Name: Kush Munot
Roll No. 47

Practical No. 2

Theory:

YACC:

Yacc (Yet Another Compiler-Compiler) is a computer program for the Unix operating system developed by Stephen C. Johnson. It is a Look Ahead Left-to-Right (LALR) parser generator, generating a parser, the part of a compiler that tries to make syntactic sense of the source code, specifically a LALR parser, based on an analytic grammar written in a notation similar to Backus–Naur Form (BNF). Yacc is supplied as a standard utility on BSD and AT&T Unix. GNU-based Linux distributions include Bison, a forward-compatible Yacc replacement.

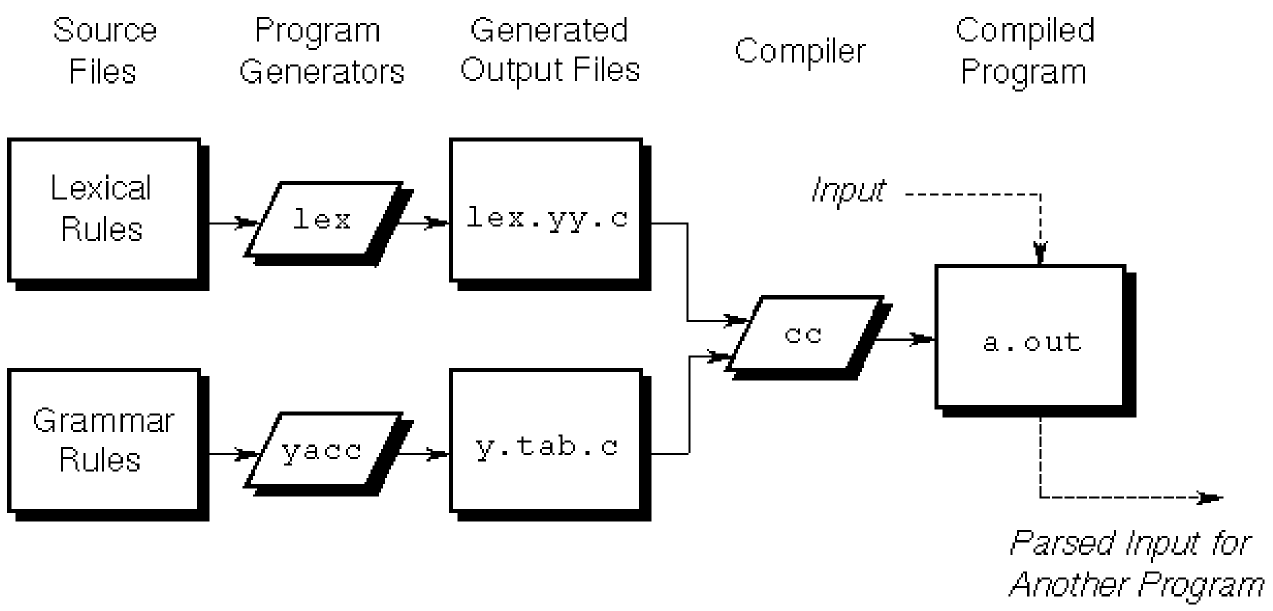
The input to Yacc is a grammar with snippets of C code (called "actions") attached to its rules. Its output is a shift-reduce parser in C that executes the C snippets associated with each rule as soon as the rule is recognized. Typical actions involve the construction of parse trees. Using an example from Johnson, if the call node (label, left, right) constructs a binary parse tree node with the specified label and children, then the rule.

recognizes summation expressions and constructs nodes for them. The special identifiers $$, $1 and $3 refer to items on the parser's stack.

Yacc produces only a parser (phrase analyzer); for full syntactic analysis this requires an external lexical analyzer to perform the first tokenization stage (word analysis), which is then followed by the parsing stage proper. Lexical analyzer generators, such as Lex or Flex are widely available. The IEEE POSIX P1003.2 standard defines the functionality and requirements for both Lex and Yacc.

Some versions of AT&T Yacc have become open source. For example, source code is available with the standard distributions of Plan 9.

Diagram of YACC



Basic Specifications

Names refer to either tokens or nonterminal symbols. Yacc requires token names to be declared as such. In addition, for reasons discussed in Section 3, it is often desirable to include the lexical analyzer as part of the specification file; it may be useful to include other programs as well. Thus, every specification file consists of three sections: the declarations, (grammar) rules, and programs. The sections are separated by double percent ``%%'' marks. (The percent ``%'' is generally used in Yacc specifications as an escape character.)

In other words, a full specification file looks like

```
        declarations
        %%
        rules
        %%
        Programs
```

How the parser works?

Yacc turns the specification file into a C program, which parses the input according to the specification given. The algorithm used to go from the specification to the parser is complex, and will not be discussed here (see the references for more information). The parser itself, however, is relatively simple, and understanding how it works, while not strictly necessary, will nevertheless make treatment of error recovery and ambiguities much more comprehensible.

The parser produced by Yacc consists of a finite state machine with a stack. The parser is also capable of reading and remembering the next input token (called the lookahead token). The current state is always the one on the top of the stack. The states of the finite state machine are given small integer labels; initially, the machine is in state 0, the stack contains only state 0, and no lookahead token has been read.

The machine has only four actions available to it, called shift, reduce, accept, and error. A move of the parser is done as follows:

1. Based on its current state, the parser decides whether it needs a lookahead token to decide what action should be done; if it needs one, and does not have one, it calls yylex to obtain the next token.

2. Using the current state, and the lookahead token if needed, the parser decides on its next action, and carries it out. This may result in states being pushed onto the stack, or popped off of the stack, and in the lookahead token being processed or left alone.

Actions

With each grammar rule, you can associate actions to be performed when the rule is recognized. Actions can return values and can obtain the values returned by previous actions. Moreover, the lexical analyzer can return values for tokens, if desired.

An action is an arbitrary C-language statement and as such can do input and output, call subroutines, and alter arrays and variables. An action is specified by one or more statements enclosed in { and }. For example, the following two examples are grammar rules with actions:

```
A       : '(' B ')'
        {
                hello(1, "abc" );
     }

and
```

```
XXX      : YYY ZZZ
         {
                         (void) printf("a message\n");
                         flag = 25;
         }
```

The $ symbol is used to facilitate communication between the actions and the parser. The pseudo-variable $$ represents the value returned by the complete action.

For example, the action:

```
{$$ = 1;}
```

returns the value of one; in fact, that's all it does.

To obtain the values returned by previous actions and the lexical analyzer, the action can use the pseudo-variables $1, $2, ... $n. These refer to the values returned by components 1 through n of the right side of a rule, with the components being numbered from left to right. If the rule is

```
A: B C D ;
```

then $2 has the value returned by C, and $3 the value returned by D. The following rule provides a common example:

```
expr: '(' expr ')' ;
```

You would expect the value returned by this rule to be the value of the expr within the parentheses. Since the first component of the action is the literal left parenthesis, the desired logical result can be indicated by:

```
expr: '(' expr ')'
{
$$ = $2 ;
}
```

By default, the value of a rule is the value of the first element in it ($1). Thus, grammar rules of the following form frequently need not have an explicit action:

```
A : B ;
```

In previous examples, all the actions came at the end of rules. Sometimes, it is desirable to get control before a rule is fully parsed. yacc permits an action to be written in the middle of a rule as well as at the end.

This action is assumed to return a value accessible through the usual $ mechanism by the actions to the right of it. In turn, it can access the values returned by the symbols to its left. Thus, in the rule below, the effect is to set x to 1 and y to the value returned by C:

```
A        : B
         {
                 $$ = 1;
         }
C        {
                 x = $2;
                 y = $3;
         }
         ;
```

Actions that do not terminate a rule are handled by yacc by manufacturing a new nonterminal symbol name and a new rule matching this name to the empty string. The interior action is the action triggered by recognizing this added rule.

YACC Declaration Summary

Declaration	**Description**
%start	Specify the grammar's start symbol
%token	Declare a terminal symbol (token type name) with no precedence or associativity specified
%type	Declare the type of semantic values for a nonterminal symbol
%right	Declare a terminal symbol (token type name) that is right-associative
%left	Declare a terminal symbol (token type name) that is left-associative
%nonassoc	Declare a terminal symbol (token type name) that is non-associative (using it in a way that would be associative is a syntax error, *Ex: x op. y op. z is syntax error)*

Question:

1. What is the use of yyparse()

yyparse() is a function that is part of the Lex/Yacc (or Flex/Bison) parser generator tools for generating parsers for programming languages or other structured input languages. The purpose of yyparse() is to parse the input stream according to the grammar rules defined in the Yacc/Bison specification file, and to build an abstract syntax tree (AST) or parse tree of the input.

When yyparse() is called, it reads tokens from the input stream (usually provided by the lexical analyzer generated by Lex/Flex) and uses them to construct a parse tree according to the rules defined in the Yacc/Bison grammar file. Once the parse tree is constructed, it can be used for a variety of purposes, such as generating code, performing semantic analysis, or evaluating expressions.

2. What is y.tab.h contains?

y.tab.h is a header file that is automatically generated by the Yacc (or Bison) parser generator tool when a parser is generated from a Yacc/Bison grammar file. The header file contains various definitions and declarations related to the generated parser, including:

1. Token definitions: y.tab.h defines integer constants for each terminal symbol in the grammar, which correspond to the tokens that the parser will recognize in the input stream.
2. Data types: y.tab.h may define data types for the various nonterminal symbols in the grammar, which can be used to represent the values computed by the parser.
3. Parser function declaration: y.tab.h declares the function yyparse(), which is the main entry point for the generated parser. This function is responsible for parsing the input stream and constructing the parse tree.
4. Parse tree data structures: y.tab.h may define data structures for the parse tree nodes, which represent the syntactic structure of the input according to the grammar rules.

3. How to declare terminals, nonterminals & start symbols in each file.

   In a Yacc/Bison file, terminals, nonterminals, and the start symbol are declared using specific syntax.

   1. Terminals: Terminals are the basic symbols in the input stream, such as identifiers, numbers, and operators. In Yacc/Bison, terminals are typically defined using a %token declaration.
   2. Nonterminals: Nonterminals are symbols that represent sequences of terminals and other nonterminals in the grammar. In Yacc/Bison, nonterminals are typically defined using production rules. A production rule has the form nonterminal: symbols, where nonterminal is a nonterminal symbol and symbols is a sequence of terminals and nonterminals that can be derived from nonterminal.
   3. Start symbol: The start symbol is the nonterminal that represents the entire input stream. In Yacc/Bison, the start symbol is typically declared using the %start declaration.

   In summary, terminals are declared using %token, nonterminals are defined using production rules, and the start symbol is declared using %start.

4. Justify the need of yyerror(). Specify its syntax

   yyerror() is a function in Yacc/Bison that is used to report syntax errors or other parsing errors that occur during the parsing process. It allows the parser to report errors to the user in a way that is customizable and flexible.

   The need for yyerror() arises because Yacc/Bison-generated parsers are typically designed to be used for complex input languages, such as programming languages, that have many different possible syntax errors. When an error occurs, the parser needs to be able to report the error to the user in a way that is informative and understandable.

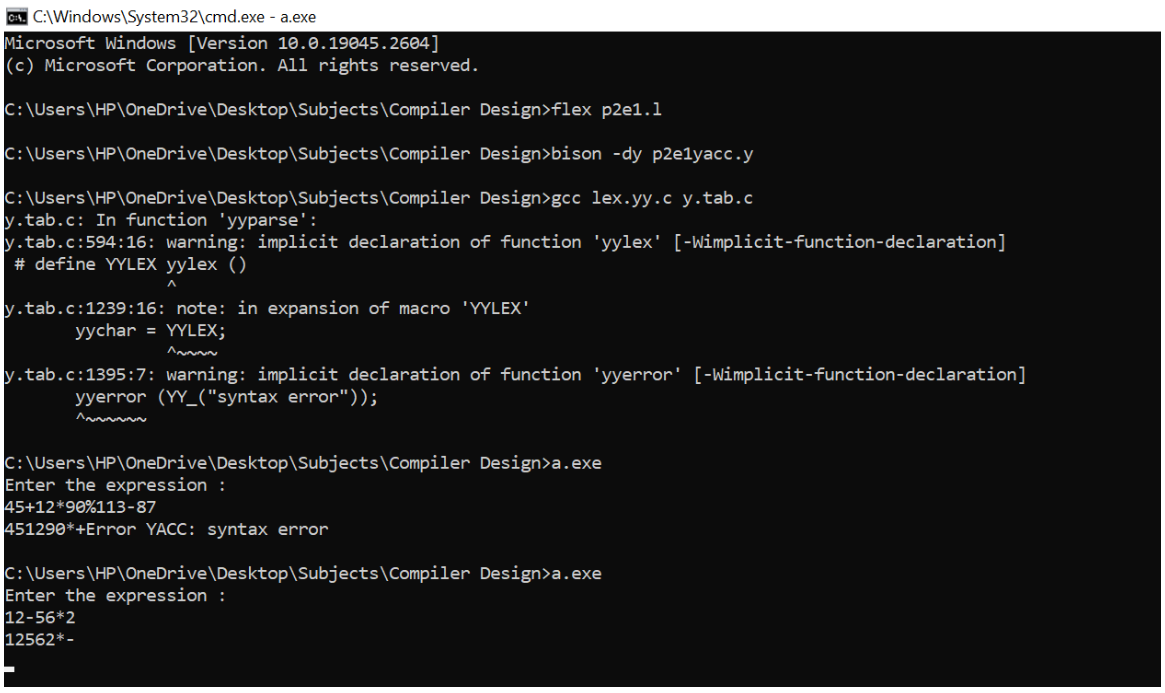
   The yyerror() function provides a way for the user to customize the error reporting process. By default, yyerror() simply prints an error message to the standard error stream, but it can be overridden by the user to provide a more customized error message or to handle errors in a different way.

Practical E1

Aim: Check the Validity of an expression.

Program:
```
%{
#include "y.tab.h"
%}
%%
[0-9]+ {yylval=atoi(yytext); return NUMBER;}
[a-zA-Z] {return ID;}
\n {return NL;}
. {return yytext[0];}
%%
%{
#include<stdio.h>
#include<stdlib.h>
int answer=0;
%}
%token NUMBER ID NL
%left '+' '-'
%left '*' '/'
%%
stmt : exp NL { printf("\nValid expression & Answer: %d \n",$1);
     exit(0);}
|
exp1 NL { printf("Valid Expression \nBut, Calculation Can Be
Performed On Variables \n");
     exit(0);}
;
exp : exp '+' exp     {$$=$1+$3;printf("+");}
| exp '-' exp         {$$=$1-$3;printf("-");}
| exp '*' exp         {$$=$1*$3;printf("*");}
| exp '/' exp         {$$=$1/$3;printf("/");}
| '(' exp ')'         {$$=$2;}
| NUMBER        {$$=$1;printf("%d",$1);}
;
exp1 : exp1 '+' exp1       {$$=$1+$3;printf("+");}
| exp1 '-' exp1       {$$=$1-$3;printf("-");}
| exp1 '*' exp1       {$$=$1*$3;printf("*");}
| exp1 '/' exp1       {$$=$1/$3;printf("/");}
| '(' exp1 ')'        {$$=$2;}
| ID                  {$$=$1;printf("%s",$1);}
;
%%
int yyerror(char *msg)
{
printf("Invalid Expression \n");
exit(0);
}
main()
{
printf("Enter the expression : \n");
yyparse();
}
int yywrap(){return 1;}
```

Output:



```
Microsoft Windows [Version 10.0.19045.2604]
(c) Microsoft Corporation. All rights reserved.

C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>flex p2e1.l

C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>bison -dy p2e1yacc.y

C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>gcc lex.yy.c y.tab.c
y.tab.c: In function 'yyparse':
y.tab.c:594:16: warning: implicit declaration of function 'yylex' [-Wimplicit-function-declaration]
 # define YYLEX yylex ()
                ^
y.tab.c:1239:16: note: in expansion of macro 'YYLEX'
       yychar = YYLEX;
                ^~~~~
y.tab.c:1395:7: warning: implicit declaration of function 'yyerror' [-Wimplicit-function-declaration]
       yyerror (YY_("syntax error"));
       ^~~~~~~

C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>a.exe
Enter the expression :
45+12*90%113-87
451290*+Error YACC: syntax error

C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>a.exe
Enter the expression :
12-56*2
12562*-
```

Practical E2

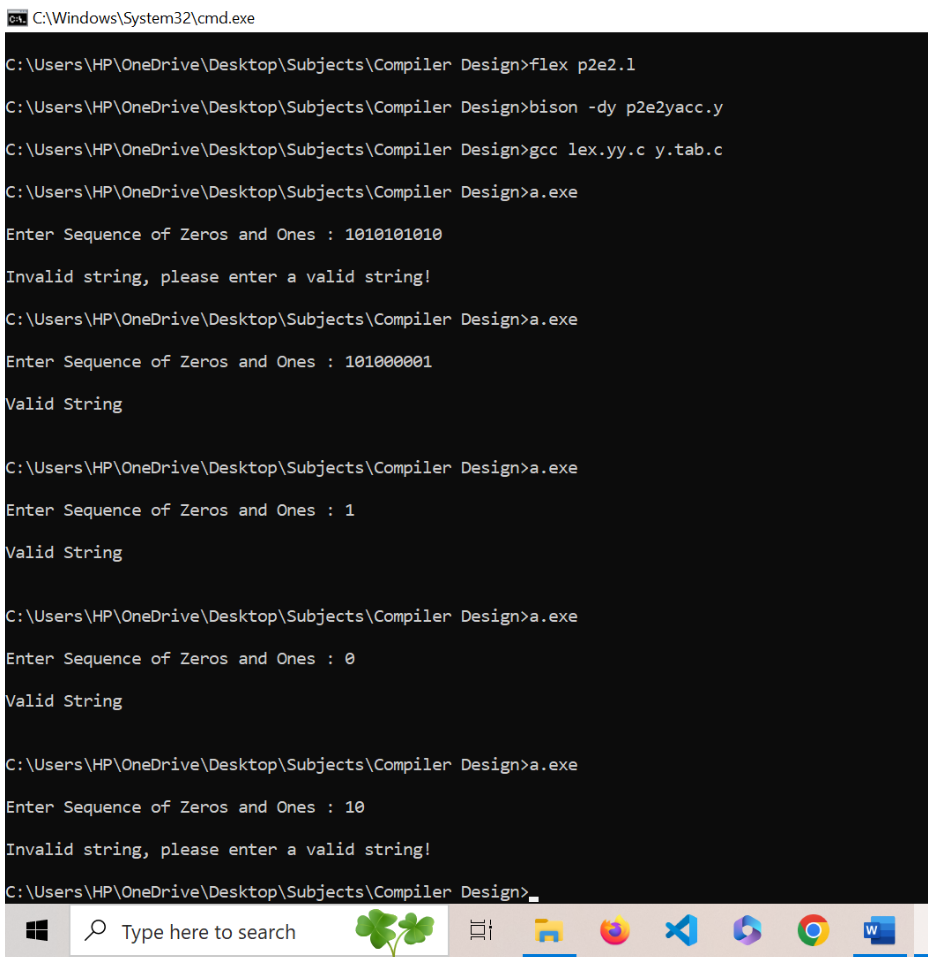
Aim: Write a YACC specification to accept strings that starts and ends with 0 or 1
L= {strings that starts and ends with 0 or 1}

Program:

```
%{
#include "y.tab.h"
%}
%%
0 {return ZERO;}
1 {return ONE;}
\n {return NL;}
. {return yytext[0];}
%%}
%{
#include<stdio.h>
#include<stdlib.h>
%}
%token ZERO ONE NL
%%
stmt : ZERO exp ZERO NL { printf("Valid expression"); exit(0); }
| ZERO exp ONE NL { printf("Valid expression"); exit(0); }
;
exp : ZERO
| ONE
| exp ZERO
| exp ONE
;
%%
int yyerror(char *msg)
{
printf("Invalid Expression \n");
```

```
exit(0);
}
main()
{
printf("Enter the expression : \n");
yyparse();
}
int yywrap(){return 1;}
```

Output:



```
C:\Windows\System32\cmd.exe
C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>flex p2e2.l

C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>bison -dy p2e2yacc.y

C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>gcc lex.yy.c y.tab.c

C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>a.exe

Enter Sequence of Zeros and Ones : 1010101010

Invalid string, please enter a valid string!

C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>a.exe

Enter Sequence of Zeros and Ones : 101000001

Valid String


C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>a.exe

Enter Sequence of Zeros and Ones : 1

Valid String


C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>a.exe

Enter Sequence of Zeros and Ones : 0

Valid String


C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>a.exe

Enter Sequence of Zeros and Ones : 10

Invalid string, please enter a valid string!

C:\Users\HP\OneDrive\Desktop\Subjects\Compiler Design>_
```

Practical E3

Aim: The input &amp; output is provided for the if statement. The same is used for while loop

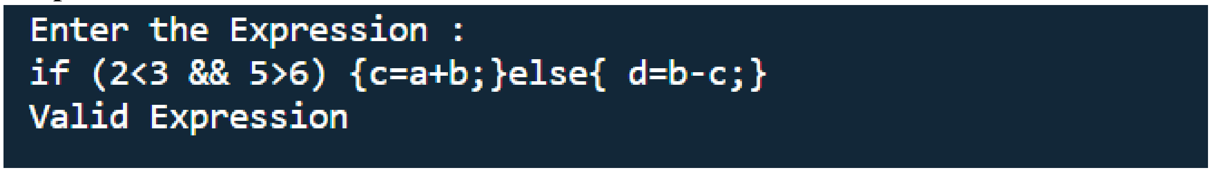
Program:

```
%{
%}
%%
"while" {return key;}
"(" {return ob;}
")" {return cb;}
" " {return sp;}
";" {return sc;}
"int"|"char"|"float" {return dec;}
"&&"|"||" {return tt;}
[a-z]+ {return vb;}
```

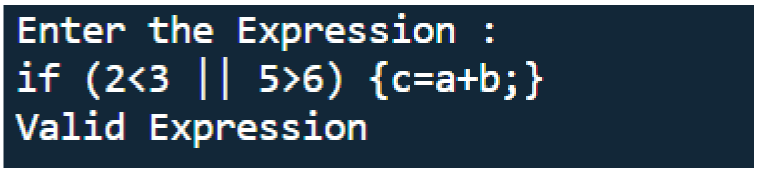
```
[0-9]+ {return nu;}
">"|"<"|">="|"<="|"="|"!=" {return op;}
"{" {return co;}
"}" {return cc;}
%%
```

```
%{
#include<stdio.h>
%}
%token key
%token ob
%token op
%token vb
%token cb
%token nu
%token co
%token cc
%token cn
%token tt
%token sp
%token sc
%token dec
%%
line:key ob rp cb co a cc {printf("\n correct");}
    ;
a:vb
    |nu
    |vb nu
    |a a
    |dec sp vrb sc
    ;
vrb:vb nu
    |vb
    ;
rp:ob vrb op a cb
    |rp tt rp
    |vb op nu
    |vrb op vrb
    |vrb op nu
    ;
%%
#include"lex.yy.c"
int main()
{
yyparse();
}
int yywrap()
{
return 1;
}
int yyerror()
{
return 1;
}
```

Output:



```
Enter the Expression :
if (2<3 && 5>6) {c=a+b;}else{ d=b-c;}
Valid Expression
```



```
Enter the Expression :
if (2<3 || 5>6) {c=a+b;}
Valid Expression
```