Language Syntax, Semantics, Runtime Errors

CS 536: Science of Programming, Fall 2020

Due Sat Oct 10, 11:59 pm

Problems [50 points]

Class 5: Language Syntax/Operational Semantics

1. [8 points] Translate the program below into our programming language.
   \[ p = 1; \ k = x = 0; \textbf{while} (k++ < n) \{ ++x; \ p *= \ x; \} \]

2. [12 = 3 * 4 points] Let \( S \equiv \text{if } x > 0 \text{ then } x := x \ast z \text{ else if } y > 0 \text{ then } y := y \ast z \text{ fi fi.} \)
   a. Evaluate \( \langle S, \{ x = 2, y = 6 \} \rangle \) to completion, using step-by-step operational (i.e., \( \rightarrow \)) semantics.
   b. Evaluate \( \langle S, \{ x = -2, y = 8 \} \rangle \) to completion, using step-by-step operational semantics.
   c. Evaluate \( \langle S, \{ x = -1, y = -2 \} \rangle \) to completion, using step-by-step operational semantics.

3. [10 points] Let \( W \equiv \text{while } k \neq n \text{ do } S \text{ od} \) where \( S \equiv k := k+1; x := x+k \ast k \).
   Let \( \sigma_0 = \{ k = 0, x = 1, n = 4 \} \).
   Evaluate \( \langle W, \sigma_0 \rangle \) to completion. Show all configurations of the form \( \langle W, \text{state} \rangle \) and the final \( \langle E, \bot \rangle \).
   You can use \( \rightarrow^n \) to skip other configurations if you like, or you can show them (your choice).

Class 6: Denotational Semantics, Runtime Errors

4. [9 = 3 * 3 points] Give the denotational semantics \( (M(S, \ldots) = ?) \) of the configurations in Problem 2a – 2c.

5. [4 points] Take the \( W \) from Problem 3. What is the set of \( \sigma \) such that \( \langle W, \sigma \rangle \rightarrow^* \langle E, \bot \rangle \)?

6. [8 points] Let \( S = x := b[m-2] / \sqrt{k} \) and let \( \sigma = \{ m = \alpha, k = \gamma, b = \beta \} \).
   Let \( \delta \) be the length of \( b \), so \( \beta(0), \ldots, \beta(\delta-1) \) are the values of \( b[0], b[1], \ldots \).
   Describe the set of all \( \sigma \) that cause \( M(S, \sigma) = \{ \bot_e \} \).
   (As in class, divide by zero and square root of a negative number cause errors.)