

CMPE 320 PRINCIPLES OF PROGRAMMING LANGUAGES
MIDTERM

15.4.2008

1. Suppose that, in a programming language, an assignment statement consists of a left-hand side (a single variable), equality sign, and a right-hand side. On the right-hand side, there may be variables, five types of binary operator (+, -, *, /, ^; where ^ indicates exponentiation), and parentheses. (The expressions on the right-hand side have the usual semantics.) Variables are single letters.

Some example expressions are given below:

```
a = b
a = (b ^ (x * y))
x = ((d) + e / f) * x ^ r / (k + l)
```

The precedence order among operators is as follows (from highest to lowest): 1) ^, 2) * and /, 3) + and -. In addition, ^ has right precedence while the rest have left precedence.

Write BNF description for assignment statements in this language. *Do not use EBNF.*

2. Consider the following grammar taken from your book:

```
<expr>  -> <expr> + <term>
         | <term>

<term>  -> <term> * <factor>
         | <factor>

<factor> -> ( <expr> )
         | <id>
```

Suppose that the elements in an expression are two-dimensional matrices instead of simple variables. For instance, the expression “ $m_1 * m_2 + m_3$ ” indicates that m_1 , m_2 and m_3 are matrices (of appropriate sizes) and the result is also a matrix. Write an attribute grammar that evaluates an expression. You may assume that each nonterminal in the grammar has the attributes m (number of rows), n (number of columns) and $value$ (contents of the matrix; a particular element in a matrix can be accessed using subscripts, e.g. $value(i, j)$). The attribute grammar will have only semantic functions and there will be no predicate functions. Semantic functions will be used to calculate the result of matrix operation and our goal is to get the result of a given expression. For instance, given the expression “ $m_1 * m_2 + m_3$ ” and knowing (via intrinsic attributes) the values of m , n , $value$ for the matrices (i.e. $m_1.m$, $m_1.n$, $m_1.value$, etc.), the grammar will return the matrix (attributes m , n and $value$) which is the result of “ $m_1 * m_2 + m_3$ ”.

3. In a language, we have a loop construct called *repeat* whose syntax is given below:

```
<repeat> → repeat <st-list> until <bool>
<st-list> → <ass-st> <st-list> | <ass-st>
<bool> → <var> == <var>
<ass-st> → <var> = <var>
```

The semantics is as follows: The body of the loop (<st-list>) is executed until the boolean condition (<bool>) is true. It is a posttest loop, thus the body is executed at least once (i.e. when the loop is initiated, first <st-list> is executed, then <bool> is checked. If <bool> evaluates to true then the loop terminates, otherwise <st-list> is executed again, then <bool> is checked, and so on).

As can be seen, <st-list> is a sequence of assignment statements (at least one); each assignment is a simple statement in the form of assigning a variable to another variable; and boolean condition is a simple statement in the form of checking equality of two variables.

Write denotational semantics description of the *repeat* construct. You must define every function in your description formally; do not assume the existence of any functions (except a function which returns the value of a given variable). Also, all possible errors should be handled.

(continued on next page)

4. We have a list of data in the following format:

((team_{1a} team_{1b} score_{1a} score_{1b}) (team_{2a} team_{2b} score_{2a} score_{2b}) ...)

where each sublist denotes a football match between two teams and the score of the match. For instance, (Fenerbahçe Galatasaray 1 3) means that Galatasaray won the match against Fenerbahçe with a score of 3-1.

Write a Scheme program **Points** that, given a list in the above format and a team, finds the total points earned by that team. For each match, the winner team earns 3 points and the other team does not earn any point. In the case of a tie, both teams earn 1 point.

Example: If the program is called with the statement

(Points '((FB GS 1 3) (GS TS 2 2) (GS BJK 2 3) (BJK FB 0 0)) 'GS)
the output will be 4.

Notes:

- Questions 1-4 : 25 points
- Time: 2:00 hours
- Close notes and books

Değil kardeşim, dal yeşil değil, gök mavi değil.
Bilsen! Ben hangi âlemdeyim, sen hangi âlemde!
Aklından geçer mi dersin aklımdan geçen şeyler?
Sanmam! Yıldız ve rüzgâr payımız müsavi değil;
Sen kendi gecende gidersin, ben kendi gecemde;
Vazgeç kardeşim, ayrıdır bindiğimiz gemiler!
