Programming Language Qualifying Exam
Spring 2009

Answer all five of the following problems.

1. **Languages and Compilation**

   (a) What is the difference between *static typing* and *dynamic typing*? Give an advantage for each of them.

   (b) What is the difference between *interpretation* and *compilation*?

   (c) Most modern languages come with automatic memory management. Give an example of a situation in which this would **not** be desirable.

2. **Abstraction**

   (a) What is an abstract data-type?

   (b) Suppose you are implementing a library function and will need to return a stack to the caller. You don't have a stack class written yet, but you discover that there is a readily available singly-linked list class `LinkList` that happens to contain `push` and `pop` methods. Should your function make use of this class and return an instance of it, or should you rather write a dedicated stack class? (Most of your grade will be in the justification of your answer.)

3. **Grammars**

   Consider the following grammar:

$$\begin{array}{lcl} S & \rightarrow & x\ E \\ E & \rightarrow & x\ E \\ & | & y\ F \\ F & | & x \end{array}$$

   (a) Construct the Characteristic Finite State Machine for the above grammar.

   (b) Convert the above grammar to an LL grammar (or explain why it is already LL).

   (c) Is the above grammar ambiguous? Give a proof with your answer.

4. **Weakest Precondition**

   (a) Give the definition of *weakest precondition*.

   (b) Give the definition of *weakest liberal precondition*.

   (c) Give a simple program S and assertions P and Q such that $WLP(S, P) = Q$ but that $WP(S, P) \neq Q$.

   (d) What does it mean if $WP(S, True) = False$? What does it mean if $WP(S, True) = True$? You will not get credit if you merely repeat in English the definition of the formulas; we want to know that you understand the property of S in this question.

5. **Loop Verification**

   (a) To verify a loop, you need to solve five equations. List each equation and give a one sentence description of its role in the verification.

   (b) There are two monotonic functions f_1 and f_2 from integers to integers. In other words, if $i < j$, then $f_1(i) < f_1(j)$, and $f_2(i) < f_2(j)$. We do not know the relationship between $f_1(i)$ and $f_2(i)$ for any particular i.

   We have been told that there is one integer in the range of both functions, i.e., there exists x and y such that $f_1(x) = f_2(y)$.

   Write a totally correct program that finds the values of x and y that reveal this integer. Give a full proof outline (including invariants and loop bounds).