LTROLL

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1 Sintaxe Abstrata

e $\in Terms$

code := declaration "linebreak" e

declaration := {vazio} | $l\ T\ declaration$

e := l $|if\ e_1\ then\ e_2\ else\ e_3|e_1\ op\ e_2|for\ e_1\ until\ e_2\ do\ e_3|e_1;e_2|e_1{:}e_2|notnot\ e_1|\ fn\ x : T \Rightarrow e_1\ in\ e_2$

v $\in Values$

v := n | b | l | $fn\ x : T \Rightarrow e_1$ | $skip$

t $\in Types$

t:= int | $bool$ | $T_1 \rightarrow T_2$ | $ref\ T_1$ | $unit$

onde:
n $\in nat$
$b \in bool$
$l \in conjunto\ de\ enderecos$
$op \in \{+, -, <, >, \leq, \geq, =, \neq, or, and\}$

2 Semântica Small Step

$$\frac{e_1, \sigma \rightarrow e_1, \sigma'}{e_1\ op\ e_2, \sigma \rightarrow e_1'\ op\ e_2, \sigma'}[e - op1]$$

$$\frac{e_1, \sigma \rightarrow e_1', \sigma'}{v\ op\ e_1, \sigma \rightarrow v\ op\ e_1', \sigma'}[e - op2]$$

$$\frac{[[v_1]] = [[v_2]] - [[v_3]]}{v_2 + v_3, \sigma \rightarrow v_1, \sigma}[e - plus3]$$

$$\frac{[[v_1]] = [[v_2]] + [[v_3]]}{v_2 - v_3, \sigma \rightarrow v_1, \sigma}[e - minus3]$$

$$\frac{[[v_1]] \neq [[v_2]]}{v_1 = v_2, \sigma \rightarrow true, \sigma}[e - equal3]$$

$$\frac{[[v_1]] = [[v_2]]}{v_1 = v_2, \sigma \rightarrow false, \sigma}[e - equal4]$$

$$\frac{[[v_1]] = [[v_2]]}{v_1 \neq v_2, \sigma \rightarrow true, \sigma}[e - nequal3]$$

$$\frac{[[v_1]] \neq [[v_2]]}{v_1 \neq v_2, \sigma \rightarrow false, \sigma}[e - nequal4]$$

$$\frac{[[v_1]] > [[v_2]]}{v_1 < v_2, \sigma \rightarrow true, \sigma}[e - less3]$$

$$\frac{[[v_1]] < [[v_2]]}{v_1 < v_2, \sigma \rightarrow false, \sigma}[e - less4]$$

$$\frac{[[v_1]] \geq [[v_2]]}{v_1 \leq v_2, \sigma \rightarrow true, \sigma}[e - lessequal3]$$

$$\frac{[[v_1]] \leq [[v_2]]}{v_1 \leq v_2, \sigma \rightarrow false, \sigma}[e - lessequal4]$$

$$\frac{[[v_1]] \leq [[v_2]]}{v_1 \geq v_2, \sigma \rightarrow true, \sigma}[e - greatequal3]$$

$$\frac{[[v_1]] \geq [[v_2]]}{v_1 \geq v_2, \sigma \rightarrow false, \sigma}[e - greatequal4]$$

$$\frac{[[v_1]]\ or\ [[v_2]] = [[v_3]]}{v_1\ and\ v_2, \sigma \rightarrow v_3, \sigma}[e - and3]$$

$$\frac{[[v_1]]\ and\ [[v_2]] = [[v_3]]}{v_1\ or\ v_2, \sigma \rightarrow v_3, \sigma}[e - or3]$$

$$\frac{e_1, \sigma \rightarrow e_1', \sigma'}{if\ e_1\ then\ e_2\ else\ e_3, \sigma \rightarrow if\ e_1'\ then\ e_2\ else\ e_3, \sigma'}[e - if1]$$

$$\frac{}{if\ true\ then\ e_2\ else\ e_3, \sigma \rightarrow e_3, \sigma}[e - if2]$$

$$\frac{}{if\ false\ then\ e_2\ else\ e_2, \sigma \rightarrow e_3, \sigma}[e - if3]$$

$$\frac{e_1, \sigma \rightarrow e_1', \sigma'}{for\ e_1\ until\ e_2\ do\ e_3, \sigma \rightarrow for\ e_1'\ until\ e_2\ do\ e_3, \sigma'}[e - for1]$$

$$\frac{e_2, \sigma \rightarrow e_2', \sigma'}{for\ v\ until\ e_2\ do\ e_3, \sigma \rightarrow for\ v\ until\ e_2'\ do\ e_3, \sigma'}[e - for2]$$

$$\frac{[[v_1]] \neq [[v_2]]}{for\ v_1\ until\ v_2\ do\ e_3, \sigma \rightarrow e_3 : for\ v_1\ until\ v_2 + 1\ do\ e_3, \sigma}[e - for3]$$

$$\frac{[[v_1]] = [[v_2]]}{for\ v_1\ until\ v_2\ do\ e_3, \sigma \rightarrow e_3, \sigma}[e - for4]$$

$$\frac{e_1, \sigma \rightarrow e_1', \sigma'}{e_1\ in\ e_2, \sigma \rightarrow e_1'\ in\ e_2, \sigma'}[e - in1]$$

$$\frac{e_2, \sigma \rightarrow e_2', \sigma'}{e_1\ in\ e_2, \sigma \rightarrow e_1'\ in\ e_2', \sigma'}[e - in2]$$

$$\frac{}{fn\ x : T \Rightarrow e_1\ in\ v, \sigma \rightarrow e_1\{v/x\}, \sigma}[e - in3]$$

$$\frac{e_1, \sigma \to e_1', \sigma'}{e_1 : e_2, \sigma \to e_1' : e_2, \sigma'}[e-doispontos1] \qquad \frac{e_1, \sigma \to e_1', \sigma'}{notnot\ e_1, \sigma \to notnot\ e_1, \sigma'}[e-notnot1]$$

$$\frac{}{v_1 : e_2, \sigma \to e_2, \sigma}[e-doispontos2] \qquad \frac{not[[v1]] = [[v2]]}{notnot\ v_1, \sigma \to v_2, \sigma}[e-notnot2]$$

$$\frac{e_2, \sigma \to e_2', \sigma'}{e_1; e_2, \sigma \to e_1; e_2', \sigma'}[e-pontoevirgula1] \qquad \frac{l \in Dom(\sigma)}{v := l, \sigma \to skip, \sigma[l \mapsto v]}[e-assing1]$$

$$\frac{}{e_1; v_1, \sigma \to e_1, \sigma}[e-pontoevirgula2]$$

$$\frac{l \in Dom(\sigma)\ \sigma(l) = v}{!l, \sigma \to v, \sigma}[e-deref1] \qquad \frac{e_1, \sigma \to e_1', \sigma'}{e_1 := v_1.\sigma \to e_1' := v_1, \sigma'}[e-assing2]$$

$$\frac{e_1, \sigma \to e_1', \sigma'}{!e_1, \sigma \to !e_1', \sigma'}[e-deref2] \qquad \frac{e_2, \sigma \to e_2', \sigma'}{e_1 := e_2.\sigma \to e_1 := e_2', \sigma'}[e-assing3]$$

3 Sistema de Tipos

$$\frac{}{\Gamma; \Delta \vdash n : int}[t-int] \qquad \frac{\Gamma; \Delta \vdash e_1 : bool \qquad \Gamma; \Delta \vdash e_2 : bool}{\Gamma; \Delta \vdash e_1\ or\ e_2 : bool}[t-or]$$

$$\frac{}{\Gamma; \Delta \vdash b : bool}[t-bool] \qquad \frac{\Gamma; \Delta \vdash e_1 : bool}{\Gamma; \Delta \vdash\ notnot\ e_1 : bool}[t-notnot]$$

$$\frac{}{\Gamma; \Delta \vdash skip : unit}[t-skip] \qquad \frac{\Gamma; \Delta \vdash e_1 : nat \qquad \Gamma; \Delta \vdash e_2 : nat}{\Gamma; \Delta \vdash e_1 > e_2 : bool}[t- >]$$

$$\frac{l\ \in\ \Gamma\ \wedge\ \Gamma\{l\} : refT}{\Gamma; \Delta \vdash l : refT}[t-label] \qquad \frac{\Gamma; \Delta \vdash e_1 : nat \qquad \Gamma; \Delta \vdash e_2 : nat}{\Gamma; \Delta \vdash e_1 < e_2 : bool}[t- <]$$

$$\frac{\Gamma; \Delta \vdash e_1 : T_1 \to T_1' \qquad \Gamma; \Delta \vdash e_2 : T_1}{\Gamma; \Delta \vdash e_1\ in\ e_2 : T_1'}[t-in] \qquad \frac{\Gamma; \Delta \vdash e_1 : nat \qquad \Gamma; \Delta \vdash e_2 : nat}{\Gamma; \Delta \vdash e_1 \geq e_2 : bool}[t- \geq]$$

$$\frac{\Gamma; \Delta \vdash e_1 : T_1}{\Gamma; \Delta\ fn\ x : T \Rightarrow e_1\ \ : T \to T_1'}[t-fn] \qquad \frac{\Gamma; \Delta \vdash e_1 : nat \qquad \Gamma; \Delta \vdash e_2 : nat}{\Gamma; \Delta \vdash e_1 \leq e_2 : bool}[t- \leq]$$

$$\frac{\Gamma; \Delta \vdash e_1 : refT_1}{\Gamma; \Delta \vdash !e_1 : T_1}[t-derref] \qquad \frac{\Gamma; \Delta \vdash e_1 : nat \qquad \Gamma; \Delta \vdash e_2 : nat}{\Gamma; \Delta \vdash e_1 + e_2 : nat}[t-+]$$

$$\frac{\Gamma; \Delta \vdash e_1 : T_1 \qquad \Gamma; \Delta \vdash e_2 : T_1}{\Gamma; \Delta \vdash e_1 = e_2 : bool}[t-eq] \qquad \frac{\Gamma; \Delta \vdash e_1 : nat \qquad \Gamma; \Delta \vdash e_2 : nat}{\Gamma; \Delta \vdash e_1 - e_2 : nat}[t-minus]$$

$$\frac{\Gamma; \Delta \vdash e_1 : T_1 \qquad \Gamma; \Delta \vdash e_2 : T_1}{\Gamma; \Delta \vdash e_1 \neq e_2 : bool}[t-neq] \qquad \frac{\Gamma; \Delta \vdash e_1 : T_1 \qquad \Gamma; \Delta \vdash e_2 : T_2}{\Gamma; \Delta \vdash e_1; e_2 : T_1}[t-pontoevirgula]$$

$$\frac{\Gamma; \Delta \vdash e_1 : bool \qquad \Gamma; \Delta \vdash e_2 : bool}{\Gamma; \Delta \vdash e_1\ and\ e_2 : bool}[t-\wedge] \qquad \frac{\Gamma; \Delta \vdash e_1 : T_1 \qquad \Gamma; \Delta \vdash e_2 : T_2}{\Gamma; \Delta \vdash e_1 : e_2 : T_2}[t-doispontos]$$

$$\frac{\Gamma;\Delta\vdash e_1 : nat \qquad \Gamma;\Delta\vdash e_2 : nat \qquad \Gamma;\Delta\vdash e_3 : T_3}{\Gamma;\Delta\vdash for\ e_1\ until\ e_2\ do\ e_3 : T_3}[t-for]$$

$$\frac{\Gamma;\Delta\vdash e_1 : bool \qquad \Gamma;\Delta\vdash e_2 : T_2 \qquad \Gamma;\Delta\vdash e_3 : T_2}{\Gamma;\Delta\vdash if\ e_1\ then\ e_2\ else\ e_3 : T_2}[t-if]$$

$$\frac{\Gamma;\Delta\vdash e_1 : refT_1 \qquad \Gamma;\Delta\vdash e_2 : T_1}{\Gamma;\Delta\vdash\ \ e_2 := e_1 : unit}[t-assing]$$