Bangladesh University of Engineering and Technology (BUET)
Department of Computer Science and Engineering (CSE)
CSE310: Compiler Sessional
Session: July 2023

Assignment 2
Lexical Analysis

December 7, 2023

1 Introduction

In this assignment, we are going to construct a lexical analyzer, also known as a tokenizer. *Lexical Analysis* is the process of scanning the source program as a sequence of characters and converting them into a sequence of tokens. A program that performs this task is called a *Lexical Analyzer* or a *Tokenizer* or a *Lexer* or a *Scanner*. For example, if a portion of the source program contains a statement like, `int x = 5;` then the scanner will convert it into a sequence of tokens like **`<INT,int><ID,x><ASSIGNOP,=><COST_NUM,5><SEMICOLON,;>`**..

After *successfully* completing the implementation of a simple symbol table, we will, now, construct a scanner for a subset of the C programming language. This task will be done using a tool named *Flex* (Fast Lexical Analyzer Generator) which is a widely used tool for conveniently generating scanners.

2 Tasks

You have to complete the following tasks in this assignment for the implementation of a working scanner.

2.1 Tokens Identification

2.1.1 Keywords

You have to identify the keywords listed in **Table 1** and print the corresponding `<TOKEN,KEYWORD>` pairs in the output file. For example, you have to print `<IF,if>` in case you find the keyword `if` in the source program. **Keywords will not be inserted into the symbol table.**

Keyword	**Token**	**Keyword**	**Token**
`if`	`IF`	`else`	`ELSE`
`for`	`FOR`	`while`	`WHILE`
`do`	`DO`	`break`	`BREAK`
`int`	`INT`	`char`	`CHAR`
`float`	`FLOAT`	`double`	`DOUBLE`
`void`	`VOID`	`return`	`RETURN`
`switch`	`SWITCH`	`case`	`CASE`
`default`	`DEFAULT`	`continue`	`CONTINUE`

Table 1: Keywords List

2.1.2 Constants

For each constant, you have to print a token of the format `<TYPE,SYMBOL>` in the output file. **You do not have to insert the constants in the symbol table.**

- **Integer Literals:** One or more consecutive digits form an integer literal. In this case, the `TYPE` of the token will be `CONST_INT`. Note that the sign of an integer + and − will not be considered as part of an integer.
- **Floating-point Literals:** Numbers like `3.14159`, `3.14159E-10`, `.314159`, and `314159E10` will be considered as floating-point literals or constants. In this case, the `TYPE` of the token will be `CONST_FLOAT`. Just like the integer literals, the sign of a floating-point number + and − will not be considered as part of a number.
- **Character Literals:** Character literals are enclosed within single quotation marks `''`. There will be a single character within the single quotation enclosing with the exception of `'\''` (single quotation), `'\"'` (double quotation), `'\n'`, `'\t'`, `'\\'`, `'\''`, `'\a'`, `'\f'`, `'\r'`, `'\b'`, `'\v'`, and `'\0'`. For character literals, the `TYPE` of the token will be `CONST_CHAR`. Note that you need to convert the detected *lexeme* into an actual character. For example, if you find `'a'` inside a source program, then you need to print `<CONST_CHAR,a>`. This means that we only need the actual character represented (ASCII code), not the quotation symbols around it. Similarly, you need a *newline* character (ASCII code of which is `10`) in your token if you detect `'\n'`.

2.1.3 Operators and Punctuators

The operators from the subset of the C programming language that we will be dealing with in this assignment are listed in **Table 2**. A token in the form of `<TYPE,SYMBOL>` should be printed in the output file. **You do not have to insert operators and punctuators in the symbol table.**

Symbols	Type
+, -	ADDOP
*, /, %	MULOP
++, --	INCOP
<, <=, >, >=, ==, !=	RELOP
=	ASSIGNOP
&&, ||	LOGICOP
&, |, ^, <<, >>	BITOP
!	NOT
(	LPAREN
)	RPAREN
{	LCURL
}	RCURL
[	LSQUARE
]	RSQUARE
,	COMMA
;	SEMICOLON

Table 2: Operators and Punctuators List

2.1.4 Identifiers

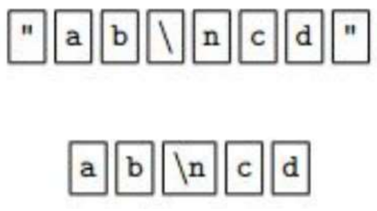
Identifiers are the names given to entities in the C programming language such as variables, functions, structures, etc. An identifier can only contain alphanumeric characters (A-Z, a-z, 0-9) and underscore ‘_’. The first character of an identifier can be either an alphabet (A-z, a-z) or an underscore. For each identifier, encountered in the input file, you have to print the corresponding token <ID,SYMBOL> and also, **insert it in the symbol table.**

2.1.5 Strings

String literals are enclosed within double quotation marks “”. String can consist of a single line or multiple lines. A multiline string ends with a \ (backslash) character in each line except in the last line. You have to print a token of the form `<STRING,hello>` if you encounter a string `“hello”` in the input file. **Strings will not be inserted into the symbol table.**

```
“This is an example of a single line string”;
“This is an example\
of a multiline\
string”;
```

Note that, just like character literals, you need to convert the special characters into their original ASCII values. If a string contains a newline character `‘\n’`, then you need to replace these two characters `‘\’` and `‘n’` with the character representation of the ASCII value `10` for the newline character. For example, if the source program contains the following eight (8) characters, then the scanner will convert them into the five (5) characters as depicted in the diagram below.



2.1.6 Comments

Comments can consist of a single line or multiple lines. A single-line comment usually starts with `//` symbols. However, a comment started with `//` can continue to the next line if the first line ends with a backslash character `‘\’`. A multiline comment starts with `/*` and ends with `*/` character pairs. If there is any comment in the input file, then you have to recognize it, **but not generate any token in the output token file for the corresponding comment. Also, you do not need to insert comments in the symbol table.**

```
// This is a single line comment
// This is a multiline comment\
starting with double slash
/* This is another multiple line comment
starting and ending with slash and asterisk */
```

2.1.7 Whitespaces

You have to ignore all the occurrences of whitespace in the input file. You may want to check the sample code for further clarification if required.

2.2 Line Count

You should count the total number of lines in the source program.

2.3 Lexical Error Detection

You should detect the lexical errors in the source program and report them along with the corresponding line number. You will detect the following types of lexical errors.

- Appearance of redundant decimal points in a number like `3.1.4159`.
- Ill-formed numbers such as `1E10.7`.
- Invalid suffixes in numeric constants or invalid prefixes in identifiers like `12abcd`.
- Appearance of multiple characters in a character literal like `‘ab’`.
- Unfinished character literal such as `‘a` or `‘\’`. You may explore the sample files to see what to do with empty characters `‘’`.
- Unfinished string. You may explore different cases where a string remains unfinished.
- Unfinished comment.
- Unrecognized character.

Also, you have to count the total number of errors detected.

2.4 Wrong Indentation Detection

The lexical analyzer, being the primary component scanning user-provided code in a compiler, can potentially assess code quality aspects such as formatting and indentation. For this task, we aim to create a warning system that notifies users of irregular or inconsistent indentation within C code.

```
1 #include <stdio.h>

2 int main() {}
3     printf("Welcome, ");
4         printf("to, "); if(1) {printf("flex!");}
5  return 0;

6 }
```

The above-mentioned code should give a warning - “Line no 4: warning, 1 of tabs needed but got 2 tabs.” and “Line no 5: Warning, tab required but got space.”

3 Input

The input to the lexical analyzer will be a text file containing a source program written in C programming language. The input file name will have to be provided from the terminal/command line.

4 Output

There will be two output files from the lexical analyzer.

One is a file containing the tokens. This file should be named as `<your_student_id>_token.txt`. For example, a student with ID `2005123` will name the output file for tokens as `2005123_token.txt`. You will output all the corresponding tokens in this file.

The other file is a log file named as `<your_student_id>_log.txt`. In this file, you will log all the actions performed inside the source program. After detecting any lexeme except for the one representing whitespaces, you will print a line as follows.

```
Line# <line_count>: Token <TOKEN> Lexeme <LEXEME> found
```

For example, if you encounter a comment such as `//hello` at line `5` in the source program, then you will print as follows.

```
Line# 5: Token <COMMENT> Lexeme <hello> found
```

Note that, although you will not print any token in the corresponding `token.txt` file for comments, you will print the corresponding log message in `log.txt` file. For any insertion into thesymbol table, you have to print the current symbol table in the `log.txt` file. Only print the non-empty buckets in this scenario. If a symbol already exists, then you have to print the appropriate message in the `log.txt` file. For any detected error, you have to print the following message in the `log.txt` file.

```
Error at line# <line_count>: <corresponding_error_message>
```

You need to print the total line count and the total number of errors detected at the end of the `log.txt` file.

For further clarification about input and output, kindly refer to the provided sample input and output files. **You are highly encouraged to produce the output exactly like the sample output.**

5 Submission Guidelines

All submissions will be taken only via Moodle. Please, follow the steps listed below to submit your assignment.

1. On your local machine, create a new folder with your 7 digit Student ID as its name.
2. Put inside the newly created folder the *lex* file named as `<your_student_id>.l` which contains your implementation of the scanner. Also, put additional `<your_student_id>.cpp` file or `<your_student_id>.h` header file necessary to compile your *lex* file. Do not put the generated `lex.yy.c` file or executable file inside this folder.
3. Compress the folder in a *zip* file which should be named after your 7 digit Student ID.
4. Submit the *zip* file.

You are strongly encouraged to follow this submission guideline and naming convention for the files.

6 Warning

If you adopt any unfair means or get yourselves involved in acts of plagiarism, **then you will be penalized with -100% marks for this assignment regardless of your role in the incident.**

7 Submission Deadline

The submission deadline for this assignment is set for **Saturday, December 17, 2023 at 09:59 PM** for all the lab groups.