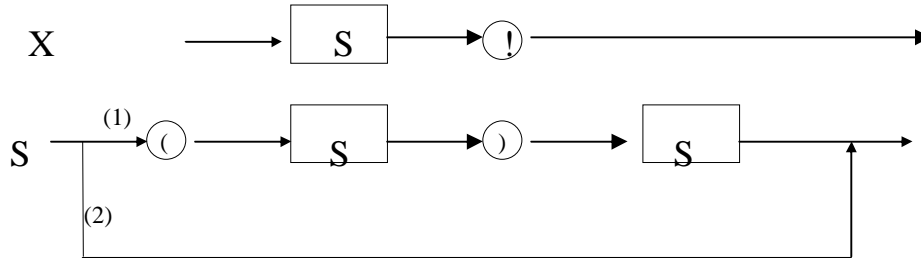


Tutorial on Examination 2006 : Compiler Part

Answers at <http://www.cosc.canterbury.ac.nz/tad.takaoka/cosc230/>

Question 1. [15 marks for the whole question] A syntax chart for generating parenthesis strings is given as follows:



We define X as the starting symbol. The symbol “!” is an end marker explicitly used in the syntax chart.

- [5 marks] Show selection sets at branches (1) and (2).
- [5marks] Write a recursive descent parser for this chart in C, Pascal, or Java. Pseudo code notation is allowed, similar to the one in the notes.
- [5 marks] The trace for the string () ! is given as follows:

History	put string	Comment

X	()!	Enter S
XS	()!	Consume (
XS)!	Enter S
XSS)!	Exit from S
XS)!	Consume)
XS	!	Enter S
XSS	!	Exit from S
XS	!	Exit from S
X	!	Consume !
X		Exit from X
empty		Accept

Following this example, trace your parser with the string (()) !.

Question 2. [25 marks for the whole question] The following is a PL/0 program with parameters for multiplication of two integers a and b, and its object code.

```

var a, b, w;
procedure mult(x, y, var z)      /** comment x, y: call by value   **/
  var w;                        /** comment z: call by address  **/
begin
  if x>0 then begin
    call mult(x-1, y, &w);      /** comment w=(x-1)*y   **/
    w:=w+y;                     /** comment w=x*y       **/
  end;
  z:=w;
end;
begin
  a:=3; b:=5;
  call mult(a, b, &w);          /** comment w=a*b       **/
  write(w);
end.

```

```

0 jmp 0 23
1 jmp 0 2
2 inc 0 7
3 lod 0 3
4 lit 0 0
5 opr 0 12
6 jpc 0 20
7 lod 0 3
8 lit 0 1
9 opr 0 3
10 lod 0 4
11 lda 0 6
12 stp 0 0
13 stp 0 0
14 stp 0 0
15 cal 1 2
16 lod 0 6
17 lod 0 4
18 opr 0 2
19 sto 0 6
20 lod 0 6
21 sid 0 5
22 opr 0 0
23 inc 0 6
24 lit 0 3
25 sto 0 3
26 lit 0 5
27 sto 0 4
28 lod 0 3
29 lod 0 4
30 lda 0 5
31 stp 0 0
32 stp 0 0
33 stp 0 0
34 cal 0 2
35 lod 0 5
36 wrt 0 0
37 opr 0 0

```

```
15 /** comment This is the output given by the above "wrt" **/
```

(a) [10 marks] Copy this object code onto your answer book, and give a comment to each machine instruction, explaining the meaning in the source program.

(b) [10 marks] When the procedure is entered three times, and the instruction at 17 is executed for the first time, the stack looks like as follows:

```
0 0 0 3 5 0 1 1 35 3 5 6 0 1 7 16 2 5 13 0 1 14 16 1 5 20 0 0
5
```

Explain the meaning of each element. Undefined values are initialised to 0.

(c) [5marks] Give the snapshot of the stack after the instruction at 17 is executed for the third time.