

# Programming Languages

Spring 2011 Qualifying Examination

November 26, 2010

**Note:** this exam is open books and open notes.

## Problem 1 [30 Points]

Consider the following program

```
1: m=0;
2: y = 0;
3: while (y < c) do
4:   x = 0;
5:   while (x < a) do
6:     m = m+b;
7:     x = x+1;
8:   endwhile;
9:   y = y+1;
10: endwhile
```

Consider the precondition  $p = \{a \geq 0 \wedge b \geq 0 \wedge c \geq 0\}$ . Assume that  $m$  is the output variable. Answer the following questions:

- develop the appropriate post-condition capturing the meaning of the computation;
- provide the appropriate loop invariants;
- use Hoare's method to prove the partial correctness of the loop part of the program (i.e., focus only on lines 3-10 of the program).

## Problem 2 [60 Points]

Consider a language for the management of a file system; the syntax of the programs is given next:

```
<program>    ::= <session>
<session>    ::= epsilon
              |   <command> <session>
<command> ::= open <id>
              |   close
              |   seek <number>
              |   insert <record>
              |   delete
              |   search <record>
<record>    ::= <number>
```

The file system is a flat collection of named files; files are sequential. During a session we can have any number of files opened for processing, but all the operations will apply to the file that has been opened last; when we close a file, the content of the file is written back into the file system and the operations are applied to the file that was opened before the one just been closed. Observe

- The open command opens a new file (getting it from the file system into memory for manipulation); the file pointer is positioned on the first record of the file (assume that the files contain only numbers); all the following operations will be applied to this file until it is closed.
- The close command moves the file back into the file system, under its original name and reflecting all the changes made during the session.
- The seek command moves the file pointer to the given position in the file (e.g., **seek 5** positions the file pointer on the fifth record of the file).
- The insert command inserts a new record after the current file pointer and moves the file pointer on the new record.
- The delete command removes the record currently pointed by the file pointer.

- The search command moves the file pointer to the first occurrence of the given record in the file (e.g., `search 6` locates the first occurrence of 6 in the file and moves the file pointer to that occurrence).

At the end of the session, all the open files should be closed and put back into the file system.

Provide the complete denotational semantics (including both semantic algebras and valuation functions) for this language.

### **Problem 3 [10 Points]**

Provide the operational semantics sequents for the `switch/case` construct as available in the C programming language.