ASSIGNMENT B3

TITLE :Lexical Analysis to count number of words, lines and characters.

Problem Statement:
Write a program using LEX specifications to implement lexical analysis phase of compiler to count no. of words, lines and characters of given input file.

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
- Count the number of words, lines and characters

Outcomes:
I will be able to understand and implement lex programs and count the number of lines, words and characters.

Software and Hardware Requirements:

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

Theory

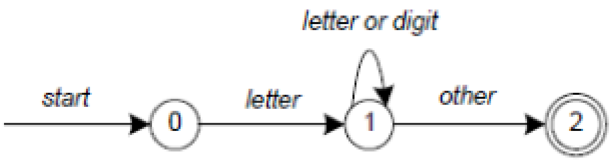
During the first phase the compiler reads the input and converts strings in the source to tokens. With
regular expressions we can specify patterns to lex so it can generate code that will allow it to scan and
match strings in the input. Each pattern specified in the input to lex has an associated action. 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.

letter (letter | 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 som
e 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	Matches
.	any character except newline
\\.	literal .
\n	newline
\t	tab
^	beginning of line
$	end of line

Table 1: Special Characters

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

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

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

Regular expressions are used for pattern matching.
Two patterns have been specified in the rules section. Each pattern must begin in column one. This is
followed by whitespace (space, tab or newline) and an optional action associated with the pattern. The
action may be a single C statement, or multiple C statements, enclosed in braces. Anything not
starting in column one is copied verbatim to the generated C file. We may take advantage of this
behavior to specify comments in our lex file. In this example there are two patterns, "**.**" and "\ **n**" , with
an **ECHO** action associated for each pattern. Several macros and variables are predefined by lex.
ECHO is a macro that writes code matched by the pattern. This is the default action for any
unmatched strings. Typically, **ECHO** is defined as:

 # define ECHO fwrite(yytext, yyleng, 1, yyout)

Variable **yytext** is a pointer to the matched string (NULL-terminated) and **yyleng** is the length of the
matched string. Variable **yyout** is the output file and defaults to stdout. Function **yywrap** is called by
lex when input is exhausted. Return 1 if you are done or 0 if more processing is required. Every C
program requires a **main** function. In this case we simply call **yylex** that is the main entry-point for
lex. Some implementations of lex include copies of **main** and **yywrap** in a library thus eliminating the
need to code them explicitly. This is why our first example, the shortest lex program, functioned
properly.

Here is a program that does nothing at all. All input is matched but no action is associated with any
pattern so there will be no output.

% %
.
\ n
The following example prepends line numbers to each line in a file. Some implementations of lex
predefine and calculate **yylineno**. The input file for lex is **yyin** and defaults to **stdin**.

```
% {
int yylineno;
% }
% %
ˆ (.∗ )\ n printf("% 4d\ t% s", ++yylineno, yytext);
% %
int main(int argc, char ∗ argv[]) {
yyin = fopen(argv[1], "r");
yylex();
fclose(yyin);
}
```

The definitions section is composed of substitutions, code, and start states. Code in the definitions
section is simply copied as-is to the top of the generated C file and must be bracketed with "% { " and
"% } " markers. Substitutions simplify pattern-matching rules. For example, we may define digits and
letters:

```
digit [0-9]
letter [A-Za-z]
% {
int count;
% }
% %
/∗ match identifier ∗ /
{ letter} ({ letter} | { digit} )∗ count++;
% %
int main(void) {
yylex();
printf("number of identifiers = % d\ n", count);
return 0;
}
```

Whitespace must separate the defining term and the associated expression. References to substitutions in the rules section are surrounded by braces ({ **letter**}) to distinguish them from literals. When we have a match in the rules section the associated C code is executed. Here is a scanner that counts the number of characters, words, and lines in a file (similar to Unix wc):

```
% {
int nchar, nword, nline;
% }
% %
```

```
\ n { nline++; nchar++; }
[^ \ t\ n]+ { nword++, nchar += yyleng; }
. { nchar++; }
% %
int main(void) {
yylex();
printf("% d\ t% d\ t% d\ n", nchar, nword, nline);
return 0;
}
```

TEST CASES:

DESCRIPTION	INPUT	OUTPUT (Expected)	OUTPUT (Actual)	RESULT
Number of Character	Hi, I am abc def. I am 20. PICT Pune	35	35	Success
Number of lines	Hi, I am abc def. I am 20. PICT Pune	3	3	Success
Number of words	Hi, I am abc-def. I am 20. PICT Pune	9	9	Success

Conclusion:

Thus we have successfully implemented a lexical analysis phase of a compiler to count the number of words, character and lines in an external file.