbf{if} \ Exp' : Stm'_1 ; \mathbf{else} : Stm'_2 ; Stm') \\
& \quad = \mathbf{if} \ (Exp \sqcup Exp') : (Stm_1 \sqcup Stm'_1) ; \mathbf{else} : (Stm_2 \sqcup Stm'_2) ; (Stm \sqcup Stm') \\
& \mathbf{match} \ Exp : \qquad \qquad \mathbf{match} \ Exp' : \qquad \qquad \mathbf{match} \ Exp \sqcup Exp' : \\
& \quad \mathbf{case} \ id_a : Stm'_a; \qquad \quad \mathbf{case} \ id_a : Stm''_a; \qquad \quad \mathbf{case} \ id_a : Stm'_a \sqcup Stm''_a; \\
& \quad \dots \qquad \qquad \dots \qquad \qquad \dots \\
& \quad \mathbf{case} \ id_x : Stm'_x; \qquad \sqcup \qquad \mathbf{case} \ id_x : Stm''_x; \qquad = \qquad \mathbf{case} \ id_x : Stm'_x \sqcup Stm''_x; \\
& \quad \mathbf{case} \ id_y : Stm'_y; \qquad \qquad \mathbf{case} \ id_z : Stm'_z; \qquad \mathbf{case} \ id_y : Stm'_y; \\
& \quad \mathbf{case} \ _ : Stm'_{ex}; \qquad \mathbf{case} \ _ : Stm''_{ex}; \qquad \mathbf{case} \ id_z : Stm'_z; \\
& \quad Stm \qquad \qquad \qquad Stm' \qquad \qquad \qquad \mathbf{case} \ _ : Stm'_{ex} \sqcup Stm''_{ex}; \\
& \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad Stm \sqcup Stm'
\end{aligned}$$

tryexcept

Expression

$$\begin{aligned}
& f(\overline{Exp}) \sqcup f(\overline{Exp'}) = f(\overline{Exp \sqcup Exp'}) \\
& Exp.f(\overline{Exp}) \sqcup Exp'.f(\overline{Exp'}) = (Exp \sqcup Exp').f(\overline{Exp \sqcup Exp'})
\end{aligned}$$

Normaliser

Statements

$\llbracket \text{pass} \rrbracket = \text{pass}$

$\llbracket \text{return } Exp \rrbracket = \text{return } \llbracket Exp \rrbracket$

$\text{noop}(Exp) = \begin{cases} [blank] & \text{if } Exp \in \{\text{Unit.id}, \text{None}\} \\ Exp & \text{otherwise} \end{cases}$

$\llbracket Exp_1 \text{ AsgOp } Exp_2; Stm \rrbracket = \begin{cases} \llbracket Exp_1 \rrbracket; \llbracket Stm \rrbracket & \text{if } \text{noop}(\llbracket Exp_2 \rrbracket) = [blank] \\ \llbracket Exp_2 \rrbracket; \llbracket Stm \rrbracket & \text{if } \text{noop}(\llbracket Exp_1 \rrbracket) = [blank] \\ \llbracket Stm \rrbracket & \text{if } \text{noop}(\llbracket Exp_1 \rrbracket, \llbracket Exp_2 \rrbracket) = [blank] \\ \llbracket Exp_1 \rrbracket \text{ AsgOp } \llbracket Exp_2 \rrbracket; \llbracket Stm \rrbracket & \text{otherwise} \end{cases}$

$\llbracket Exp; Stm \rrbracket = \begin{cases} \llbracket Stm \rrbracket & \text{if } \text{noop}(\llbracket Exp \rrbracket) = [blank] \\ \llbracket Exp \rrbracket; \llbracket Stm \rrbracket & \text{otherwise} \end{cases}$

$\llbracket \text{if } Exp : Stm_1 ; \text{else} : Stm_2 ; Stm \rrbracket = \text{if } \llbracket Exp \rrbracket : \llbracket Stm_1 \rrbracket ; \text{else} : \llbracket Stm_2 \rrbracket ; \llbracket Stm \rrbracket$

$\llbracket \text{match } Exp : \overline{\text{case } id : Stm'} ; \text{case } _ : Stm'' ; Stm \rrbracket = \text{match } \llbracket Exp \rrbracket : \overline{\text{case } id : \llbracket Stm' \rrbracket} ; \text{else} : \llbracket Stm'' \rrbracket$