Saint Petersburg Electrotechnical University "LETI"

The department MOEVM

The report on laboratory works

by discipline

“Development of linguistic processes”

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«Разработка языковых процессов»

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In progress of the course work necessary to develop a programming language is a subset of the specified language, and the compiler from this language into an intermediate language, the type of which is determined by the option of individual tasks. Method of syntactic analysis (parsing) is also determined by the task.

The language must provide operations on variables and constants defined base types, as well as on the variables and the components of the derived type, which are defined for this assignment. The composition of operations should include both provided basic language, and listed in the job variant. In the language must be defined transaction type conversion when structural equivalence types or names. In the language has to be also possible to create user-defined types.

The language must allow the use of arithmetic expressions, in which may include constants and simple variables of basic types, the components of the structured type, parentheses, and signs of operations: addition, subtraction, multiplication, division. Priority of operations - an ordinary.

The language must allow the use of logical expressions of the relationship which may include parentheses and symbols of logic operations: AND, OR, NOT, and, in the case of a language in a Boolean constants and variables of this type. Priority of operations is usual.

Operations on variables of a structured type are defined for this job.

The composition of the operators of the language:

• assignment operator;

• operator input;

• output operator;

• composite operator;

• operator of unconditional transition;

• conditional statement, a condition in which a Boolean expression;

• cycle operator, a condition in which a Boolean expression.

The particular form of the operators is defined for this job.

The program in the input language can contain comments.

# Description of the source language.

## General information.

In the work describes the development of a compiler for the language is a subset of Pascal.

Variant 19.

Basic language - Pascal.

Basic types: integer, real, char.

A structured type: character string.

Operations on strings: the definition of the string length, string concatenation, replacing the substring, substring search, access to the substring.

Additional requirements: functions, conditional assignment.

The operator of the cycle - a precondition.

The operator of overloading - allowed.

Class of grammar - the grammar of operator precedence.

The intermediate language - the triad.

## The formalism for describing the syntax.

The language syntax is described using modified Backus-Naur Form:

- Metalinguistic variables are composed of lowercase letters of the Russian alphabet, and underscores; the name of each variable is taken in <angle brackets>;

- Reserved words indicated by the words of the English language, consisting of lowercase Latin letters;

- In [brackets] are concluded elements that may be absent;

- Repeated zero or more elements are in {curly braces};

## Lexis of the language.

## Terminal symbols of the language.

By the terminal symbols of language are:

• 26 letters of the alphabet, uppercase and lowercase:

**A B C** ... **Y Z a b c** ... **y z**

• 33 letters of the Russian alphabet:

**А Б В** ... **Ю Я а б в** ... **ю я**

• 10 numbers:

**0 1 2 3 4 5 6 7 8 9**

• 16 special characters:

**+ - \* / = < > . , ( ) : { } \_ '**

• space character

• ending character of line

• a tab character

* + 1. **Tokens and an agreement on delimiters.**

The program text is tokenized, which are identifiers, keywords, integers and real numbers, Boolean values, special characters **+ - \* / = < > . , ( ) : { } \_ '** - a single-character delimiters, as well as combinations of special characters:

<= Sign of the operator is less than or equal to.

> = Sign of greater than or equal operator.

= Mark assignment

<> Not equal sign operator.

## Comments.

## Comments - any characters enclosed in {}.

## Identifiers.

## Identifiers are used as names for variables, constants names and labels.

## Syntax:

**<identifier>**::=<letter> < sequence\_of\_letters\_and\_ digits>

**<letter>**::='\_'|'a'|'b'|'c'|'d'|'e'|'f'|'g'|'h'|'i'|'j'|'k'|'l'|'m'|'n'|'o'|'p'|'q'|'r'|'s'|'t'|'u'|'v'|'w'|'x'|'y'|'z'|

|'A'|'B'|'C'|'D'|'E'|'F'|'G'|'H'|'I'|'J'|'K'|'L'|'M'|'N'|'O'|'P'|'Q'|'R'|'S'|'T'|'U'|'V'|'W'|'X'|'Y'|'Z'

**<digit>**::='0'|'1'|'2'|'3'|'4'|'5'|'6'|'7'|'8'|'9'

< **sequence\_of\_letters\_and\_ digits** >::={<letter>|<digit>}

## Uppercase and lowercase letters are not distinguished. The restriction on the length of the length identifier can not be more than 127 characters. The identifier must be unique.

## Constants.

## Constants are divided into integer, real, char, Boolean, and string. The constant is defined only once and can not be changed.

**<constant>**::=<decimal\_constant>|<real\_constant>|<char\_constant>|< Boolean\_constant>|< string\_constant >

**<** **decimal\_constant >**::=[<sign>]<sequence\_of\_digits>

< **sequence\_of\_digits** >::=<digit>{<digit>}

**<** **real\_constant >**::=< fractional\_constant >[< exponential\_part >]

< **fractional\_constant** >::=< sequence\_of\_digits >[.< sequence\_of\_digits >]

< **exponential\_part** >::=’e’[<sign>]< sequence\_of\_digits>|’E’[<sign>] < sequence\_of\_digits >

**<** **char\_constant >**::='''[<letter>|<digit>]'''

< **Boolean\_constant** >::=’true’|’false’

**<** **string\_constant >**::='''< sequence\_of\_letters\_and\_ digits >'''

## Keywords

## The following keywords are reserved and can not be used as identifiers:

**and begin boolean char const do else end false function goto if integer label not operator or program real string then true var while**

## Keywords are perceived as common symbols with fixed meaning, which is set in the definition of the language.

## Strings

## A string is any sequence of characters enclosed in ‘apostrophes’.

## Descriptions and types.

## Types

## Integer signed type Integer: 2 bytes, range -32768..32767

## Real type Real: 4 bytes, range ±3.4\*10±38

## Boolean (logic) type Boolean: 1 bytes, range True-False

## Character type Char: 1 bytes

Operations:

|  |  |  |
| --- | --- | --- |
| Operator | Type of operator | Valid types of parameter |
| + | unary | integer, real |
| - | unary | integer, real |
| + | binary | integer, real |
| - | binary | integer, real |
| \* | binary | integer, real |
| / | binary | real |
| And | binary | boolean |
| Or | binary | boolean |
| =, <>, <, >, <=, >= | binary | integer, real, boolean, char |
| Not | unary | boolean |

## Expressions

## Arithmetic expressions

**<arithmetic\_expression**>::=[<sign>]< therm >|< arithmetic\_expression ><sign><therm>

**< therm>::=<** multiplier>|< therm >’\*’< multiplier >|< therm >’/’< multiplier >

**<multiplier**>::='('<arithmetic\_expression>')'|<identifier>|<decimal\_constant>|< real\_constant>

**<sign>::='+'|'-'**

## Logical expressions

**<** **logical\_expressions>**::=<logical\_therm>{’or ’< logical\_therm>}

**<** **logical\_therm >**::=< logical\_therm>’ and ’<logical\_multiplier>|<logical\_multiplier>

**<** **logical\_multiplier>**::=< identifier>|< arithmetic\_expression><ratio><arithmetic\_expression>| <string\_constant><ratio><string\_constant>|’not’<logical\_multiplier>|’(‘<logical\_expressions >’)’

**<** **ratio >**::='='|'<'|'>'|'<='|'>=’

## Descriptions.

## Any description compares with notion of described by some identifier - variable name.

## Rules of the type conversions.

## This is a translation of "lower" types to "higher" in the interests of accuracy and consistency of the presentation data.

integer  real

## If in the operation are taking part operands of types of different levels (eg integer, and real), then the conversion is performed to the higher of the those present type (in this example to the real).

## More details about transformations:

|  |  |  |  |
| --- | --- | --- | --- |
| **Operation** | **Operand type1** | **Operand type2** | **Result Type** |
| + , -, \* | integer | integer | integer |
| +, -, \* | integer | real | real |
| +, -, \* | real | integer | real |
| +, -, \* | real | real | real |
| / | integer | integer | real |
| / | integer | real | real |
| / | real | integer | real |
| / | real | real | real |

## The transformation in the performance of the assignment operation:

|  |  |  |
| --- | --- | --- |
| **Variable type** | **Type assigned by the value** | **The variable type after executing operator** |
| Integer | integer | Integer |
| Real | real | Real |
| Real | integer | Real |

## Converting types to perform of the operation relations.

|  |  |  |
| --- | --- | --- |
| **Operand1** | **Operand2** | **Conversion** |
| integer | integer | not |
| real | real | not |
| integer | real | Operand1  real |
| real | integer | Operand2  real |

## Operators.

## The assignment operator.

## Syntax:

<**assignment\_operator**>::=<identifier>':='<arithmetic\_expression>|<logical\_expression>|<constant>

## The operator of unconditional transition.

## Syntax:

**<** **operator\_of\_unconditional\_transition >**::='goto' <identifier>

## The operator performs an unconditional transition to the labeled statement. The label must be unique within the program.

## The output operator.

## Syntax:

**<output\_operator**>::='write('<message> {','<message>} ')'

**<message**>::= <arithmetic\_expression>|<logical\_expression>|<string\_constant**>**

## The operator outputs the standard output stream.

## The input operator.

## Syntax:

**<input\_operator>**::='read(' <identifier> {','<identifier>} ')'

## The input operator reads from standard input (keyboard). The identifier cannot be a constant name.

## The composite operator.

## Syntax:

**<composite\_operator>**::= 'begin' {<operator> ';'} 'end'

Operators that are part of a compound statement, is performed in order they were written.

## The conditional operator.

## Syntax:

**<** **conditional\_operator >**::='if '<logical\_expression>' then '<operator>|<composite\_operator> [' else '<operator>|<composite\_operator>]

## First calculated <logical\_expression>. If it is true, then the first < operator > is performed, else the second < operator >, if it there is.

## The operator of the while loop.

## Syntax:

**<while\_loop>**::='while '<logical\_expression> ' do ' <operator>|<composite\_operator>

## Execute the operators <operator>, until the true is <logical\_expression>.

## Operator of determining the length of the string.

## Syntax:

**<operator\_length\_string>**::='length('<identifier>|<string\_constant>')'

## The operator returns the length of the string.

## The operator of the string concatenation.

## Syntax:

**<operator\_string\_concatenation>**::='concat('<identifier>|<string\_constant>', '<identifier>|< string\_constant >')'

The operator returns a string representing is passed the two series-connected the string.

## The operator of the replacement of the substring in a string.

## Syntax:

**<operator\_replacement\_substring>**::='replace('<identifier>|<string\_constant>', '<identifier>|<string\_constant>', '<identifier >|< string\_constant >')'

## The operator returns the modified string. If the substring is not found, the original string is returned.

## The search operator of substring in a string.

## Syntax:

**<search\_operator\_substring>**::='search('<identifier>|<string\_constant>', '<identifier>|<string\_constant>')'

## The operator returns the index of element from which to start the substring, otherwise -1 is returned.

## The operator of access to the substring.

## Syntax:

**<operator\_access\_substring >**::='substr('<identifier>|<string\_constant>', '<identifier>|<sequence\_of\_digits>', '< identifier>|<sequence\_of\_digits >')'

## The operator returns the substring of a given number of elements starting at the specified.

## The operator of functions.

## Syntax:

<**operator\_function**>::=<function\_header> [<block\_definitions \_variables >] <composite\_operate> ‘;’

< **function\_header**>::=’function’ <identifier> ‘:’ <simply\_type> ‘;’

## Function allows splitting the logic of the program into smaller, more manageable fragments, and is similar to subprograms in other languages.

## The operator new.

## Syntax:

<**operator\_new**>::=’new(‘ <identifier> ‘)’

## The operator of conditional assignment.

## Syntax:

< **operator\_conditional\_assignment** >::= ‘if’ <logical\_expression> 'then' <assignment\_operator> ['else' <assignment\_operator >]

## As such, the ternary operator in Pascal is not. Use alternative is “if then else”.

## The operator of overloading.

## Syntax:

< **operator\_ overloading** >::= ‘operator’ < overloaded \_operations > ‘(‘<description\_overloaded\_variables > ’)’ <identifier> ‘:’ <simple\_type> ‘;’ <composite\_operator > ‘;’

< **description\_overloaded\_variables \_1**>::= < identifier> ‘:’ < simple\_type > ‘;’ < identifier> ‘:’ < simple\_type >

< **description\_overloaded\_variables \_2**>::= < identifier> ‘,’ < identifier> ‘:’ < simple\_type >

< **description\_overloaded\_variables** >::=< description\_overloaded\_variables \_1> | < description\_overloaded\_variables \_2>

< **overloaded \_operations**> ::= <ratio>|’+’|’-’|’**\***’|’/’

# The full syntax of the language in Backus-Naur Form.

**<program>**::= ['program' < identifier>;] {<block\_definitions\_constant>|<block\_definitions\_label>| < block\_definitions \_variables >|< block\_definitions \_function>} < composite\_operator > '.'

< **block\_definitions \_function**>::= < operator\_function >|< operator\_ overloading>

< **block\_definitions \_variables** >::=’var’ < variable\_description > {< variable\_description >}

**<** **variable\_description >**::=< identifier >{','< identifier >}': '< simple\_type >';'

< **block\_definitions\_constant** >::=’const’ <constant\_description> ‘;’ { < constant\_description > ‘;’ }

**<** **constant\_description>**::=< identifier >'='<constant>

< **block\_definitions\_label** >::= ‘label’ < identifier > {‘,’ <identifier>} ‘;’

**<** **simple\_type>**::='integer'|'real'|’boolean’|’char’|’string’

**<** **identifier >**::=<letter><sequence\_of\_letters\_and\_ digits> **<letter>**::='\_'|'a'|'b'|'c'|'d'|'e'|'f'|'g'|'h'|'i'|'j'|'k'|'l'|'m'|'n'|'o'|'p'|'q'|'r'|'s'|'t'|'u'|'v'|'w'|'x'|'y'|'z'|

|'A'|'B'|'C'|'D'|'E'|'F'|'G'|'H'|'I'|'J'|'K'|'L'|'M'|'N'|'O'|'P'|'Q'|'R'|'S'|'T'|'U'|'V'|'W'|'X'|'Y'|'Z'

**<digit>**::='0'|'1'|'2'|'3'|'4'|'5'|'6'|'7'|'8'|'9'

< **sequence\_of\_letters\_and\_ digits** >::={<letter>|<digit>}

**<arithmetic\_expression**>::=[<sign>]< therm >|< arithmetic\_expression ><sign><therm>

**< therm>::=<** multiplier>|< therm >’\*’< multiplier >|< therm >’/’< multiplier >

**<multiplier**>::='('<arithmetic\_expression>')'|<identifier>|<decimal\_constant>|< real\_constant>

**<sign>::='+'|'-'**

**<** **logical\_expressions>**::=<logical\_therm>{’or ’< logical\_therm>}

**<** **logical\_therm >**::=< logical\_therm>’ and ’<logical\_multiplier>|<logical\_multiplier>

**<** **logical\_multiplier>**::=< identifier>|< arithmetic\_expression><ratio><arithmetic\_expression>| <string\_constant><ratio><string\_constant>|’not’<logical\_multiplier>|’(‘<logical\_expressions >’)’

**<** **ratio >**::='='|'<'|'>'|'<='|'>=’

**<constant>**::=<decimal\_constant>|<real\_constant>|<char\_constant>|< Boolean\_constant>|< string\_constant >

**<** **decimal\_constant >**::=[<sign>]<sequence\_of\_digits>

< **sequence\_of\_digits** >::=<digit>{<digit>}

**<** **real\_constant >**::=< fractional\_constant >[< exponential\_part >]

< **fractional\_constant** >::=< sequence\_of\_digits >[.< sequence\_of\_digits >]

< **exponential\_part** >::=’e’[<sign>]< sequence\_of\_digits>|’E’[<sign>] < sequence\_of\_digits >

**<** **char\_constant >**::='''[<letter>|<digit>]'''

< **Boolean\_constant** >::=’true’|’false’

**<** **string\_constant >**::='''< sequence\_of\_letters\_and\_ digits >'''

**<operator>**::= { [<identifier>':']< unlabeled\_operator > }

**<** **unlabeled\_operator >**::= <assignment\_operator>|< operator\_of\_unconditional\_transition >| <output\_operator>| <input\_operator>|<composite\_operator>|<conditional\_operator>|<while\_loop>|<operator\_function>|<operator\_new>|< operator\_conditional\_assignment >|<operator\_ overloading>|ε

**<assignment\_operator**>::=<identifier>':='<arithmetic\_expression>|<logical\_expression>|<constant>

|< operator\_string\_concatenation>|< operator\_replacement\_substring >|< operator\_access\_substring >

**<** **operator\_of\_unconditional\_transition >**::='goto' <identifier>

**<output\_operator**>::='write('<message> {','<message>} ')'

**<message**>::= <arithmetic\_expression>|<logical\_expression>|<string\_constant**>**

**<input\_operator>**::='read(' <identifier> {','<identifier>} ')'

**<composite\_operator>**::= 'begin' {<operator> ';'} 'end'

**<** **conditional\_operator >**::='if '<logical\_expression>' then '<operator>|<composite\_operator> [' else '<operator>|<composite\_operator>]

**<while\_loop>**::='while '<logical\_expression> ' do ' <operator>|<composite\_operator>

**<operator\_length\_string>**::='length('<identifier>|<string\_constant>')'

**<operator\_string\_concatenation>**::='concat('<identifier>|<string\_constant>', '<identifier>|< string\_constant >')'

**<operator\_replacement\_substring>**::='replace('<identifier>|<string\_constant>', '<identifier>|<string\_constant>', '<identifier >|< string\_constant >')'

**<search\_operator\_substring>**::='search('<identifier>|<string\_constant>', '<identifier>|<string\_constant>')'

**<operator\_access\_substring >**::='substr('<identifier>|<string\_constant>', '<identifier>|<sequence\_of\_digits>', '< identifier>|<sequence\_of\_digits >')'

<**operator\_function**>::=<function\_header> [<block\_definitions \_variables >] <composite\_operate> ‘;’

< **function\_header**>::=’function’ <identifier> ‘:’ <simply\_type> ‘;’

<**operator\_new**>::=’new(‘ <identifier> ‘)’

< **operator\_conditional\_assignment** >::= ‘if’ <logical\_expression> 'then' <assignment\_operator> ['else' <assignment\_operator >]

< **operator\_ overloading** >::= ‘operator’ < overloaded \_operations > ‘(‘<description\_overloaded\_variables > ’)’ <identifier> ‘:’ <simple\_type> ‘;’ <composite\_operator > ‘;’

< **description\_overloaded\_variables \_1**>::= < identifier> ‘:’ < simple\_type > ‘;’ < identifier> ‘:’ < simple\_type >

< **description\_overloaded\_variables \_2**>::= < identifier> ‘,’ < identifier> ‘:’ < simple\_type >

< **description\_overloaded\_variables** >::=< description\_overloaded\_variables \_1> | < description\_overloaded\_variables \_2>

< **overloaded \_operations**> ::= <ratio>|’+’|’-’|’**\***’|’/’

# Description of lexical analysis stage.

The ratio between the tokens and lexemes for different of language constructions.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Token | Lexemes | Language constractions | Token | Lexemes | Language constractions |
| \_ID | str, count | Identifier | Sign of operations | | |
| \_NUM | 10, 1023 | An unsigned integer | + | + | Arithmetic |
| \_STR | 'some string' | Character string | - | - |
| Keywords | | | \* | \* |
| \_PROG | program | Relevant keywords | / | / |
| \_CONST | const | \_NOT | Not | Logical |
| \_INT | integer | \_AND | And |
| \_REAL | real | \_OR | Or |
| \_STRING | string |  |  |  |
| \_GOTO | goto | \_REL | <, <=, >=,>, <>, = | Ratio |
| \_WHILE | while | \_EQ | := | Assignment |
| \_IF | If | Special symbols | | |
| \_THEN | then |
| \_ELSE | else |
| \_READ | read | . | . | The relevant symbols |
| \_WRITE | write |  |  |
| \_TRUE | true |  |  |
| \_FALSE | false | = | = |
| \_BOOL | boolean | ( | ( |
| \_DO | do | ) | ) |
| \_CHAR | char | ; | ; |
| \_BEGIN | begin | , | , |
| \_END | end |  |  |
| \_VAR | var | : | : |
| \_LABEL | label |  |  |
| \_CONC | concat |  |  |
| \_LEN | length |  |  |
| \_REPL | replace |  |  |
| \_SUBS | substr |  |  |
| \_SRCH | search |  |  |
| \_FUNC | function |  |  |
| \_OPER | operator |  |  |
| \_NEW | new |  |  |
| \_L | \_|a|b|c|d|e|f|g|h|i|j|k|l|m|n|o|p|q|r|s|t|u|v|w|x|y|z|A|B|C|D|E|F|G|H|I|J|K|L|M|N|O|P|Q|R|S|T|U|V|W|X|Y|Z |  | \_RC | 12.345e±67 | Real constant |
| \_N | 0|1|2|3|4|5|6|7|8|9 |  | \_CC | ‘a’, ‘b’, ‘2’, ' ' | Character constant |

## Description of the types lexemes.

## Considered the lexical analyzer lexemes can be one of the following types:

## Identifiers - the names of the user objects in the program;

## Constants - numeric or logical values ​​specified explicitly;

## Keywords - reserved identifiers, which have strictly defined meaning;

## Signs of operations - symbols that represent unary and binary operations;

## Special characters - the square brackets, parentheses, commas, etc;

## Separators - the gaps and newline characters. If the text includes the program in any place can be at least one delimiter, then the place can be any number of separators.

## Modeling of the work of the lexical analyzer.

## For example, we have the following program at the input:

program HelloWorld;

var a:integer; b:boolean;

begin

a:=3;

b:=true;

if b and (a = 3) then

write(‘hello world’);

end.

Formed output stream of tokens:

\_PROG \_ID ; \_VAR \_ID : \_INT ; \_ID : \_BOOL ; \_BEGIN \_ID \_EQ \_NUM ; \_ID \_EQ \_TRUE ; \_IF \_ID \_AND ( \_ID = \_NUM ) \_THEN \_WRITE ( \_STR ) ; \_END .

Formed symbol table:

Table variables:

|  |  |  |  |
| --- | --- | --- | --- |
| Offset | Variable identifier | Variable type | The value of the variable |
| 1 | "a" | integer | 3 |
| 2 | “b” | boolean | true |

Table tags and constants have remained empty because the program has never encountered this type of ads identifiers.

As a result of the lexical analysis:

1. The program parsed into separate lexemes.

2. Lexemes are converted to tokens.

3. Fill the table identifiers, user-defined in the program.

# Description of the syntax analysis.

## Construction of CFG(context-free grammar) input language.

For the construction of CFG input language is necessary:

* replace metalinguistic variables BNF notation of non-terminal symbols, using short names;
* terminal symbols as used tokens;
* metalinguistic symbol ":: =" to replace the symbol «→»;
* replace one metalinguistic formula n alternatives by n grammar rules with the same symbol on the left of inference rules;
* exclude metalinguistic symbols {} and [] to include the rules of grammar to recursive rules and ε-rule.

The correspondences between the non-terminal symbols of the grammar and meta linguistic variables Backus-Naur Form:

|  |  |  |  |
| --- | --- | --- | --- |
| **<program>** | PROG | < **sequence\_of\_letters\_and\_ digits** > | NLN |
| < **block\_definitions \_variables** > | VARS | **<operator>** | OP |
| **<** **variable\_description >** | VAR | **<** **unlabeled\_operator >** | UMOP |
| < **block\_definitions\_constant**> | CONSTS |  |  |
| **< constant\_description >** | CONST | **<** **assignment\_operator >** | AOP |
| < **block\_definitions\_labels**> | LABELS | **<** **operator\_of\_unconditional\_transition>** | GOP |
| **<simple\_type>** | TYPE | **<output\_operator>** | WOP |
| **<identifier>** | ID | **<massage>** | MSG |
| **<letter>** | L | **<input\_operator>** | ROP |
| **<digit>** | N | **<composite\_operator>** | COP |
| **<arithmetic\_expression>** | AEXP | **<** **conditional\_operator >** | IFOP |
| **<therm>** | TERM | **<** **while\_loop >** | FOROP |
| **<** **multiplier >** | MULT | **<** **operator\_length\_string >** | LENOP |
| **<sign>** | SIGN | **<** **operator\_string\_concatenation >** | CONOP |
| **<** **logical\_expression >** | LEXP | **<** **operator\_replacement\_substring >** | REPOP |
| **<logical\_therm>** | LTERM | **<** **search\_operator\_substring >** | SEOP |
| **<logical\_multiplier>** | LMULT | **<** **operator\_access\_substring >** | SUBOP |
| **<ratio>** | REL | < **operator\_function** > | FUNOP |
| **<constant>** | C | < **function\_header** > | HFUN |
| **<** **decimal\_constant >** | DEC | <**operator\_new**> | NEWOP |
| < **sequence\_of\_digits** > | NN | < **operator\_conditional\_assignment** > | IFAOP |
| **<** **real\_constant >** | RC | < **operator\_ overloading** > | OPOP |
| < **fractional\_constant** > | DC | < **description\_overloaded\_variables \_1**> | OVAR1 |
| < **exponential\_part** > | EXP | < **description\_overloaded\_variables \_2**> | OVAR2 |
| **<** **char\_constant >** | CC | < **description\_overloaded\_variables** > | OVAR |
| < **Boolean\_constant** > | BC | <**overloaded \_operations**> | OOP |
| **<** **string\_constant >** | SC | <**block\_definitions\_function**> | FUNCS |

**<program>**::= ['program' <identifier>;] {<block\_definitions\_constant>|<block\_definitions\_labels>| < block\_definitions \_variables >|< block\_definitions\_function >} < composite\_operator > '.'

Grammar programs G0 = <T,N,PROG,R>

N = {PROG, ID, COP, *CLV*, *OPROG, OCOP*}

T = {\_PROG, ., ;}

R = {

|  |  |  |
| --- | --- | --- |
| PROG →\_PROG ID ; OPROG  PROG → OPROG | OCOP→COP.  OPROG → OCOP | OPROG → CLV; OCOP |

}

The grammar of block definitions of variables G1 = <T,N,VARS,R>

N = {VARS, VAR, ID, TYPE, *RVAR*, *RID*}

T = {\_VAR, ,, ;, :}

R = {

|  |  |  |
| --- | --- | --- |
| VARS→\_VAR RVAR  RVAR→VAR ; RVAR | RVAR→VAR  VAR→RID : TYPE | RID→ ID , RID  RID→ ID |

}

The grammar of block definitions of constants G2 = <T,N,CONSTS,R>

N = {CONSTS, CONST, ID, C, *RCONST*}

T = {\_CONST, =, ;}

R = {

|  |  |  |
| --- | --- | --- |
| CONSTS →\_CONST CONST ; RCONST  CONSTS →\_CONST CONST  RCONST → CONST ; RCONST | RCONST → CONST  CONST→ID = C |  |

}

The grammar of block definitions of labels G3 = <T,N,LABELS,R>

N = {LABELS, *RID*}

T = {\_LABEL}

R = {

|  |  |  |
| --- | --- | --- |
| LABELS →\_LABEL RID |  |  |

}

The grammar of block definitions of functions G4 = <T,N,FUNCS,R>

N = {FUNCS, FUNOP, OPOP, HFUN, CLV, COP, ID, TYPE }

T = {\_FUNC, :, ;}

R = {

|  |  |  |
| --- | --- | --- |
| FUNCS→FUNOP  FUNOP → HFUN ; COP ;  FUNOP → HFUN ; VARS ; COP ; | FUNCS→OPOP  HFUN → \_FUNC ID : TYPE |  |

}

The grammar of simple type G5 = <T,N,TYPE,R>

N = {TYPE}

T = {\_INT, \_REAL, \_BOOL, \_CHAR, \_STRING}

R = {

|  |  |  |
| --- | --- | --- |
| TYPE→\_INT  TYPE→\_REAL | TYPE→\_BOOL  TYPE→\_CHAR | TYPE→\_STRING |

}

The grammar of identifier G6 = <T,N,ID,R>

N = {ID}

T = { \_ID}

R = {

|  |  |  |
| --- | --- | --- |
| ID→\_ID |  |  |

}

The grammar of arithmetic expression G7 = <T,N,AEXP,R>

N = {AEXP, TERM, MULT, ID, DC, RC, LENOP, SEOP }

T = {\*, /, (, ), +, -}

R = {

|  |  |  |
| --- | --- | --- |
| AEXP → TERM  AEXP → + TERM  AEXP → - TERM  AEXP → AEXP + TERM  AEXP → AEXP - TERM  TERM → MULT | TERM → TERM \* MULT  TERM → TERM / MULT  MULT → ( AEXP ) | MULT → ID  MULT → DC  MULT → RC  MULT → LENOP  MULT → SEOP |

}

The grammar of logical expression G8 = <T,N,LEXP,R>

N = {LEXP, LTERM, LMULT, ID, AEXP, SC, *RLTERM*}

T = {\_OR, \_AND, \_NOT, \_REL, (, )}

R = {

|  |  |  |
| --- | --- | --- |
| LEXP → LTERM  LEXP → LTERM \_OR RLTERM  RLTERM → LTERM \_OR RLTERM  RLTERM → LTERM  LTERM → LTERM \_AND LMULT | LTERM → LMULT  LMULT → ID  LMULT → AEXP \_REL AEXP  LMULT → SC \_REL SC | LMULT → \_NOT LMULT  LMULT → ( LEXP ) |

}

The grammar of constant G9 = <T,N,C,R>

N = {C, DEC, RC, CC, BC, SC, N, DC, L}

T = {., \_TRUE, \_FALSE, \_NUM, \_STR, +, -, \_L, \_N, \_CC, \_RC }

R = {

|  |  |  |
| --- | --- | --- |
| C→ DEC  C → RC  C → CC  C → BC  C → SC  DEC → + \_NUM  DEC → - \_NUM | DEC → \_NUM  RC → DC  RC → \_RC  DC → \_NUM  DC → \_NUM . \_NUM  L→ \_L  N→ \_N | CC → \_CC  BC → \_TRUE  BC → \_FALSE  SC → \_STR |

}

The grammar of operator G10 = <T,N,C,R>

N = {OP, ID, UMOP, AOP, GOP, WOP, ROP, COP, IFOP, FOROP, FUNOP, NEWOP, IFAOP, OPOP, *RECUROP* }

T = {:, ;}

R = {

|  |  |  |
| --- | --- | --- |
| OP → RECUROP  RECUROP → ID : UMOP ; RECUROP  RECUROP → UMOP ; RECUROP  RECUROP → UMOP | UMOP → AOP|GOP|WOP|ROP|COP|IFOP|FOROP|FUNOP|NEWOP|IFAOP|OPOP |  |

}

The grammar of assignment operator G11 = <T,N,AOP,R>

N = {AOP, ID, AEXP, LEXP, C, CONOP, SUBOP, REPOP, *ALEXP*}

T = {\_EQ}

R = {

|  |  |  |
| --- | --- | --- |
| AOP → ID \_EQ ALEXP  ALEXP → C  ALEXP → SUBOP | ALEXP → AEXP  ALEXP → CONOP | ALEXP → LEXP  ALEXP → REPOP |

}

The grammar of operator of unconditional transition G12 = <T,N,GOP,R>

N = {GOP, ID }

T = {\_GOTO}

R = {

|  |  |  |
| --- | --- | --- |
| GOP → \_GOTO ID |  |  |

}

The grammar of output operator G13 = <T,N,WOP,R>

N = {WOP, MSG, AEXP, LEXP, SC, *RMSG*}

T = {\_WRITE, (, ), ,}

R = {

|  |  |  |
| --- | --- | --- |
| WOP → \_WRITE ( MSG )  RMSG → MSG , RMSG | RMSG → MSG  MSG → AEXP | MSG → LEXP  MSG → SC |

}

The grammar of input operator G14 = <T,N,ROP,R>

N = {ROP, ID, *RID*}

T = {\_READ, (, ), ,}

R = {

|  |  |  |
| --- | --- | --- |
| ROP → \_READ ( RID ) |  |  |

}

The grammar of composite operator G15 = <T,N,COP,R>

N = {COP, OP, *ZOMOP*}

T = {\_BEGIN, \_END, ;}

R = {

|  |  |  |
| --- | --- | --- |
| COP → \_BEGIN ZOMOP \_END  COP → \_BEGIN \_END | ZOMOP → OP ; ZOMOP | ZOMOP → OP ; |

}

The grammar of conditional\_operator G16 = <T,N,IFOP,R>

N = {IFOP, LEXP, OP, COP, *OCOP*}

T = {\_IF, \_THEN, \_ELSE}

R = {

|  |  |  |
| --- | --- | --- |
| IFOP → \_IF LEXP \_THEN OCOP  IFOP → \_IF LEXP \_THEN OCOP \_ELSE OCOP | OCOP → COP  OCOP → OP |  |

}

The grammar of while loop operator G17 = <T,N,FOROP,R>

N = {FOROP, LEXP, OP, COP, *OCOP*}

T = {\_WHILE, \_DO}

R = {

|  |  |  |
| --- | --- | --- |
| FOROP → \_WHILE LEXP \_DO OCOP |  |  |

}

The grammar of operator length string G18 = <T,N,LENOP,R>

N = {LENOP, ID, SC, *IDSC*}

T = {\_LEN, (, )}

R = {

|  |  |  |
| --- | --- | --- |
| LENOP → \_LEN ( IDSC ) | IDSC → ID | IDSC → SC |

}

The grammar of operator of string concatenation G19 = <T,N,CONOP,R>

N = {CONOP, ID, SC, *IDSC*}

T = {\_CONC, (, ), ,}

R = {

|  |  |  |
| --- | --- | --- |
| CONOP → \_CONC ( IDSC , IDSC ) |  |  |

}

The grammar of operator of replacement substring to string G20 = <T,N,REPOP,R>

N = {REPOP, ID, SC, *IDSC*}

T = {\_REPL, (, ), ,}

R = {

|  |  |  |
| --- | --- | --- |
| REPOP → \_REPL ( IDSC , IDSC, IDSC ) |  |  |

}

The grammar of operator of search substring in the string G21 = <T,N,SEOP,R>

N = {SEOP, ID, SC, *IDSC*}

T = {\_SRCH, (, ), ,}

R = {

|  |  |  |
| --- | --- | --- |
| SEOP → \_SRCH ( IDSC , IDSC ) |  |  |

}

The grammar of operator of access substring to string G22 = <T,N,SUBOP,R>

N = {SUBOP, ID, SC, NN, *IDSC, IDNN*}

T = {\_SUBS, (, ), ,}

R = {

|  |  |  |
| --- | --- | --- |
| SUBOP → \_SUBS ( IDSC , IDNN, IDNN ) | IDNN → ID | IDNN → \_NUM |

}

The grammar of program G23 = <T,N,CLV,R>

N = {PROG, ID, CONSTS, LABELS, VARS, COP, FUNCS, *CLV*, *OPROG, OCOP*}

T = { ; }

R = {

|  |  |  |
| --- | --- | --- |
| CLV → CONSTS  CLV → CONSTS ; CLV  CLV → LABELS | CLV→VARS  CLV→VARS ; CLV  CLV → LABELS ; CLV | CLV→FUNCS  CLV→FUNCS ; CLV |

}

The grammar of operator new G24 = <T,N,NEWOP,R>

N = {NEWOP, ID}

T = {\_NEW, (, )}

R = {

|  |  |
| --- | --- |
| NEWOP → \_NEW ( ID ) |  |

}

The grammar of operator conditional assignment G25 = <T,N,IFAOP,R>

N = {IFAOP, LEXP, AOP, *OEAOP*}

T = {\_IF, \_THEN, \_ELSE}

R = {

|  |  |  |
| --- | --- | --- |
| IFAOP → \_IF LEXP \_THEN AOP \_ELSE AOP  IFAOP → \_IF LEXP \_THEN AOP |  |  |

}

The grammar of operator of overloading G26 = <T,N,OPOP,R>

N = {OPOP, OOP, OVAR, ID, TYPE, COP, OVAR1, OVAR2, REL}

T = {\_OPER, (, ), :, ;, ,, +, -, \*, /, \_REL}

R = {

|  |  |  |
| --- | --- | --- |
| OPOP → \_OPER OOP ( OVAR ) ID : TYPE ; COP ;  OVAR1 → ID : TYPE ; ID : TYPE  OVAR2 → ID , ID : TYPE | OVAR → OVAR1  OVAR → OVAR2  OOP → REL|+|-|\*|/ | REL → \_REL |

}

Italics are non-terminals which are subsidiary in removing symbols {} and [] from the BNF.

## Definition of the class CFG of the input language.

Each of the constructed CFG in the previous point belongs to the class of grammars of operator precedence.

## DMP converter.

The control table:

File : "G0.TXT" .

NON-TERMINALS: [CLV, COP, ID, OCOP, OPROG, PROG]

TERMINALS: [., ;, \_prog]

START SYMBOL: PROG

RULES:

(0) PROG -> \_prog ID ; OPROG

(1) PROG -> OPROG

(2) OPROG -> OCOP

(3) OPROG -> CLV ; OCOP

(4) OCOP -> COP .

The grammar of operator precedence

Table of transfer and convolution

| €

-------------------------+---------

# [\_prog, PROG, ;, PROG] | 0, PROG

-------------------------+---------

; [PROG, ;, PROG] | 3, PROG

-------------------------+---------

# [PROG, ;, PROG] | 3, PROG

-------------------------+---------

; [PROG, .] | 4, PROG

-------------------------+---------

# [PROG, .] | 4, PROG

| . | ; | \_prog | $

-----------+---+---+-------+---

[., C] | | | | R

-----------+---+---+-------+---

[;, C] | S | S | | R

-----------+---+---+-------+---

[\_prog, C] | | S | |

-----------+---+---+-------+---

[#] | S | S | S |

-----------+---+---+-------+---

[#, PROG] | S | S | S | A

The relationship of precedence

| . | ; | \_prog | $

------+------+------+-------+------

. | | | | [.>]

------+------+------+-------+------

; | [<.] | [<.] | | [.>]

------+------+------+-------+------

\_prog | | [=.] | |

------+------+------+-------+------

# | [<.] | [<.] | [<.] |

End.

File : "G1.TXT" .

NON-TERMINALS: [ID, RID, RVAR, TYPE, VAR, VARS]

TERMINALS: [,, :, ;, \_var]

START SYMBOL: VARS

RULES:

(0) VARS -> \_var RVAR

(1) RVAR -> VAR ; RVAR

(2) RVAR -> VAR

(3) VAR -> RID : TYPE

(4) RID -> ID , RID

(5) RID -> ID

The grammar of operator precedence

Table of transfer and convolution

| €

---------------------+---------

# [\_var, VARS] | 0, VARS

---------------------+---------

; [VARS, ;, VARS] | 1, VARS

---------------------+---------

\_var [VARS, ;, VARS] | 1, VARS

---------------------+---------

; [VARS, :, VARS] | 3, VARS

---------------------+---------

\_var [VARS, :, VARS] | 3, VARS

---------------------+---------

, [VARS, ,, VARS] | 4, VARS

---------------------+---------

; [VARS, ,, VARS] | 4, VARS

---------------------+---------

\_var [VARS, ,, VARS] | 4, VARS

| , | : | ; | \_var | $

----------+---+---+---+------+---

[,, C] | S | R | | |

----------+---+---+---+------+---

[:, C] | | | R | | R

----------+---+---+---+------+---

[;, C] | S | S | S | | R

----------+---+---+---+------+---

[\_var, C] | S | S | S | | R

----------+---+---+---+------+---

[#] | | | | S |

----------+---+---+---+------+---

[#, VARS] | | | | S | A

The relationship of precedence

| , | : | ; | \_var | $

-----+------+------+------+------+------

, | [<.] | [.>] | | |

-----+------+------+------+------+------

: | | | [.>] | | [.>]

-----+------+------+------+------+------

; | [<.] | [<.] | [<.] | | [.>]

-----+------+------+------+------+------

\_var | [<.] | [<.] | [<.] | | [.>]

-----+------+------+------+------+------

# | | | | [<.] |

End.

File : "G2.TXT" .

NON-TERMINALS: [C, CONST, CONSTS, ID, RCONST]

TERMINALS: [;, =, \_const]

START SYMBOL: CONSTS

RULES:

(0) CONSTS -> \_const CONST ; RCONST

(1) CONSTS -> \_const CONST

(2) RCONST -> CONST ; RCONST

(3) RCONST -> CONST

(4) CONST -> ID = C

The grammar of operator precedence

Table of transfer and convolution

| €

------------------------------+-----------

# [\_const, CONSTS, ;, CONSTS] | 0, CONSTS

------------------------------+-----------

# [\_const, CONSTS] | 1, CONSTS

------------------------------+-----------

; [CONSTS, ;, CONSTS] | 2, CONSTS

------------------------------+-----------

; [CONSTS, =, CONSTS] | 4, CONSTS

------------------------------+-----------

\_const [CONSTS, =, CONSTS] | 4, CONSTS

| ; | = | \_const | $

------------+---+---+--------+---

[;, C] | S | S | | R

------------+---+---+--------+---

[=, C] | R | | | R

------------+---+---+--------+---

[\_const, C] | S | S | | R

------------+---+---+--------+---

[#] | | | S |

------------+---+---+--------+---

[#, CONSTS] | | | S | A

The relationship of precedence

| ; | = | \_const | $

-------+------+------+--------+------

; | [<.] | [<.] | | [.>]

-------+------+------+--------+------

= | [.>] | | | [.>]

-------+------+------+--------+------

\_const | [=.] | [<.] | | [.>]

-------+------+------+--------+------

# | | | [<.] |

End.

File : "G3.TXT" .

NON-TERMINALS: [LABELS, RID]

TERMINALS: [\_label]

START SYMBOL: LABELS

RULES:

(0) LABELS -> \_label RID

The grammar of operator precedence

Table of transfer and convolution

| €

-------------------+-----------

# [\_label, LABELS] | 0, LABELS

| \_label | $

------------+--------+---

[\_label, C] | | R

------------+--------+---

[#] | S |

------------+--------+---

[#, LABELS] | S | A

The relationship of precedence

| \_label | $

-------+--------+------

\_label | | [.>]

-------+--------+------

# | [<.] |

End.

File : "G4.TXT" .

NON-TERMINALS: [COP, FUNCS, FUNOP, HFUN, ID, OPOP, TYPE, VARS]

TERMINALS: [:, ;, \_func]

START SYMBOL: FUNCS

RULES:

(0) FUNCS -> FUNOP

(1) FUNCS -> OPOP

(2) FUNOP -> HFUN ; COP ;

(3) FUNOP -> HFUN ; VARS ; COP ;

(4) HFUN -> \_func ID : TYPE

The grammar of operator precedence

Table of transfer and convolution

| €

---------------------------------+----------

# [FUNCS, ;, FUNCS, ;] | 2, FUNCS

---------------------------------+----------

# [FUNCS, ;, FUNCS, ;, FUNCS, ;] | 3, FUNCS

---------------------------------+----------

# [\_func, FUNCS, :, FUNCS] | 4, FUNCS

| : | ; | \_func | $

-----------+---+---+-------+---

[:, C] | | R | |

-----------+---+---+-------+---

[;, C] | | S | | R

-----------+---+---+-------+---

[\_func, C] | S | | |

-----------+---+---+-------+---

[#] | | S | S |

-----------+---+---+-------+---

[#, FUNCS] | | S | S | A

The relationship of precedence

| : | ; | \_func | $

------+------+------+-------+------

: | | [.>] | |

------+------+------+-------+------

; | | [=.] | | [.>]

------+------+------+-------+------

\_func | [=.] | | |

------+------+------+-------+------

# | | [<.] | [<.] |

End.

File : "G5.TXT" .

NON-TERMINALS: [TYPE]

TERMINALS: [\_bool, \_char, \_int, \_real, \_string]

START SYMBOL: TYPE

RULES:

(0) TYPE -> \_int

(1) TYPE -> \_real

(2) TYPE -> \_bool

(3) TYPE -> \_char

(4) TYPE -> \_string

The grammar of operator precedence

Table of transfer and convolution

| €

------------+---------

# [\_int] | 0, TYPE

------------+---------

# [\_real] | 1, TYPE

------------+---------

# [\_bool] | 2, TYPE

------------+---------

# [\_char] | 3, TYPE

------------+---------

# [\_string] | 4, TYPE

| \_bool | \_char | \_int | \_real | \_string | $

-------------+-------+-------+------+-------+---------+---

[\_bool, C] | | | | | | R

-------------+-------+-------+------+-------+---------+---

[\_char, C] | | | | | | R

-------------+-------+-------+------+-------+---------+---

[\_int, C] | | | | | | R

-------------+-------+-------+------+-------+---------+---

[\_real, C] | | | | | | R

-------------+-------+-------+------+-------+---------+---

[\_string, C] | | | | | | R

-------------+-------+-------+------+-------+---------+---

[#] | S | S | S | S | S |

-------------+-------+-------+------+-------+---------+---

[#, TYPE] | S | S | S | S | S | A

The relationship of precedence

| \_bool | \_char | \_int | \_real | \_string | $

--------+-------+-------+------+-------+---------+------

\_bool | | | | | | [.>]

--------+-------+-------+------+-------+---------+------

\_char | | | | | | [.>]

--------+-------+-------+------+-------+---------+------

\_int | | | | | | [.>]

--------+-------+-------+------+-------+---------+------

\_real | | | | | | [.>]

--------+-------+-------+------+-------+---------+------

\_string | | | | | | [.>]

--------+-------+-------+------+-------+---------+------

# | [<.] | [<.] | [<.] | [<.] | [<.] |

File : "G6.TXT" .

NON-TERMINALS: [ID]

TERMINALS: [\_id]

START SYMBOL: ID

RULES:

(0) ID -> \_id

The grammar of operator precedence

Table of transfer and convolution

| €

--------+-------

# [\_id] | 0, ID

| \_id | $

---------+-----+---

[\_id, C] | | R

---------+-----+---

[#] | S |

---------+-----+---

[#, ID] | S | A

The relationship of precedence

| \_id | $

----+------+------

\_id | | [.>]

----+------+------

# | [<.] |

End.

File : "G7.TXT" .

NON-TERMINALS: [AEXP, DC, ID, LENOP, MULT, RC, SEOP, TERM]  
TERMINALS: [(, ), \*, +, -, /]  
START SYMBOL: AEXP  
 RULES:  
(0) AEXP -> TERM  
(1) AEXP -> + TERM  
(2) AEXP -> - TERM  
(3) AEXP -> AEXP + TERM  
(4) AEXP -> AEXP - TERM  
(5) TERM -> MULT  
(6) TERM -> TERM \* MULT  
(7) TERM -> TERM / MULT  
(8) MULT -> ( AEXP )  
(9) MULT -> ID  
(10) MULT -> DC  
(11) MULT -> RC  
(12) MULT -> LENOP  
(13) MULT -> SEOP  
The grammar of operator precedence

Table of transfer and convolution  
 | €   
------------------+---------  
 ( [+, AEXP] | 1, AEXP  
------------------+---------  
 # [+, AEXP] | 1, AEXP  
------------------+---------  
 ( [-, AEXP] | 2, AEXP  
------------------+---------  
 # [-, AEXP] | 2, AEXP  
------------------+---------  
( [AEXP, +, AEXP] | 3, AEXP  
------------------+---------  
# [AEXP, +, AEXP] | 3, AEXP  
------------------+---------  
( [AEXP, -, AEXP] | 4, AEXP  
------------------+---------  
# [AEXP, -, AEXP] | 4, AEXP  
------------------+---------  
( [AEXP, \*, AEXP] | 6, AEXP  
------------------+---------  
+ [AEXP, \*, AEXP] | 6, AEXP  
------------------+---------  
- [AEXP, \*, AEXP] | 6, AEXP  
------------------+---------  
# [AEXP, \*, AEXP] | 6, AEXP  
------------------+---------  
( [AEXP, /, AEXP] | 7, AEXP  
------------------+---------  
+ [AEXP, /, AEXP] | 7, AEXP  
------------------+---------  
- [AEXP, /, AEXP] | 7, AEXP  
------------------+---------  
# [AEXP, /, AEXP] | 7, AEXP  
------------------+---------  
 ( [(, AEXP, )] | 8, AEXP  
------------------+---------  
 \* [(, AEXP, )] | 8, AEXP  
------------------+---------  
 + [(, AEXP, )] | 8, AEXP  
------------------+---------  
 - [(, AEXP, )] | 8, AEXP  
------------------+---------  
 / [(, AEXP, )] | 8, AEXP  
------------------+---------  
 # [(, AEXP, )] | 8, AEXP  
  
 | ( | ) | \* | + | - | / | $  
----------+---+---+---+---+---+---+---  
 [(, C] | S | S | S | S | S | S |   
----------+---+---+---+---+---+---+---  
 [), C] | | R | R | R | R | R | R  
----------+---+---+---+---+---+---+---  
 [\*, C] | S | R | R | R | R | R | R  
----------+---+---+---+---+---+---+---  
 [+, C] | S | R | S | R | R | S | R  
----------+---+---+---+---+---+---+---  
 [-, C] | S | R | S | R | R | S | R  
----------+---+---+---+---+---+---+---  
 [/, C] | S | R | R | R | R | R | R  
----------+---+---+---+---+---+---+---  
 [#] | S | | S | S | S | S |   
----------+---+---+---+---+---+---+---  
[#, AEXP] | S | | S | S | S | S | A  
  
The relationship of precedence  
 | ( | ) | \* | + | - | / | $   
--+------+------+------+------+------+------+------  
( | [<.] | [=.] | [<.] | [<.] | [<.] | [<.] |   
--+------+------+------+------+------+------+------  
) | | [.>] | [.>] | [.>] | [.>] | [.>] | [.>]  
--+------+------+------+------+------+------+------  
\* | [<.] | [.>] | [.>] | [.>] | [.>] | [.>] | [.>]  
--+------+------+------+------+------+------+------  
+ | [<.] | [.>] | [<.] | [.>] | [.>] | [<.] | [.>]  
--+------+------+------+------+------+------+------  
- | [<.] | [.>] | [<.] | [.>] | [.>] | [<.] | [.>]  
--+------+------+------+------+------+------+------  
/ | [<.] | [.>] | [.>] | [.>] | [.>] | [.>] | [.>]  
--+------+------+------+------+------+------+------  
# | [<.] | | [<.] | [<.] | [<.] | [<.] |

End.

File : "G8.TXT" .

NON-TERMINALS: [AEXP, ID, LEXP, LMULT, LTERM, RLTERM, SC]

TERMINALS: [(, ), \_and, \_not, \_or, \_rel]

START SYMBOL: LEXP

RULES:

(0) LEXP -> LTERM

(1) LEXP -> LTERM \_or RLTERM

(2) RLTERM -> LTERM \_or RLTERM

(3) RLTERM -> LTERM

(4) LTERM -> LTERM \_and LMULT

(5) LTERM -> LMULT

(6) LMULT -> ID

(7) LMULT -> AEXP \_rel AEXP

(8) LMULT -> SC \_rel SC

(9) LMULT -> \_not LMULT

(10) LMULT -> ( LEXP )

The grammar of operator precedence

Table of transfer and convolution

| €

------------------------+----------

( [LEXP, \_or, LEXP] | 1, LEXP

------------------------+----------

\_or [LEXP, \_or, LEXP] | 1, LEXP

------------------------+----------

# [LEXP, \_or, LEXP] | 1, LEXP

------------------------+----------

( [LEXP, \_and, LEXP] | 4, LEXP

------------------------+----------

\_or [LEXP, \_and, LEXP] | 4, LEXP

------------------------+----------

# [LEXP, \_and, LEXP] | 4, LEXP

------------------------+----------

( [LEXP, \_rel, LEXP] | 7, LEXP

------------------------+----------

\_and [LEXP, \_rel, LEXP] | 7, LEXP

------------------------+----------

\_not [LEXP, \_rel, LEXP] | 7, LEXP

------------------------+----------

\_or [LEXP, \_rel, LEXP] | 7, LEXP

------------------------+----------

# [LEXP, \_rel, LEXP] | 7, LEXP

------------------------+----------

( [\_not, LEXP] | 9, LEXP

------------------------+----------

\_and [\_not, LEXP] | 9, LEXP

------------------------+----------

\_not [\_not, LEXP] | 9, LEXP

------------------------+----------

\_or [\_not, LEXP] | 9, LEXP

------------------------+----------

# [\_not, LEXP] | 9, LEXP

------------------------+----------

( [(, LEXP, )] | 10, LEXP

------------------------+----------

\_and [(, LEXP, )] | 10, LEXP

------------------------+----------

\_not [(, LEXP, )] | 10, LEXP

------------------------+----------

\_or [(, LEXP, )] | 10, LEXP

------------------------+----------

# [(, LEXP, )] | 10, LEXP

| ( | ) | \_and | \_not | \_or | \_rel | $

----------+---+---+------+------+-----+------+---

[(, C] | S | S | S | S | S | S |

----------+---+---+------+------+-----+------+---

[), C] | | R | R | | R | | R

----------+---+---+------+------+-----+------+---

[\_and, C] | S | R | R | S | R | S | R

----------+---+---+------+------+-----+------+---

[\_not, C] | S | R | R | S | R | S | R

----------+---+---+------+------+-----+------+---

[\_or, C] | S | R | S | S | S | S | R

----------+---+---+------+------+-----+------+---

[\_rel, C] | | R | R | | R | | R

----------+---+---+------+------+-----+------+---

[#] | S | | S | S | S | S |

----------+---+---+------+------+-----+------+---

[#, LEXP] | S | | S | S | S | S | A

The relationship of precedence

| ( | ) | \_and | \_not | \_or | \_rel | $

-----+------+------+------+------+------+------+------

( | [<.] | [=.] | [<.] | [<.] | [<.] | [<.] |

-----+------+------+------+------+------+------+------

) | | [.>] | [.>] | | [.>] | | [.>]

-----+------+------+------+------+------+------+------

\_and | [<.] | [.>] | [.>] | [<.] | [.>] | [<.] | [.>]

-----+------+------+------+------+------+------+------

\_not | [<.] | [.>] | [.>] | [<.] | [.>] | [<.] | [.>]

-----+------+------+------+------+------+------+------

\_or | [<.] | [.>] | [<.] | [<.] | [<.] | [<.] | [.>]

-----+------+------+------+------+------+------+------

\_rel | | [.>] | [.>] | | [.>] | | [.>]

-----+------+------+------+------+------+------+------

# | [<.] | | [<.] | [<.] | [<.] | [<.] |

End.

File : "G9.TXT" .

NON-TERMINALS: [BC, C, CC, DC, DEC, L, N, RC, SC]

TERMINALS: [+, -, ., \_cc, \_e, \_false, \_num, \_rc, \_str, \_true]

START SYMBOL: C

RULES:

(0) C -> DEC

(1) C -> RC

(2) C -> CC

(3) C -> BC

(4) C -> SC

(5) DEC -> + \_num

(6) DEC -> - \_num

(7) DEC -> \_num

(8) RC -> DC

(9) RC -> \_rc

(10) DC -> \_num

(11) DC -> \_num . \_num

(12) CC -> \_cc

(13) BC -> \_true

(14) BC -> \_false

(15) SC -> \_str

The grammar of operator precedence

Table of transfer and convolution

| €

------------------+-------

# [+, \_num] | 5, C

------------------+-------

# [-, \_num] | 6, C

------------------+-------

# [\_num] | 7, C

------------------+-------

# [\_rc] | 9, C

------------------+-------

# [\_num, ., \_num] | 11, C

------------------+-------

# [\_cc] | 12, C

------------------+-------

# [\_true] | 13, C

------------------+-------

# [\_false] | 14, C

------------------+-------

# [\_str] | 15, C

| + | - | . | \_cc | \_e | \_false | \_num | \_rc | \_str | \_true | $

------------+---+---+---+-----+----+--------+------+-----+------+-------+---

[+, C] | | | | | | | S | | | |

------------+---+---+---+-----+----+--------+------+-----+------+-------+---

[-, C] | | | | | | | S | | | |

------------+---+---+---+-----+----+--------+------+-----+------+-------+---

[., C] | | | | | | | S | | | |

------------+---+---+---+-----+----+--------+------+-----+------+-------+---

[\_cc, C] | | | | | | | | | | | R

------------+---+---+---+-----+----+--------+------+-----+------+-------+---

[\_e, C] | | | | | | | | | | |

------------+---+---+---+-----+----+--------+------+-----+------+-------+---

[\_false, C] | | | | | | | | | | | R

------------+---+---+---+-----+----+--------+------+-----+------+-------+---

[\_num, C] | | | S | | | | | | | | R

------------+---+---+---+-----+----+--------+------+-----+------+-------+---

[\_rc, C] | | | | | | | | | | | R

------------+---+---+---+-----+----+--------+------+-----+------+-------+---

[\_str, C] | | | | | | | | | | | R

------------+---+---+---+-----+----+--------+------+-----+------+-------+---

[\_true, C] | | | | | | | | | | | R

------------+---+---+---+-----+----+--------+------+-----+------+-------+---

[#] | S | S | | S | | S | S | S | S | S |

------------+---+---+---+-----+----+--------+------+-----+------+-------+---

[#, C] | S | S | | S | | S | S | S | S | S | A

The relationship of precedence

| + | - | . | \_cc | \_e | \_false | \_num | \_rc | \_str | \_true | $

-------+------+------+------+------+----+--------+------+------+------+-------+------

+ | | | | | | | [=.] | | | |

-------+------+------+------+------+----+--------+------+------+------+-------+------

- | | | | | | | [=.] | | | |

-------+------+------+------+------+----+--------+------+------+------+-------+------

. | | | | | | | [=.] | | | |

-------+------+------+------+------+----+--------+------+------+------+-------+------

\_cc | | | | | | | | | | | [.>]

-------+------+------+------+------+----+--------+------+------+------+-------+------

\_e | | | | | | | | | | |

-------+------+------+------+------+----+--------+------+------+------+-------+------

\_false | | | | | | | | | | | [.>]

-------+------+------+------+------+----+--------+------+------+------+-------+------

\_num | | | [=.] | | | | | | | | [.>]

-------+------+------+------+------+----+--------+------+------+------+-------+------

\_rc | | | | | | | | | | | [.>]

-------+------+------+------+------+----+--------+------+------+------+-------+------

\_str | | | | | | | | | | | [.>]

-------+------+------+------+------+----+--------+------+------+------+-------+------

\_true | | | | | | | | | | | [.>]

-------+------+------+------+------+----+--------+------+------+------+-------+------

# | [<.] | [<.] | | [<.] | | [<.] | [<.] | [<.] | [<.] | [<.] |

End.

File : "G10.TXT" .

NON-TERMINALS: [AOP, COP, FOROP, FUNOP, GOP, ID, IFAOP, IFOP, NEWOP, OP, OPOP, RECUROP, ROP, UMOP, WOP]  
TERMINALS: [:, ;]  
START SYMBOL: OP  
 RULES:  
(0) OP -> RECUROP  
(1) RECUROP -> ID : UMOP ; RECUROP  
(2) RECUROP -> UMOP ; RECUROP  
(3) RECUROP -> UMOP  
(4) UMOP -> AOP  
(5) UMOP -> GOP  
(6) UMOP -> WOP  
(7) UMOP -> ROP  
(8) UMOP -> COP  
(9) UMOP -> IFOP  
(10) UMOP -> FOROP  
(11) UMOP -> FUNOP  
(12) UMOP -> NEWOP  
(13) UMOP -> IFAOP  
(14) UMOP -> OPOP  
The grammar of operator precedence

Table of transfer and convolution  
 | €   
---------------------+-------  
; [OP, :, OP, ;, OP] | 1, OP  
---------------------+-------  
# [OP, :, OP, ;, OP] | 1, OP  
---------------------+-------  
 ; [OP, ;, OP] | 2, OP  
---------------------+-------  
 # [OP, ;, OP] | 2, OP  
  
 | : | ; | $  
--------+---+---+---  
[:, C] | | S |   
--------+---+---+---  
[;, C] | S | S | R  
--------+---+---+---  
 [#] | S | S |   
--------+---+---+---  
[#, OP] | S | S | A  
  
The relationship of precedence  
 | : | ; | $   
--+------+------+------  
: | | [=.] |   
--+------+------+------  
; | [<.] | [<.] | [.>]  
--+------+------+------  
# | [<.] | [<.] |

End.

File : "G11.TXT" .

NON-TERMINALS: [AEXP, ALEXP, AOP, C, CONOP, ID, LEXP, REPOP, SUBOP]  
TERMINALS: [\_eq]  
START SYMBOL: AOP  
 RULES:  
(0) AOP -> ID \_eq ALEXP  
(1) ALEXP -> C  
(2) ALEXP -> AEXP  
(3) ALEXP -> LEXP  
(4) ALEXP -> CONOP  
(5) ALEXP -> REPOP  
(6) ALEXP -> SUBOP  
The grammar of operator precedence

Table of transfer and convolution  
 | €   
------------------+--------  
# [AOP, \_eq, AOP] | 0, AOP  
  
 | \_eq | $  
---------+-----+---  
[\_eq, C] | | R  
---------+-----+---  
 [#] | S |   
---------+-----+---  
[#, AOP] | S | A  
  
The relationship of precedence  
 | \_eq | $   
----+------+------  
\_eq | | [.>]  
----+------+------  
 # | [<.] |

End.

File : "G12.TXT" .

NON-TERMINALS: [GOP, ID]

TERMINALS: [\_goto]

START SYMBOL: GOP

RULES:

(0) GOP -> \_goto ID

The grammar of operator precedence

Table of transfer and convolution

| €

---------------+--------

# [\_goto, GOP] | 0, GOP

| \_goto | $

-----------+-------+---

[\_goto, C] | | R

-----------+-------+---

[#] | S |

-----------+-------+---

[#, GOP] | S | A

The relationship of precedence

| \_goto | $

------+-------+------

\_goto | | [.>]

------+-------+------

# | [<.] |

End.

File : "G12.TXT" .

NON-TERMINALS: [GOP, ID]

TERMINALS: [\_goto]

START SYMBOL: GOP

RULES:

(0) GOP -> \_goto ID

The grammar of operator precedence

Table of transfer and convolution

| €

---------------+--------

# [\_goto, GOP] | 0, GOP

| \_goto | $

-----------+-------+---

[\_goto, C] | | R

-----------+-------+---

[#] | S |

-----------+-------+---

[#, GOP] | S | A

The relationship of precedence

| \_goto | $

------+-------+------

\_goto | | [.>]

------+-------+------

# | [<.] |

End.

File : "G13.TXT" .

NON-TERMINALS: [AEXP, LEXP, MSG, RMSG, SC, WOP]

TERMINALS: [(, ), ,, \_write]

START SYMBOL: WOP

RULES:

(0) WOP -> \_write ( MSG )

(1) RMSG -> MSG , RMSG

(2) RMSG -> MSG

(3) MSG -> AEXP

(4) MSG -> LEXP

(5) MSG -> SC

The grammar of operator precedence

Table of transfer and convolution

| €

----------------------+--------

# [\_write, (, WOP, )] | 0, WOP

----------------------+--------

, [WOP, ,, WOP] | 1, WOP

| ( | ) | , | \_write | $

------------+---+---+---+--------+---

[(, C] | | S | | |

------------+---+---+---+--------+---

[), C] | | | | | R

------------+---+---+---+--------+---

[,, C] | | | S | |

------------+---+---+---+--------+---

[\_write, C] | S | | | |

------------+---+---+---+--------+---

[#] | | | | S |

------------+---+---+---+--------+---

[#, WOP] | | | | S | A

The relationship of precedence

| ( | ) | , | \_write | $

-------+------+------+------+--------+------

( | | [=.] | | |

-------+------+------+------+--------+------

) | | | | | [.>]

-------+------+------+------+--------+------

, | | | [<.] | |

-------+------+------+------+--------+------

\_write | [=.] | | | |

-------+------+------+------+--------+------

# | | | | [<.] |

End.

File : "G14.TXT" .

NON-TERMINALS: [ID, RID, ROP]

TERMINALS: [(, ), ,, \_read]

START SYMBOL: ROP

RULES:

(0) ROP -> \_read ( RID )

(1) RID -> ID , RID

(2) RID -> ID

The grammar of operator precedence

Table of transfer and convolution

| €

---------------------+--------

# [\_read, (, ROP, )] | 0, ROP

---------------------+--------

( [ROP, ,, ROP] | 1, ROP

---------------------+--------

, [ROP, ,, ROP] | 1, ROP

| ( | ) | , | \_read | $

-----------+---+---+---+-------+---

[(, C] | | S | S | |

-----------+---+---+---+-------+---

[), C] | | | | | R

-----------+---+---+---+-------+---

[,, C] | | R | S | |

-----------+---+---+---+-------+---

[\_read, C] | S | | | |

-----------+---+---+---+-------+---

[#] | | | | S |

-----------+---+---+---+-------+---

[#, ROP] | | | | S | A

The relationship of precedence

| ( | ) | , | \_read | $

------+------+------+------+-------+------

( | | [=.] | [<.] | |

------+------+------+------+-------+------

) | | | | | [.>]

------+------+------+------+-------+------

, | | [.>] | [<.] | |

------+------+------+------+-------+------

\_read | [=.] | | | |

------+------+------+------+-------+------

# | | | | [<.] |

End.

File : "G15.TXT" .

NON-TERMINALS: [COP, OP, ZOMOP]

TERMINALS: [;, \_begin, \_end]

START SYMBOL: COP

RULES:

(0) COP -> \_begin ZOMOP \_end

(1) COP -> \_begin \_end

(2) ZOMOP -> OP ; ZOMOP

(3) ZOMOP -> OP ;

The grammar of operator precedence

Table of transfer and convolution

| €

----------------------+--------

# [\_begin, COP, \_end] | 0, COP

----------------------+--------

# [\_begin, \_end] | 1, COP

----------------------+--------

; [COP, ;, COP] | 2, COP

----------------------+--------

\_begin [COP, ;, COP] | 2, COP

----------------------+--------

; [COP, ;] | 3, COP

----------------------+--------

\_begin [COP, ;] | 3, COP

| ; | \_begin | \_end | $

------------+---+--------+------+---

[;, C] | S | | R |

------------+---+--------+------+---

[\_begin, C] | S | | S |

------------+---+--------+------+---

[\_end, C] | | | | R

------------+---+--------+------+---

[#] | | S | |

------------+---+--------+------+---

[#, COP] | | S | | A

The relationship of precedence

| ; | \_begin | \_end | $

-------+------+--------+------+------

; | [<.] | | [.>] |

-------+------+--------+------+------

\_begin | [<.] | | [=.] |

-------+------+--------+------+------

\_end | | | | [.>]

-------+------+--------+------+------

# | | [<.] | |

End.

File : "G16.TXT" .

NON-TERMINALS: [COP, IFOP, LEXP, OCOP, OP]

TERMINALS: [\_else, \_if, \_then]

START SYMBOL: IFOP

RULES:

(0) IFOP -> \_if LEXP \_then OCOP

(1) IFOP -> \_if LEXP \_then OCOP \_else OCOP

(2) OCOP -> COP

(3) OCOP -> OP

The grammar of operator precedence

Table of transfer and convolution

| €

----------------------------------------+---------

# [\_if, IFOP, \_then, IFOP] | 0, IFOP

----------------------------------------+---------

# [\_if, IFOP, \_then, IFOP, \_else, IFOP] | 1, IFOP

| \_else | \_if | \_then | $

-----------+-------+-----+-------+---

[\_else, C] | | | | R

-----------+-------+-----+-------+---

[\_if, C] | | | S |

-----------+-------+-----+-------+---

[\_then, C] | S | | | R

-----------+-------+-----+-------+---

[#] | | S | |

-----------+-------+-----+-------+---

[#, IFOP] | | S | | A

The relationship of precedence

| \_else | \_if | \_then | $

------+-------+------+-------+------

\_else | | | | [.>]

------+-------+------+-------+------

\_if | | | [=.] |

------+-------+------+-------+------

\_then | [=.] | | | [.>]

------+-------+------+-------+------

# | | [<.] | |

End.

File : "G17.TXT" .

NON-TERMINALS: [COP, FOROP, LEXP, OCOP, OP]

TERMINALS: [\_do, \_while]

START SYMBOL: FOROP

RULES:

(0) FOROP -> \_while LEXP \_do OCOP

The grammar of operator precedence

Table of transfer and convolution

| €

------------------------------+----------

# [\_while, FOROP, \_do, FOROP] | 0, FOROP

| \_do | \_while | $

------------+-----+--------+---

[\_do, C] | | | R

------------+-----+--------+---

[\_while, C] | S | |

------------+-----+--------+---

[#] | | S |

------------+-----+--------+---

[#, FOROP] | | S | A

The relationship of precedence

| \_do | \_while | $

-------+------+--------+------

\_do | | | [.>]

-------+------+--------+------

\_while | [=.] | |

-------+------+--------+------

# | | [<.] |

End.

File : "G18.TXT" .

NON-TERMINALS: [ID, IDSC, LENOP, SC]

TERMINALS: [(, ), \_len]

START SYMBOL: LENOP

RULES:

(0) LENOP -> \_len ( IDSC )

(1) IDSC -> ID

(2) IDSC -> SC

The grammar of operator precedence

Table of transfer and convolution

| €

----------------------+----------

# [\_len, (, LENOP, )] | 0, LENOP

| ( | ) | \_len | $

-----------+---+---+------+---

[(, C] | | S | |

-----------+---+---+------+---

[), C] | | | | R

-----------+---+---+------+---

[\_len, C] | S | | |

-----------+---+---+------+---

[#] | | | S |

-----------+---+---+------+---

[#, LENOP] | | | S | A

The relationship of precedence

| ( | ) | \_len | $

-----+------+------+------+------

( | | [=.] | |

-----+------+------+------+------

) | | | | [.>]

-----+------+------+------+------

\_len | [=.] | | |

-----+------+------+------+------

# | | | [<.] |

End.

File : "G19.TXT" .

NON-TERMINALS: [CONOP, ID, IDSC, SC]

TERMINALS: [(, ), ,, \_conc]

START SYMBOL: CONOP

RULES:

(0) CONOP -> \_conc ( IDSC , IDSC )

The grammar of operator precedence

Table of transfer and convolution

| €

---------------------------------+----------

# [\_conc, (, CONOP, ,, CONOP, )] | 0, CONOP

| ( | ) | , | \_conc | $

-----------+---+---+---+-------+---

[(, C] | | | S | |

-----------+---+---+---+-------+---

[), C] | | | | | R

-----------+---+---+---+-------+---

[,, C] | | S | | |

-----------+---+---+---+-------+---

[\_conc, C] | S | | | |

-----------+---+---+---+-------+---

[#] | | | | S |

-----------+---+---+---+-------+---

[#, CONOP] | | | | S | A

The relationship of precedence

| ( | ) | , | \_conc | $

------+------+------+------+-------+------

( | | | [=.] | |

------+------+------+------+-------+------

) | | | | | [.>]

------+------+------+------+-------+------

, | | [=.] | | |

------+------+------+------+-------+------

\_conc | [=.] | | | |

------+------+------+------+-------+------

# | | | | [<.] |

End.

File : "G20.TXT" .

NON-TERMINALS: [ID, IDSC, REPOP, SC]

TERMINALS: [(, ), ,, \_repl]

START SYMBOL: REPOP

RULES:

(0) REPOP -> \_repl ( IDSC , IDSC , IDSC )

The grammar of operator precedence

Table of transfer and convolution

| €

-------------------------------------------+----------

# [\_repl, (, REPOP, ,, REPOP, ,, REPOP, )] | 0, REPOP

| ( | ) | , | \_repl | $

-----------+---+---+---+-------+---

[(, C] | | | S | |

-----------+---+---+---+-------+---

[), C] | | | | | R

-----------+---+---+---+-------+---

[,, C] | | S | S | |

-----------+---+---+---+-------+---

[\_repl, C] | S | | | |

-----------+---+---+---+-------+---

[#] | | | | S |

-----------+---+---+---+-------+---

[#, REPOP] | | | | S | A

The relationship of precedence

| ( | ) | , | \_repl | $

------+------+------+------+-------+------

( | | | [=.] | |

------+------+------+------+-------+------

) | | | | | [.>]

------+------+------+------+-------+------

, | | [=.] | [=.] | |

------+------+------+------+-------+------

\_repl | [=.] | | | |

------+------+------+------+-------+------

# | | | | [<.] |

End.

File : "G21.TXT" .

NON-TERMINALS: [ID, IDSC, SC, SEOP]

TERMINALS: [(, ), ,, \_srch]

START SYMBOL: SEOP

RULES:

(0) SEOP -> \_srch ( IDSC , IDSC )

The grammar of operator precedence

Table of transfer and convolution

| €

-------------------------------+---------

# [\_srch, (, SEOP, ,, SEOP, )] | 0, SEOP

| ( | ) | , | \_srch | $

-----------+---+---+---+-------+---

[(, C] | | | S | |

-----------+---+---+---+-------+---

[), C] | | | | | R

-----------+---+---+---+-------+---

[,, C] | | S | | |

-----------+---+---+---+-------+---

[\_srch, C] | S | | | |

-----------+---+---+---+-------+---

[#] | | | | S |

-----------+---+---+---+-------+---

[#, SEOP] | | | | S | A

The relationship of precedence

| ( | ) | , | \_srch | $

------+------+------+------+-------+------

( | | | [=.] | |

------+------+------+------+-------+------

) | | | | | [.>]

------+------+------+------+-------+------

, | | [=.] | | |

------+------+------+------+-------+------

\_srch | [=.] | | | |

------+------+------+------+-------+------

# | | | | [<.] |

End.

File : "G22.TXT" .

NON-TERMINALS: [ID, IDNN, IDSC, SC, SUBOP]

TERMINALS: [(, ), ,, \_num, \_subs]

START SYMBOL: SUBOP

RULES:

(0) SUBOP -> \_subs ( IDSC , IDNN , IDNN )

(1) IDNN -> ID

(2) IDNN -> \_num

The grammar of operator precedence

Table of transfer and convolution

| €

-------------------------------------------+----------

# [\_subs, (, SUBOP, ,, SUBOP, ,, SUBOP, )] | 0, SUBOP

-------------------------------------------+----------

, [\_num] | 2, SUBOP

| ( | ) | , | \_num | \_subs | $

-----------+---+---+---+------+-------+---

[(, C] | | | S | | |

-----------+---+---+---+------+-------+---

[), C] | | | | | | R

-----------+---+---+---+------+-------+---

[,, C] | | S | S | S | |

-----------+---+---+---+------+-------+---

[\_num, C] | | R | R | | |

-----------+---+---+---+------+-------+---

[\_subs, C] | S | | | | |

-----------+---+---+---+------+-------+---

[#] | | | | | S |

-----------+---+---+---+------+-------+---

[#, SUBOP] | | | | | S | A

The relationship of precedence

| ( | ) | , | \_num | \_subs | $

------+------+------+------+------+-------+------

( | | | [=.] | | |

------+------+------+------+------+-------+------

) | | | | | | [.>]

------+------+------+------+------+-------+------

, | | [=.] | [=.] | [<.] | |

------+------+------+------+------+-------+------

\_num | | [.>] | [.>] | | |

------+------+------+------+------+-------+------

\_subs | [=.] | | | | |

------+------+------+------+------+-------+------

# | | | | | [<.] |

End.

File : "G23.TXT" .

NON-TERMINALS: [CLV, CONSTS, FUNCS, LABELS, VARS]

TERMINALS: [;]

START SYMBOL: CLV

RULES:

(0) CLV -> CONSTS

(1) CLV -> CONSTS ; CLV

(2) CLV -> LABELS

(3) CLV -> LABELS ; CLV

(4) CLV -> VARS

(5) CLV -> VARS ; CLV

(6) CLV -> FUNCS

(7) CLV -> FUNCS ; CLV

The grammar of operator precedence

Table of transfer and convolution

| €

----------------+--------

; [CLV, ;, CLV] | 1, CLV

----------------+--------

# [CLV, ;, CLV] | 1, CLV

| ; | $

---------+---+---

[;, C] | S | R

---------+---+---

[#] | S |

---------+---+---

[#, CLV] | S | A

The relationship of precedence

| ; | $

--+------+------

; | [<.] | [.>]

--+------+------

# | [<.] |

End.

File : "G24.TXT" .

NON-TERMINALS: [ID, NEWOP]

TERMINALS: [(, ), \_new]

START SYMBOL: NEWOP

RULES:

(0) NEWOP -> \_new ( ID )

The grammar of operator precedence

Table of transfer and convolution

| €

----------------------+----------

# [\_new, (, NEWOP, )] | 0, NEWOP

| ( | ) | \_new | $

-----------+---+---+------+---

[(, C] | | S | |

-----------+---+---+------+---

[), C] | | | | R

-----------+---+---+------+---

[\_new, C] | S | | |

-----------+---+---+------+---

[#] | | | S |

-----------+---+---+------+---

[#, NEWOP] | | | S | A

The relationship of precedence

| ( | ) | \_new | $

-----+------+------+------+------

( | | [=.] | |

-----+------+------+------+------

) | | | | [.>]

-----+------+------+------+------

\_new | [=.] | | |

-----+------+------+------+------

# | | | [<.] |

End.

File : "G25.TXT" .

NON-TERMINALS: [AOP, IFAOP, LEXP, OEAOP]

TERMINALS: [\_else, \_if, \_then]

START SYMBOL: IFAOP

RULES:

(0) IFAOP -> \_if LEXP \_then AOP

(1) IFAOP -> \_if LEXP \_then AOP \_else AOP

The grammar of operator precedence

Table of transfer and convolution

| €

-------------------------------------------+----------

# [\_if, IFAOP, \_then, IFAOP] | 0, IFAOP

-------------------------------------------+----------

# [\_if, IFAOP, \_then, IFAOP, \_else, IFAOP] | 1, IFAOP

| \_else | \_if | \_then | $

-----------+-------+-----+-------+---

[\_else, C] | | | | R

-----------+-------+-----+-------+---

[\_if, C] | | | S |

-----------+-------+-----+-------+---

[\_then, C] | S | | | R

-----------+-------+-----+-------+---

[#] | | S | |

-----------+-------+-----+-------+---

[#, IFAOP] | | S | | A

The relationship of precedence

| \_else | \_if | \_then | $

------+-------+------+-------+------

\_else | | | | [.>]

------+-------+------+-------+------

\_if | | | [=.] |

------+-------+------+-------+------

\_then | [=.] | | | [.>]

------+-------+------+-------+------

# | | [<.] | |

End.

File : "G26.TXT" .

NON-TERMINALS: [COP, ID, OOP, OPOP, OVAR, OVAR1, OVAR2, REL, TYPE]

TERMINALS: [(, ), \*, +, ,, -, /, :, ;, \_oper, \_rel]

START SYMBOL: OPOP

RULES:

(0) OPOP -> \_oper OOP ( OVAR ) ID : TYPE ; COP ;

(1) OVAR -> OVAR1

(2) OVAR -> OVAR2

(3) OVAR1 -> ID : TYPE ; ID : TYPE

(4) OVAR2 -> ID , ID : TYPE

(5) REL -> \_rel

(6) OOP -> REL

(7) OOP -> +

(8) OOP -> -

(9) OOP -> \*

(10) OOP -> /

The grammar of operator precedence

Table of transfer and convolution

| €

-------------------------------------------------------+----------

# [\_oper, OPOP, (, OPOP, ), OPOP, :, OPOP, ;, OPOP, ;] | 0, OPOP

-------------------------------------------------------+----------

( [OPOP, :, OPOP, ;, OPOP, :, OPOP] | 3, OPOP

-------------------------------------------------------+----------

( [OPOP, ,, OPOP, :, OPOP] | 4, OPOP

-------------------------------------------------------+----------

\_oper [\_rel] | 5, OPOP

-------------------------------------------------------+----------

\_oper [+] | 7, OPOP

-------------------------------------------------------+----------

\_oper [-] | 8, OPOP

-------------------------------------------------------+----------

\_oper [\*] | 9, OPOP

-------------------------------------------------------+----------

\_oper [/] | 10, OPOP

| ( | ) | \* | + | , | - | / | : | ; | \_oper | \_rel | $

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[(, C] | | S | | | S | | | S | | | |

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[), C] | | | | | | | | S | | | |

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[\*, C] | R | | | | | | | | | | |

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[+, C] | R | | | | | | | | | | |

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[,, C] | | | | | | | | S | | | |

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[-, C] | R | | | | | | | | | | |

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[/, C] | R | | | | | | | | | | |

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[:, C] | | R | | | | | | | S | | |

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[;, C] | | | | | | | | S | S | | | R

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[\_oper, C] | S | | S | S | | S | S | | | | S |

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[\_rel, C] | R | | | | | | | | | | |

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[#] | | | | | | | | | | S | |

-----------+---+---+---+---+---+---+---+---+---+-------+------+---

[#, OPOP] | | | | | | | | | | S | | A

The relationship of precedence

| ( | ) | \* | + | , | - | / | : | ; | \_oper | \_rel | $

------+------+------+------+------+------+------+------+------+------+-------+------+------

( | | [=.] | | | [<.] | | | [<.] | | | |

------+------+------+------+------+------+------+------+------+------+-------+------+------

) | | | | | | | | [=.] | | | |

------+------+------+------+------+------+------+------+------+------+-------+------+------

\* | [.>] | | | | | | | | | | |

------+------+------+------+------+------+------+------+------+------+-------+------+------

+ | [.>] | | | | | | | | | | |

------+------+------+------+------+------+------+------+------+------+-------+------+------

, | | | | | | | | [=.] | | | |

------+------+------+------+------+------+------+------+------+------+-------+------+------

- | [.>] | | | | | | | | | | |

------+------+------+------+------+------+------+------+------+------+-------+------+------

/ | [.>] | | | | | | | | | | |

------+------+------+------+------+------+------+------+------+------+-------+------+------

: | | [.>] | | | | | | | [=.] | | |

------+------+------+------+------+------+------+------+------+------+-------+------+------

; | | | | | | | | [=.] | [=.] | | | [.>]

------+------+------+------+------+------+------+------+------+------+-------+------+------

\_oper | [=.] | | [<.] | [<.] | | [<.] | [<.] | | | | [<.] |

------+------+------+------+------+------+------+------+------+------+-------+------+------

\_rel | [.>] | | | | | | | | | | |

------+------+------+------+------+------+------+------+------+------+-------+------+------

# | | | | | | | | | | [<.] | |

End.

## Analysis of the chain DMP-converter.

program HelloWorld;

var a:integer; b:boolean;

begin

a:=3;

write(‘hello world’);

end.

Chain:

\_PROG \_ID ; \_VAR \_ID : \_INT ; \_ID : \_BOOL ; \_BEGIN \_ID \_EQ \_NUM ; \_WRITE ( \_STR ) ; \_END .

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Stack | Input chain | Output chain | Action | |
| G0: ┴ | \_PROG \_ID ; \_VAR \_ID… |  | Transfer | |
| G0: ┴ \_PROG | \_ID ; \_VAR \_ID… |  | Go to G6 | |
| G6: ┴ | \_ID ; \_VAR \_ID… |  | Transfer | |
| G6: ┴ \_ID | ; \_VAR \_ID… | ID → \_ID | Conv, 0 | |
| G6: ┴ ID | ; \_VAR \_ID… |  | Admit (Go to G0) |
| G0: ┴ \_PROG ID | ; \_VAR \_ID… |  | Transfer | |
| G0: ┴ \_PROG ID ; | \_VAR \_ID : \_INT ;… |  | Go to G1 | |
| G1: ┴ | \_VAR \_ID : \_INT ;… |  | Transfer | |
| G1: ┴ ­\_VAR | \_ID : \_INT ;… |  | Go to G6 | |
| G6: ┴ ­ | \_ID : \_INT ; \_ID : \_BOOL ; |  | Transfer |
| G6: ┴ ­\_ID | : \_INT ; \_ID : \_BOOL ; \_BEGIN… | ID → \_ID | Conv, 0 |
| G6: ┴ ­ID | : \_INT ; \_ID : \_BOOL ; \_BEGIN… |  | Admit (переход к G1) | |
| G1: ┴ ­\_VAR ID | : \_INT ; \_ID : \_BOOL ; \_BEGIN… |  | Transfer | |
| G1: ┴ ­\_VAR ID : | \_INT ; \_ID : \_BOOL ; \_BEGIN… |  | Go to G5 | |
| G5: ┴ | \_INT ; \_ID : \_BOOL ; \_BEGIN… |  | Transfer | |
| G5: ┴ ­\_INT | ; \_ID : \_BOOL ; \_BEGIN… | TYPE → \_INT | Conv, 0 |
| G5: ┴ ­TYPE | ; \_ID : \_BOOL ; \_BEGIN… |  | Admit (Go to G1) | |
| G1: ┴ ­\_VAR ID : TYPE | ; \_ID : \_BOOL ; \_BEGIN… | VAR → ID : TYPE | Conv, 3 | |
| G1: ┴ ­\_VAR VAR | ; \_ID : \_BOOL ; \_BEGIN… |  | Transfer | |
| G1: ┴ ­\_VAR VAR ; | \_ID : \_BOOL ; \_BEGIN… |  | Go to G6 | |
| G6: ┴ ­ | \_ID : \_BOOL ; \_BEGIN… |  | Transfer | |
| G6: ┴ ­ \_ID | : \_BOOL ; \_BEGIN… | ID → \_ID | Conv, 0 |
| G6: ┴ ­ ID | : \_BOOL ; \_BEGIN… |  | Admit (Go to G1) | |
| G1: ┴ ­\_VAR VAR ; ID | : \_BOOL ; \_BEGIN… |  | Transfer | |
| G1: ┴ ­\_VAR VAR ; ID : | \_BOOL ; \_BEGIN… |  | Go to G5 | |
| G5: ┴ ­ | \_BOOL ; \_BEGIN… |  | Transfer | |
| G5: ┴ ­\_BOOL | ; \_BEGIN… | TYPE → \_BOOL | Conv, 0 | |
| G5: ┴ ­TYPE | ; \_BEGIN… |  | Admit (Go to G1) | |
| G1: ┴ ­\_VAR VAR ; ID : TYPE | ; \_BEGIN… | VAR → ID : TYPE | Conv, 3 | |
| G1: ┴ ­\_VAR VAR ; VAR | ; \_BEGIN… | RVAR → VAR ; RVAR | Conv, 1 | |
| G1: ┴ ­\_VAR RVAR | ; \_BEGIN … |  | Conv, 0 | |
| G1: ┴ ­VARS | ; \_BEGIN … |  | Admit (Go to G0) |
| G0: ┴ \_PROG ID ; VARS | ; \_BEGIN \_ID \_EQ \_NUM ;… |  | Transfer |
| G0: ┴ \_PROG ID ; VARS ; | \_BEGIN \_ID \_EQ \_NUM ;… |  | Go to G15 | |
| G15: ┴ ­ | \_BEGIN \_ID \_EQ \_NUM ;… |  | Transfer | |
| G15: ┴ ­\_BEGIN | \_ID \_EQ \_NUM ;… |  | Go to G6 | |
| G6: ┴ ­ | \_ID \_EQ \_NUM ;… |  | Transfer |
| G6: ┴ ­ \_ID | \_EQ \_NUM ;… | ID → \_ID | Conv, 0 | |
| G6: ┴ ­ ID | \_EQ \_NUM ;… |  | Admit (Go to G15) | |
| G15: ┴ ­\_BEGIN ID | \_EQ \_NUM ; \_WRITE ( \_STR ) ;… |  | Go to G11 | |
| G11: ┴ ­ | \_EQ \_NUM ; \_WRITE ( \_STR ) ;… |  | Transfer | |
| G11: ┴ ­\_EQ | \_NUM ; \_WRITE ( \_STR ) ;… |  | Go to G9 |
| G9: ┴ ­ | \_NUM ; \_WRITE ( \_STR ) ;… |  | Transfer | |
| G9: ┴ ­\_NUM | ; \_WRITE ( \_STR ) ;… | C → DEC → \_NUM | Conv, 7, 0 | |
| G9: ┴ ­C | ; \_WRITE ( \_STR ) ;… |  | Admit (Go to G11) | |
| G11: ┴ ­\_EQ C | ; \_WRITE ( \_STR ) ;… | AOP → ID \_EQ ALEXP | Conv, 0 | |
| G11: ┴ ­AOP | ; \_WRITE ( \_STR ) ;… |  | Admit (Go to G15) |
| G15: ┴ ­\_BEGIN AOP | ; \_WRITE ( \_STR ) ; \_END . |  | Transfer | |
| G15: ┴ ­\_BEGIN AOP ; | \_WRITE ( \_STR ) ; \_END . |  | Go to G13 | |
| G13: ┴ | \_WRITE ( \_STR ) ; \_END . |  | Transfer | |
| G13: ┴ \_WRITE | ( \_STR ) ; \_END . |  | Transfer | |
| G13: ┴ \_WRITE ( | \_STR ) ; \_END . |  | Go to G9 | |
| G9: ┴ | \_STR ) ; \_END . |  | Transfer |
| G9: ┴ \_STR | ) ; \_END . | SC → \_STR | Conv, 15 | |
| G9: ┴ SC | ) ; \_END . |  | Admit (Go to G13) | |
| G13: ┴ \_WRITE ( SC | ) ; \_END . |  | Transfer | |
| G13: ┴ \_WRITE ( SC ) | ; \_END . | WOP → \_WRITE ( MSG ) | Conv, 0 | |
| G13: ┴ WOP | ; \_END . |  | Admit (Go to G15) | |
| G15: ┴ ­\_BEGIN AOP ; WOP | ; \_END . |  | Transfer | |
| G15: ┴ ­\_BEGIN AOP ; WOP ; | \_END . | ZOMOP → OP | Conv, 3 | |
| G15: ┴ ­\_BEGIN AOP ; ZOMOP | \_END . | ZOMOP → OP ; ZOMOP | Conv, 2 |
| G15: ┴ ­\_BEGIN ZOMOP | \_END . |  | Transfer | |
| G15: ┴ ­\_BEGIN ZOMOP END | . |  | Conv, 0 | |
| G15: ┴ ­COP | . |  | Admit (Go to G0) | |
| G0: ┴ \_PROG ID ; VARS ; COP | . |  | Transfer | |
| G0: ┴ \_PROG ID ; VARS ; COP . | ε | OCOP → COP . | Conv, 4 | |
| G0: ┴ \_PROG ID ; VARS ; OCOP | ε | OPROG → CLV ; OCOP | Conv, 3 | |
| G0: ┴ \_PROG ID ; OPROG | ε | PROG → \_PROG ID ; OPROG | Conv, 0 | |
| G0: ┴ PROG | ε |  | Admit | |

# Results

As a result of laboratory works was a description of the syntax and semantics of the language, identified the concepts of construction of a lexical analyzer, to formalize the process of the syntax managed of translation and analyzed its example.

Приложение. Граф лексического анализатора

