Rubigo-lang Structural Operational Semantics

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January 15, 2021

1 Structural Operational Semantics

General Defenitions:

$$
\begin{aligned}
i &= \text{Integer} \\
f &= \text{Float} \\
n &\in \{i, f\} \\
b &= \text{Boolean} \\
v &\in \{n, b\} \\
uop &= \text{Unary Operator} \\
bop &= \text{Binary Operator} \\
x &= \text{Variable} \\
p &= \text{Pointer} \\
e &= \text{Expression} \\
stmt &= \text{Statement} \\
\sigma &= \text{State/Memory} \\
fc &= \text{Function Call}
\end{aligned}
$$

Program:

$$\frac{\langle stmt_1, \sigma\rangle \Downarrow \langle void, \sigma'\rangle}{\langle stmt_1; stmt_2; \cdots; stmt_n, \sigma\rangle \Downarrow \langle stmt_2; \cdots; stmt_n, \sigma'\rangle}$$

Block:

$$\frac{\langle stmt_1, \sigma\rangle \Downarrow \langle void, \sigma'\rangle}{\langle stmt_1; stmt_2; \cdots; stmt_n, \sigma\rangle \Downarrow \langle stmt_2; \cdots; stmt_n, \sigma'\rangle}$$

$$\frac{\langle stmt_1, \sigma\rangle \Downarrow \langle v, \sigma'\rangle}{\langle stmt_1; stmt_2; \cdots; stmt_n, \sigma\rangle \Downarrow \langle v, \sigma'\rangle}$$

Statement:

$$\frac{\langle stmt, \sigma\rangle \Downarrow \langle \mathbf{void}, \sigma'\rangle}{\langle stmt, \sigma\rangle \Downarrow \sigma'}$$

$$\frac{\langle stmt, \sigma\rangle \Downarrow \langle v, \sigma'\rangle}{\langle stmt, \sigma\rangle \Downarrow \langle v, \sigma'\rangle}$$

While:

$$\frac{\langle e, \sigma\rangle \Downarrow \langle \mathbf{true}, \sigma'\rangle \quad \langle block, \sigma'\rangle \Downarrow \sigma''}{\langle \mathbf{while}\ e\ \mathbf{do}\ block, \sigma\rangle \Downarrow \langle \mathbf{while}\ e\ \mathbf{do}\ block, \sigma''\rangle}$$

$$\frac{\langle e, \sigma\rangle \Downarrow \langle \mathbf{false}, \sigma'\rangle}{\langle \mathbf{while}\ e\ \mathbf{do}\ block, \sigma\rangle \Downarrow \sigma'}$$

If:

$$\frac{\langle e, \sigma\rangle \Downarrow \langle \mathbf{true}, \sigma'\rangle \quad \langle block_1, \sigma'\rangle \Downarrow \sigma''}{\langle \mathbf{if}\ e\ \mathbf{then}\ block_1\ \mathbf{else}\ block_2, \sigma\rangle \Downarrow \sigma''}$$

$$\frac{\langle e, \sigma\rangle \Downarrow \langle \mathbf{false}, \sigma'\rangle \quad \langle block_2, \sigma'\rangle \Downarrow \sigma''}{\langle \mathbf{if}\ e\ \mathbf{then}\ block_1\ \mathbf{else}\ block_2, \sigma\rangle \Downarrow \sigma''}$$

Return:

$$\frac{\langle e, \sigma\rangle \Downarrow \langle v, \sigma'\rangle}{\langle \mathbf{return}\ e, \sigma\rangle \Downarrow \langle v, \sigma'\rangle}$$

Let/Assignment:

$$\frac{\langle e, \sigma\rangle \Downarrow \langle v, \sigma'\rangle}{\langle x := e, \sigma\rangle \Downarrow \langle \sigma'[x := v]\rangle}$$

$$\frac{\langle e, \sigma\rangle \Downarrow \langle p, \sigma'\rangle}{\langle x := e, \sigma\rangle \Downarrow \langle \sigma'[x := p]\rangle}$$

Function Call:

$$\frac{\langle fc, \sigma\rangle \Downarrow \langle \mathbf{void}, \sigma'\rangle}{\langle fc, \sigma\rangle \Downarrow \sigma'}$$

$$\frac{\langle fc, \sigma\rangle \Downarrow \langle v, \sigma'\rangle}{\langle fc, \sigma\rangle \Downarrow \langle v, \sigma'\rangle}$$

Expression:

$$\frac{\langle e, \sigma\rangle \Downarrow \langle v, \sigma'\rangle}{\langle e, \sigma\rangle \Downarrow \langle v, \sigma'\rangle}$$

$$\frac{\langle e, \sigma\rangle \Downarrow \langle p, \sigma'\rangle}{\langle e, \sigma\rangle \Downarrow \langle p, \sigma'\rangle}$$

Binary Operations:

$$\frac{\langle e_1, \sigma\rangle \Downarrow \langle v_1, \sigma'\rangle \quad \langle e_2, \sigma'\rangle \Downarrow \langle v_2, \sigma''\rangle \quad \langle v_1 \ \mathbf{bop}\ v_2, \sigma''\rangle \Downarrow \langle v_3, \sigma''\rangle}{\langle e_1 \ \mathbf{bop}\ e_2, \sigma\rangle \Downarrow \langle v_3, \sigma''\rangle}$$

Unary Operations:

$$\frac{\langle e, \sigma\rangle \Downarrow \langle v, \sigma'\rangle \quad \langle uop\ v, \sigma'\rangle \Downarrow \langle v', \sigma'\rangle}{\langle uop\ e, \sigma\rangle \Downarrow \langle v', \sigma'\rangle}$$

Borrow Variable:

$$\frac{}{\langle \&x, \sigma\rangle \Downarrow \langle p, \sigma\rangle}$$

Dereference Pointer:

$$\frac{\langle p, \sigma\rangle \Downarrow \langle p', \sigma\rangle}{\langle p, \sigma\rangle \Downarrow \langle p', \sigma\rangle}$$

$$\frac{\langle p, \sigma\rangle \Downarrow \langle v, \sigma\rangle}{\langle p, \sigma\rangle \Downarrow \langle v, \sigma\rangle}$$

Variable:

$$\frac{}{\langle x, \sigma\rangle \Downarrow \langle v, \sigma\rangle}$$

Value:

$$\frac{}{\langle v, \sigma\rangle \Downarrow \langle v, \sigma\rangle}$$

1.1 Example Explination

Hllep