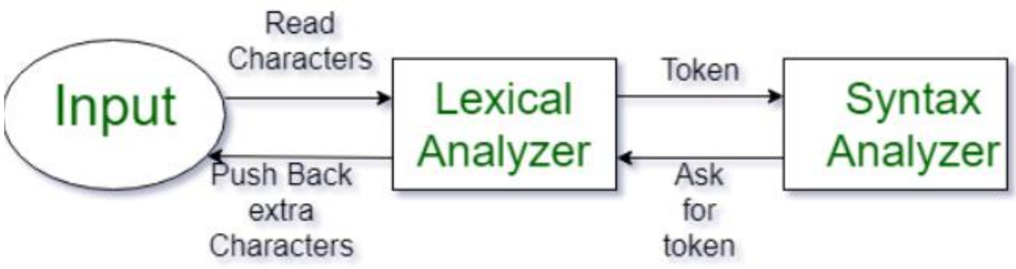
LEXICAL ANALYSIS

Lexical Analysis is the first phase of the compiler also known as a scanner. It converts the High level input program into a sequence of **Tokens**.

- Lexical Analysis can be implemented with the Deterministic finite Automata.
- The output is a sequence of tokens that is sent to the parser for syntax analysis



What is a token?

A lexical token is a sequence of characters that can be treated as a unit in the grammar of the programming languages.

Example of tokens:

- Type token (id, number, real, . . .)
- Punctuation tokens (IF, void, return, . . .)
- Alphabetic tokens (keywords)

Keywords; Examples-for, while, if etc.

Identifier; Examples-Variable name, function name, etc.

Operators; Examples '+', '++', '-' etc.

Separators; Examples ',' ';' etc

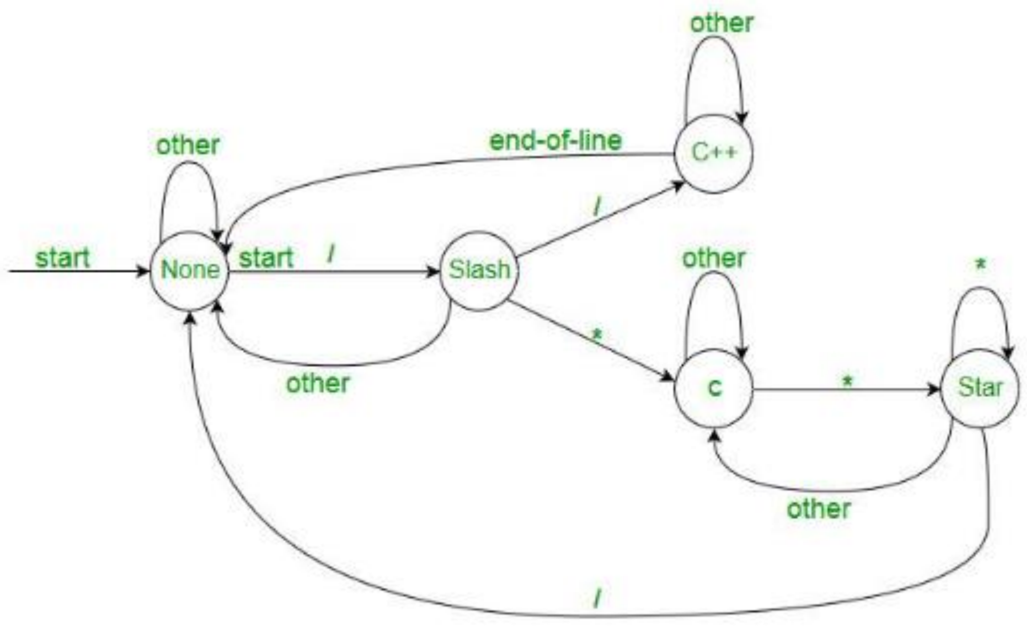
Example of Non-Tokens:

- Comments, preprocessor directive, macros, blanks, tabs, newline, etc.

Lexeme: The sequence of characters matched by a pattern to form the corresponding token or a sequence of input characters that comprises a single token is called a lexeme. eg- “float”, “abs_zero_Kelvin”, “=”, “-”, “273”, “;” .

How Lexical Analyzer works-

1. **Input preprocessing:** This stage involves cleaning up the input text and preparing it for lexical analysis. This may include removing comments, whitespace, and other non-essential characters from the input text.
2. **Tokenization**: This is the process of breaking the input text into a sequence of tokens. This is usually done by matching the characters in the input text against a set of patterns or regular expressions that define the different types of tokens.
3. **Token classification**: In this stage, the lexer determines the type of each token. For example, in a programming language, the lexer might classify keywords, identifiers, operators, and punctuation symbols as separate token types.
4. **Token validation**: In this stage, the lexer checks that each token is valid according to the rules of the programming language. For example, it might check that a variable name is a valid identifier, or that an operator has the correct syntax.
5. **Output generation**: In this final stage, the lexer generates the output of the lexical analysis process, which is typically a list of tokens. This list of tokens can then be passed to the next stage of compilation or interpretation.



- The lexical analyzer identifies the error with the help of the automation machine and the grammar of the given language on which it is based like C, C++, and gives row number and column number of the error.

Suppose we pass a statement through lexical analyzer – **a = b + c** ;

It will generate token sequence like this: **id=id+id**;

Where each id refers to it's variable in the symbol table referencing all details

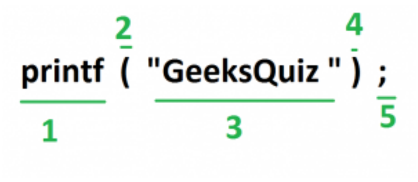
For example, consider the program

```
int main()

{

  // 2 variables

  int a, b;

  a = 10;

 return 0;

}
```

All the valid tokens are:

'int' 'main' '(' ')' '{' 'int' 'a' ',' 'b' ';' 'a' '=' '10' ';' 'return' '0' ';' '}'

Above are the valid tokens. You can observe that we have omitted comments. As another example, consider below printf statement.



There are 5 valid token in this printf statement.

Exercise 1: Count number of tokens :

```
int main()

{

  int a = 10, b = 20;
  printf("sum is :%d",a+b);

  return 0;

}
```

Answer: Total number of token: 27.

Exercise 2:

Count number of tokens : int max(int i);

- Lexical analyzer first read **int** and finds it to be valid and accepts as token
- **max** is read by it and found to be a valid function name after reading **(**
- **int** is also a token , then again **i** as another token and finally **;**

Answer: Total number of tokens 7:

int, max, (,int, i,), ;

Lexemes	**Tokens**	**Lexemes**	**Tokens**
while	WHILE	a	IDENTIEFIER
(	LAPREN	=	ASSIGNMENT
a	IDENTIFIER	a	IDENTIFIER
>=	COMPARISON	–	ARITHMETIC
b	IDENTIFIER	2	INTEGER
)	RPAREN	;	SEMICOLON

Advantages:

Efficiency: Lexical analysis improves the efficiency of the parsing process because it breaks down the input into smaller, more manageable chunks. This allows the parser to focus on the structure of the code, rather than the individual characters.

Flexibility: Lexical analysis allows for the use of keywords and reserved words in programming languages. This makes it easier to create new programming languages and to modify existing ones.

Error Detection: The lexical analyzer can detect errors such as misspelled words, missing semicolons, and undefined variables. This can save a lot of time in the debugging process.

Code Optimization: Lexical analysis can help optimize code by identifying common patterns and replacing them with more efficient code. This can improve the performance of the program.