UNIT 6: BOTTOM-UP PARSING TECHNIQUES

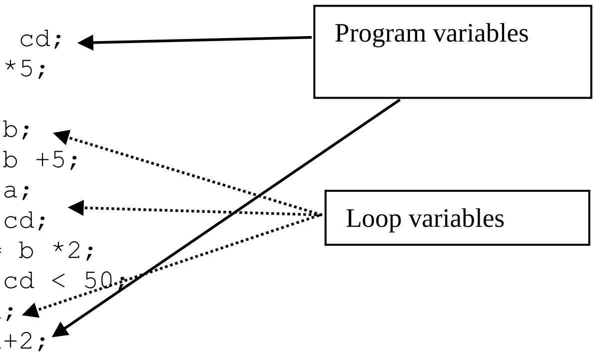
Build a compiler for the following programming language. There are three types of statements: declaration, arithmetic / logical expression and loop and two types of data: numeric and logical. The sentences are described as follows:

- Declaration
  - **`type name_variable [, name_variable]* ;`**
  - where type can be **`num`** or **`log`** and **`name_variable`** is a char string with a máximum number of 8 characters
- Arithmetic/Logic expressions
  - **`name_variable = expression_arithmetic ;`**
  - **`name_variable = expression_logic;`**
  - Arithmetic expressions can contain variables of type **`num`** and numbers with the operators: +, -, *, /
  - The logical expression relates variables of type num with numbers through logical operators: <,>, =, #. The possible results of the evaluation of the logical expression is V or F. The variable to which it is assigned must be type log.
- Loop
  - **`do [sentence]+ endo [expression_logic | variable_logic] ;`**
  - where sentences can be declaration, expression or loop.

The sentences of the loop are executed at least once, and the loop is repeated while the logical expression in endo takes the value V. The variables are local to the loop where they are declared, if variables are used in the logical expression of the endo then there must be been declared inside the loop. The variables declared in the main body of the program are considered local to it.

Example of a program without errors:

```
num a, cd;
a= cd *5;
do
  num b;
  b = b +5;
  log a;
  num cd;
  cd = b *2;
  a = cd < 50;
endo a;
cd = a+2;
```



David Griol Barres, Antonio Berlanga de Jesús, Jesús García Herrero, Juan Manuel Alonso Weber

It is required:

1. Define the G grammar that would generate valid sentences of this programming language.

2. Can the grammar G of the first exercise be used to perform an LL(1) analysis? If not, modify it so that it can. Generate the Table LL(1).

3. Construct the Table LR(1) that recognizes sentences of the language generated by the modified grammar of section 2, showing the states and the transitions between them.

Solution

A grammar that generates the given language can be defined as follows:

G = {**S**, **A**, **B**, **D**, **E**, **V**, **X**}, {**S}** , { ; , type, var, do, endo, =, o, p, “,” }

(1) **S**::= **A** ; **S**
(2) **S**::= **A** ;
(3) **A**::= **D**
(4) **A**::= **B**
(5) **A**::= **E**
(6) **D**::= type **V**
(7) **V**::= var
(8) **V**::= var , **V**
(9) **B**::= do **S** endo **X**
(10) **E**::= var = **X**
(11) **X**::= o
(12) **X**::= o p **X**

The token "type" represents the strings "num" and "log", the token "var" to the set of characters that identifies a variable, "o" is an operand (variable or number) and "p" is an operator, either of arithmetic or logical type.

After left-factoring, the modified G’ is:

G’ = {**S**, **S’**, **A**, **B**, **D**, **E**, **V**, **V’**, **X**, **X’**}, {**S}** , { ; , type, var, do, endo, =, o, p, “,” }

(1) **S**::= **A** ; **S’**
(2) **S’**::= **S**
(3) **S’**::= λ
(4) **A**::= **D**
(5) **A**::= **B**
(6) **A**::= **E**
(7) **D**::= type **V**
(8) **V**::= var **V’**
(9) **V’**::= , **V**
(10) **V’**::= λ
(11) **B**::= do **S** endo **X**
(12) **E**::= var = **X**
(13) **X**::= o **X’**
(14) **X’**::= p **X**
(15) **X’**::= λ

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Σ_N	First				Follow	
S	type	do	var		$	endo
S'	type	do	var	λ	$	endo
A	type	do	var		;	
B	do				;	
D	type				;	
E	var				;	
V	var				;	
V'	λ	,			;	
X	o				;	
X'	λ	p			;	

Table LL(1)		Σ_T									
		$	**;**	**type**	**var**	**do**	**endo**	**=**	**o**	**P**	**,**
Σ_N	**S**			1	1	1					
	S'	3		2	2	2	3				
	A			4	6	5					
	B					11					
	D			7							
	E				12						
	V				8						
	V'		10								9
	X								13		
	X'		15							14	

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State 0	Action	Go To
S’’::= · S		[0,S]=1
S::= · A ; S’		[0,A]=2
A::= · D		[0,D]=3
A::= · B		[0,B]=4
A::= · E		[0,E]=5
D::= · type V	[0,type]=D6	
B::= · do S endo X	[0,do]=D7	
E::= · var = X	[0,var]=D8	
State 1	Action	Go To
S’::= S ·	[1,$]=ACP	
State 2	Action	Go To
S::= A · ; S’	[2,”;”]=D9	
State 3	Action	Go To
A::=D ·	[3,”;”]=R4	
State 4	Action	Go To
A::=B ·	[4,”;”]=R5	
State 5	Action	Go To
A::=E ·	[5,”;”]=R6	
State 6	Action	Go To
D::= type · V		[6,V]=10
V::= · var V’	[6,var]=D11	
State 7	Action	Go To
B::= do · S endo X		[7,S]=D12
S::= · A ; S’		[7,A]=2
A::= · D		[7,D]=3
A::= · B		[7,B]=4
A::= · E		[7,E]=5
D::= · type V	[7,type]=D6	
B::= · do S endo X	[7,do]=D7	
E::= · var = X	[7,var]=D8	
State 8	Action	Go To
E::= var · = X	[8,”=”]=D13	
State 9	Action	Go To
S::= A ; · S’		[9,S’]=14
S’::= · S		[9,S’]=15
S’::= λ	[9,$]=R3 [9,endo]=R3	
S::= · A ; S’		[9,A]=2
A::= · D		[9,D]=3
A::= · B		[9,B]=4
A::= · E		[9,E]=5
D::= · type V	[9,type]=D6	
B::= · do S endo X	[9,do]=D7	
E::= · var = X	[9,var]=D8	
State 10	Action	Go To
D::= type V ·	[10,”;”]=R7	
State 11	Action	Go To
V::= var · V’		[11,V’]=1 6
V’::= · , V	[11,”,”]=D17	
V’::= λ	[11,”;”]=R10	
State 12	Action	Go To
B::= do S · endo X	[12,endo]=D1	

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tate 13	Action	Go To