University of Massachusetts Lowell — Comp 3010: Organization of Programming Languages

Assignment 3

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1 Large-Step Semantics (25 points)

Let us define the calculator language below that performs arithmetic and boolean operations. It has three different syntactic classes: (1) arithmetic expressions a (2) boolean expressions b, and (3) final values v. The following questions require you define small-step semantics. That is, first you need to define the configuration. Then, you need to write inference rules that show one configuration large-steps to another configuration. Recall that your large-step is a relation between an expression and a value.

$$\begin{array}{lll} n & \in & \mathbb{Z} \\ a & ::= & n \mid a_1 + a_2 \mid a_1 \times a_2 \\ b & ::= & \textbf{true} \mid \textbf{false} \mid a = a \mid a \neq a \\ & & \mid a \leq a \mid a > a \mid \neg b \mid b \&\& b \\ v & ::= & n \mid \textbf{true} \mid \textbf{false} \end{array}$$

(a) Write large-step semantics for the syntactic class of arithmetic expressions generated by a. Assume the standard addition and multiplication operation between integers.
The following questions require you define small-step semantics. That is, first you need to define the configuration. Then, you need to write inference rules that show one configuration large-steps to another configuration. Recall that your large-step is a relation between an expression and a value.

$$\begin{array}{l} n \in \mathbb{Z} \\ a ::= n \mid a_1 + a_2 \mid a_1 \times a_2 \\ b ::= \text{true} \mid \text{false} \mid a = a \mid a \neq a \\ \quad \mid a \leq a \mid a \rangle a \mid \neg b \mid b \&\& b \\ v ::= n \mid \text{true} \mid \text{false} \end{array}$$

Solution

(a) Large-step semantics for arithmetic expressions

$$\frac{}{n \Downarrow n} \text{ (Int part)}$$

$$\frac{a_1 \Downarrow n_1 \quad a_2 \Downarrow n_2}{a_1 + a_2 \Downarrow n_1 + n_2} \text{ (Addition part)}$$

$$\frac{a_1 \Downarrow n_1 \quad a_2 \Downarrow n_2}{a_1 \times a_2 \Downarrow n_1 \times n_2} \text{ (Multiplication part)}$$

(b) Write large-step semantics for the syntactic class of boolean expressions generated by b. Assume the standard boolean operations between integers as well as between boolean expressions.

Solution

$$\frac{}{\text{true} \Downarrow \text{true}}\ \text{(True)} \qquad \frac{}{\text{false} \Downarrow \text{false}}\ \text{(False)}$$

$$\frac{a_1 \Downarrow n_1 \quad a_2 \Downarrow n_2}{a_1 = a_2 \Downarrow \text{true}}\ \text{if } n_1 = n_2 \text{ (Eq-True)}$$

$$\frac{a_1 \Downarrow n_1 \quad a_2 \Downarrow n_2}{a_1 = a_2 \Downarrow \text{false}}\ \text{if } n_1 \neq n_2 \text{ (Eq-False)}$$

$$\frac{a_1 \Downarrow n_1 \quad a_2 \Downarrow n_2}{a_1 \neq a_2 \Downarrow \text{true}}\ \text{if } n_1 \neq n_2 \text{ (Neq-True)}$$

$$\frac{a_1 \Downarrow n_1 \quad a_2 \Downarrow n_2}{a_1 \neq a_2 \Downarrow \text{false}}\ \text{if } n_1 = n_2 \text{ (Neq-False)}$$

$$\frac{a_1 \Downarrow n_1 \quad a_2 \Downarrow n_2}{a_1 \leq a_2 \Downarrow \text{true}}\ \text{if } n_1 \leq n_2 \text{ (Leq-True)}$$

$$\frac{a_1 \Downarrow n_1 \quad a_2 \Downarrow n_2}{a_1 \leq a_2 \Downarrow \text{false}}\ \text{if } n_1 \rangle n_2 \text{ (Leq-False)}$$

$$\frac{a_1 \Downarrow n_1 \quad a_2 \Downarrow n_2}{a_1 \rangle a_2 \Downarrow \text{true}}\ \text{if } n_1 \rangle n_2 \text{ (Gt-True)}$$

$$\frac{a_1 \Downarrow n_1 \quad a_2 \Downarrow n_2}{a_1 \rangle a_2 \Downarrow \text{false}}\ \text{if } n_1 \leq n_2 \text{ (Gt-False)}$$

$$\frac{b \Downarrow \text{true}}{\neg b \Downarrow \text{false}}\ \text{(Not-True)} \qquad \frac{b \Downarrow \text{false}}{\neg b \Downarrow \text{true}}\ \text{(Not-False)}$$

$$\frac{b_1 \Downarrow \text{true} \quad b_2 \Downarrow \text{true}}{b_1 \&\& b_2 \Downarrow \text{true}}\ \text{(And-True)}$$

$$\frac{b_1 \Downarrow \text{false}}{b_1 \&\& b_2 \Downarrow \text{false}}\ \text{(And-False1)} \qquad \frac{b_1 \Downarrow \text{true} \quad b_2 \Downarrow \text{false}}{b_1 \&\& b_2 \Downarrow \text{false}}\ \text{(And-False2)}$$