ASSIGNMENT B2

TITLE : Lexical Analysis to generate tokens

Problem Statement:
Write a program using LEX specifications to implement a lexical analysis phase of the compiler to generate tokens of a subset of Java program.

Objectives:

- Understand the importance and usage of LEX automated tool
- Appreciate the role of lexical analysis phase in compilation
- Understand the theory behind design of lexical analyzers and lexical analyzer generator

Outcomes:
I will be able to understand and implement lex programs and understand the tokenization process.

Software and Hardware Requirements:

- Working PC.
- 64 bit Fedora OS
- Eclipse IDE and JAVA
- I3 processor

Theory

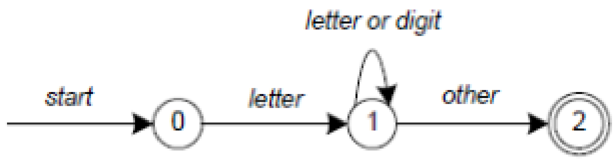
During the first phase the compiler reads the input and converts strings in the source to tokens. With
regular expressions we can specify patterns to lex so it can generate code that will allow it to scan and
match strings in the input. Each pattern specified in the input to lex has an associated action. Typically
an action returns a token that represents the matched string for subsequent use by the parser. Initially
we will simply print the matched string rather than return a token value.
The following represents a simple pattern, composed of a regular expression that scans for identifiers. Lex will read this pattern and produce C code for a lexical analyzer that scans for identifiers.

$$\textbf{letter (letter} \mid \textbf{digit)}*$$

This pattern matches a string of characters that begins with a single letter followed by zero or more
letters or digits. This example nicely illustrates operations allowed in regular expressions:

- repetition, expressed by the "$*$ " operator
- alternation, expressed by the "| " operator
- concatenation

Any regular expression may be expressed as a finite state automaton (FSA). We can represent an FSA using states, and transitions between states. There is one start state and one or more
final or accepting states.



Finite State Automata

In Figure, state 0 is the start state and state 2 is the accepting state. As characters are read we make a
transition from one state to another. When the first letter is read we transition to state 1. We remain in
state 1 as more letters or digits are read. When we read a character other than a letter or digit we
transition to accepting state 2. *Any* FSA may be expressed as a computer program. For example, our
3-state machine is easily programmed:

```
start: goto state0
state0: read c
        if c = letter goto state1
        goto state0
state1: read c
        if c = letter goto state1
        if c = digit goto state1
        goto state2
state2: accept string
```

This is the technique used by lex. Regular expressions are translated by lex to a computer program
that mimics an FSA. Using the next *input* character and *current state* the next state is easily
determined by indexing into a computer-generated state table.

Now we can easily understand some of lex's limitations. For example, lex cannot be used to recognize nested structures such as parentheses. Nested structures are handled by incorporating a stack. Whenever we encounter a "(" we push it on the stack. When a ")" is encountered we match it with the top of the stack and pop the stack. However lex only has states and transitions between states. Since it has no stack it is not well suited for parsing nested structures. Yacc augments an FSA with a stack and can process constructs such as parentheses with ease. The important thing is to use the right tool for the job. Lex is good at pattern matching. Yacc is appropriate for more challenging tasks.

Pattern	Matches
?	zero or one copy of the preceding expression
*	zero or more copies of the preceding expression
+	one or more copies of the preceding expression
a|b	a or b
(ab)+	one or more copies of ab (grouping)
"a+b"	literal "a+b" (C escapes still work)
abc	abc
abc*	ab abc abcc abccc ...
"abc*"	literal abc*
abc+	abc abcc abccc ...
a(bc)+	abc abcbc abcbcbc ...
a(bc)?	a abc

Table 2: Operators

Name	Function
int yylex(void)	call to invoke lexer, returns token
char *yytext	pointer to matched string
yyleng	length of matched string
yylval	value associated with token
int yywrap(void)	wrapup, return 1 if done, 0 if not done
FILE *yyout	output file
FILE *yyin	input file
INITIAL	initial start condition
BEGIN	condition switch start condition
ECHO	write matched string

Table 4: Lex Predefined Variables

Pattern	Matches
.	any character except newline
\.	literal .
\n	newline
\t	tab
^	beginning of line
$	end of line

Table 1: Special Characters

Pattern	Matches
[abc]	one of: a b c
[a-z]	any letter a-z
[a\-z]	one of: a - z
[-az]	one of: - a z
[A-Za-z0-9]+	one or more alphanumeric characters
[\t\n]+	whitespace
[^ab]	anything except: a b
[a^b]	one of: a ^ b
[a|b]	one of: a | b

Table 3: Character Class

Regular expressions are used for pattern matching. A character class defines a single character and normal operators lose their meaning. Two operators allowed in a character class are the hyphen ("-") and circumflex ("^ "). When used between two characters the hyphen represents a range of characters. The circumflex, when used as the first character, negates the expression. If two patterns match the same string, the longest match wins. In case both matches are the same length, then the first pattern listed is used.

... definitions ...
% %
... rules ...
% %
... subroutines ...
Input to Lex is divided into three sections with % % dividing the sections. This is best illustrated by example. The first example is the shortest possible lex file:

% %

Input is copied to output one character at a time. The first % % is always required, as there must always be a rules section. However if we don't specify any rules then the default action is to match

everything and copy it to output. Defaults for input and output are **stdin** and **stdout**, respectively.
Here is the same example with defaults explicitly coded:

```
% %
/* match everything except newline * /
. ECHO;
/* match newline * /
\ n ECHO;
% %
int yywrap(void) {
return 1;
}
int main(void) {
yylex();
return 0;
}
```

TEST CASES:

DESCRIPTION	INPUT	OUTPUT	RESULT
Preprocessor	import java.io.*	Preprocessor	Success
Access Specifier	Public class input	Public-access specifier	Success
Parenthesis	if(a>10)	(=parenthesis begin)=parenthesis end	Success
Data type	int a;	Int =data type	Success
End of line	a =12;	; delimiter	Success
Equal to sign	a - 12;	= - assignment op	Success
Relational operator	if(a==13)	== relational op	Success
Identifier	a =12;	a-identifier	Success
Constant value	a=12;	12 - constant int	Success

Conclusion:

Thus we have successfully implemented the lexical analysis phase of a compiler to generate tokens of a java program.