## Homework 2: An Interpreter for SpartanLang

CS 152: Programming Language Paradigms Prof. Thomas H. Austin San José State University

## 1 Introduction

In this assignment, you will develop an interpreter for a small language, called SpartanLang. The valid expressions for SpartanLang are given in Figure 1.

SpartanLang supports mutable references. The state of these references is maintained in an environment, a mapping of variables to values. With mutable references, other language constructs become more useful, such as sequencing operations  $(e_1; e_2)$ .

```
e ::=
                                                   Expressions
                                                   values
                                                   assignment
            x := e
                                                   variable dereferencing (i.e. getting a variable's value)
            !x
            e; e
                                                   sequential expressions
                                                   binary operations
            e op e
            if e then e else e end
                                                   conditional expressions
            while e do e end
                                                   while expressions
                                                    Values
v ::=
            i
                                                   integer values
                                                   boolean values
            + \mid - \mid * \mid > \mid > = \mid < \mid < = Binary operators
```

Figure 1: Expressions in SpartanLang

## 2 YOUR ASSIGNMENT

Create an interpreter for SpartanLang. You can assume that the parsing has been done for you – your job is to write an interpreter when given an abstract syntax tree (AST).

Download interp.rkt from the course website and implement the evaluate function, as well as any additional functions it uses. The file test.rkt provides some additional testing cases (though not necessarily a comprehensive set of tests). The files parser.rkt and sl-run.rkt allow you to run on programs written in text files; test1.sparta is provided as an example.

The input to evaluate consists of two arguments, an expression and the environment. The expression will be represented as a struct, which could be:

• sp-val, representing some constant (such as 42 or true).

- sp-binop represents a binary expression (e.g. 2+4).
- sp-if represents a conditional expression (e.g. if true then 1 else 0 end).
- sp-assign represents an update to a variable (e.g. x := 4).
- sp-var represents getting the value of a variable, such as !x. Note: this is not the 'not' operator of languages like Java.
- sp-seq represents a sequence of expressions, like x:=1; y:=2.
- sp-while represents a loop, like while i < 10 do i := !i + 1 end.

The environment is an *immutable* map of variables to values.

The return value of evaluate is a pair of a value and a new environment. While we cannot mutate the map, we simulate imperative updates by creating a new environment based on the old environment<sup>1</sup>.

Submit your modified interp.rkt to Canvas.

## 3 Operational Semantics

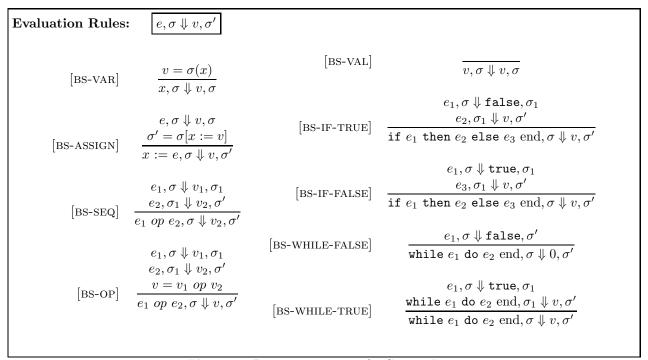


Figure 2: Big-step semantics for SpartanLang

While the behavior of most of our constructs is straightforward, a formal semantics can be useful for clarifying the behavior of the language in corner cases.

Operational semantics allow us to specify the behavior of a language in concrete terms. In Figure 3, we are specifically using big step operational semantics. With big step, we define how to evaluate an expression

<sup>&</sup>lt;sup>1</sup>This approach is similar to how Java deals with Strings. A String is immutable, but String s2 = s.substring(2) creates a new immutable String derived from the value of s.

e down to a value v in the context of an environment (or "store")  $\sigma$ . (For those not up on their Greek letters, this is "sigma".)

The big step relation is defined by

$$e, \sigma \downarrow v, \sigma'$$

Note that this corresponds exactly with the specification for our evaluate method in Racket. Our input parameters are on the left hand side of the  $\Downarrow$ . We take an expression (e) and a store  $(\sigma)$  and evaluate them, returning a pair of a value (v) and a possible modified store  $(\sigma')$ .

In each rule, the details above the lines are the *preconditions*. If these conditions hold, then the rule applies. For instance, if we were to translate the rule [BS-VAR] into English, we might say:

If x maps to the value v in the store  $\sigma$ , then evaluating x in the context of store  $\sigma$  results in the value v and the unchanged store  $\sigma$ .

While these rules might be tricky to parse at first, your Racket code is essentially a straight translation of these rules.