Language Syntax, Semantics, Runtime Errors

CS 536: Science of Programming, Fall 2021

Due Tue Sep 21, 11:59 pm

Problems [60 points]

Class 5: Language Syntax/Operational Semantics

1. [12 = 4 * 3 points] Translate the program below into our programming language.
   a. \( p = 1; k = x = 0; \text{while} \ (k++ < n) \{ \quad \text{++x; } p *= x; \} \)
   b. \( q = y = 1; j = n; \text{while} \ (- - j < n) \{ \quad \text{x++; } q += y; \} \)
   c. \( r = z = 1; j = n; \text{while} \ (- - j < n) \{ \quad \text{z++; } r += z; \} \)
   d. \( a = z = 1; j = n; \text{while} \ (- - j < n) \{ \quad \text{++a; } a += z; a++; \text{a += z;} \} \)

For Problems 2 and 3, write out the operational semantics as a directed graph. (With \( \langle S, \sigma \rangle \to \langle S', \sigma \rangle \), the two configurations become nodes and the semantics \( \to \) becomes a graph \( \to \).) For these problems, it's okay to draw your answers on paper and scan it in to be part of your pdf.

2. [12 = 3 * 4 points] Let \( S \equiv \text{if } x > 0 \text{ then } x := x \times z \text{ else if } y > 0 \text{ then } y := y \times z \fi \fi \).
   a. Evaluate \( \langle S, \{ x = 2, y = 6, z = 4 \} \rangle \) to completion.
   b. Evaluate \( \langle S, \{ x = -2, y = 8, z = 5 \} \rangle \) to completion.
   c. Evaluate \( \langle S, \{ x = -1, y = -2, z = 6 \} \rangle \) to completion.

3. [9 points] Let \( W = \text{while } k \neq n \text{ do } S \text{ od} \) where \( S = k := k + 1; x := x + k \times k \). 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 \( \langle E, \text{state} \rangle \). You can use \( \to^n \) to skip other configurations if you like, or you can show them (your choice).

Class 6: Denotational Semantics, Runtime Errs

4. [9 = 3 * 3 points]
   a. Take the operational semantics of Problem 2a and translate it to a corresponding denotational semantics \( (M(S, \ldots) = \ldots ? \)).
   b. Repeat, on Problem 2b.
   c. Repeat, on Problem 2c.
5. [6 points]. Take the operational semantics of Problem 3 and translate it to a corresponding denotational semantics. \( M(S, \sigma_0) = \ldots ? \)

6. [4 points] Take the \( W \) from Problem 3. What is the set of \( \sigma \) such that \( \langle W, \sigma \rangle \rightarrow^* \langle E, \perp \rangle ? \)

7. [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 \( M(S, \sigma) = \{ \perp e \} \). (As in usual, dividing by zero and taking square root of a negative number cause errors.)