2016 Midterm Exam for Compiler (Totally 4 pages)

(by Prof. Jenq-Kuen Lee)

1. (10%) Manually execute the following program

```
program parameter-passing;
  var i: integer;
      a: array [1..3] of integer;
  procedure  mess(v : integer);
    var i: integer;
   begin
        i:= 3;
        v := v + 1;
        a[i] := a[i] + 12;
        i := 1;
        v := v +1;
    end;
begin
  for i:= 1 to 3 do a[i] := 9;
  a[2] := 5;
  i := 2;
  mess(a[i]);
  . . .          <--------  Observation Point 1
end.
```

(a) if by assuming Call-by-Text, what's the value in the array a and the variable i in the observation point 1 of the program?
(a[1]=?,a[2]=?,a[3]=?,i=?)

(b) If by assuming Call-by-Need, what's the value in the array a and the variable i in the observation point 1 of the program?
(a[1]=?,a[2]=?,a[3]=?,i=?)

2. (10%) (a) Is the following grammar a LL(1) grammar?
S, E, and F are nonterminals, and ``(``, ``)", ``+", and ``a" are terminals in the grammar below.

S -> E
E -> (a a a)
| F

F -> (a)

(b) Convert the grammar in (a) into LL(1) if it's not a LL(1) yet.

3. (15%) Explain the following concepts?

(a) Why is a left-recursion grammar not in LL(1)?

(b) Discuss the difference among LL(0), LL(1), and LL(2).

(c) Explain how to decide if a grammar is a LL(1) grammar.

4. (20%) If we use BNF form to write a grammar for an arithmetic expression includes ``*" (multiplication), ``#" (exponential operators), ``+" (addition), and parenthesis. We get a grammar below:

E -> E * E
E -> E # E
E -> E + E
E -> (E)
E -> Number

Assume the precedence order from the highest to the lowest is parenthesis, ``\#", ``*", ``+". The exponential operation is right associate, and all other operators are left associate.

(a) Re-Write the above grammar into an un-ambiguous grammar following the given precedence and associativity.

(b) Is the grammar generated in (a) a LL(1) grammar? If it's not a LL(1) grammar, try to convert it into a LL(1) grammar?

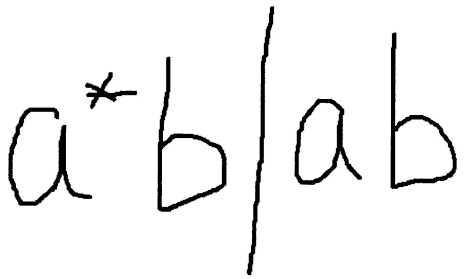
(c) To use the concept of selection set to explain why the grammar you generated in (b) is a LL(1) grammar.

(d) Write a C program for the top-down recursive parser of the LL(1) grammar generated in (b).

5. (12%) (a) To write a Lex-style regular expression to represent the syntax of the "Variable Name" in C language.
(b) Write a Lex Program that copies a C program, replacing all instance of int by double. In addition, please print out those replacements happen in which lines.

6. (8%) Please give two different strings which match the regular expression.
(1) [abc]d?
(2) x+y*z
(3) a{2,4}(b|c|d)a{2,4}
(4) [1-9]"."[0-9]*[1-9]

7. (20%) (a) Describe the language denoted by the following regular expressions.



(b) Construct nondeterministic finite automata for the regular expression above.

(c) Construct the DFA (deterministic finite state automata) for the machine generated in (b)?

(d) Construct the minimum-state DFA for the DFA machine generated in (c).

8. (10%) Convert the following NFA to DFA.