Lex & Yacc

References

*Tom Niemann. “A Compact Guide to Lex & Yacc ”. Portland, Oregon. 18 April 2010 <http://epaperpress.com>

*Levine, John R., Tony Mason and Doug Brown [1992]. Lex & Yacc. O’Reilly & Associates, Inc. Sebastopol, California.

Outline

- **References.**
- **Lex:**
    - **Theory.**
    - **Execution.**
    - **Example.**
- **Yacc:**
    - **Theory.**
    - **Description.**
    - **Example.**
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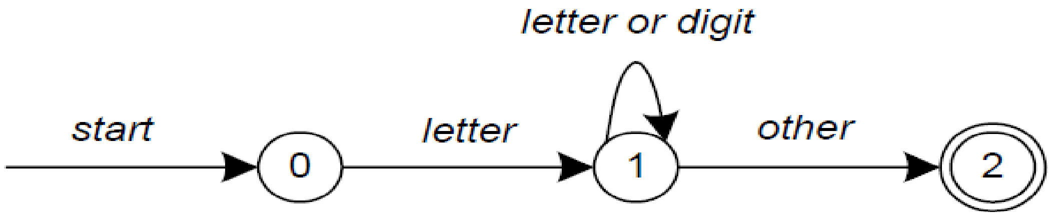
Lex

- lex is a program (generator) that generates lexical analyzers, (widely used on Unix).
- It is mostly used with Yacc parser generator.
- Written by Eric Schmidt and Mike Lesk.
- It reads the input stream (specifying the lexical analyzer) and outputs source code implementing the lexical analyzer in the C programming language.
- Lex will read patterns (regular expressions); then produces C code for a lexical analyzer that scans for identifiers.

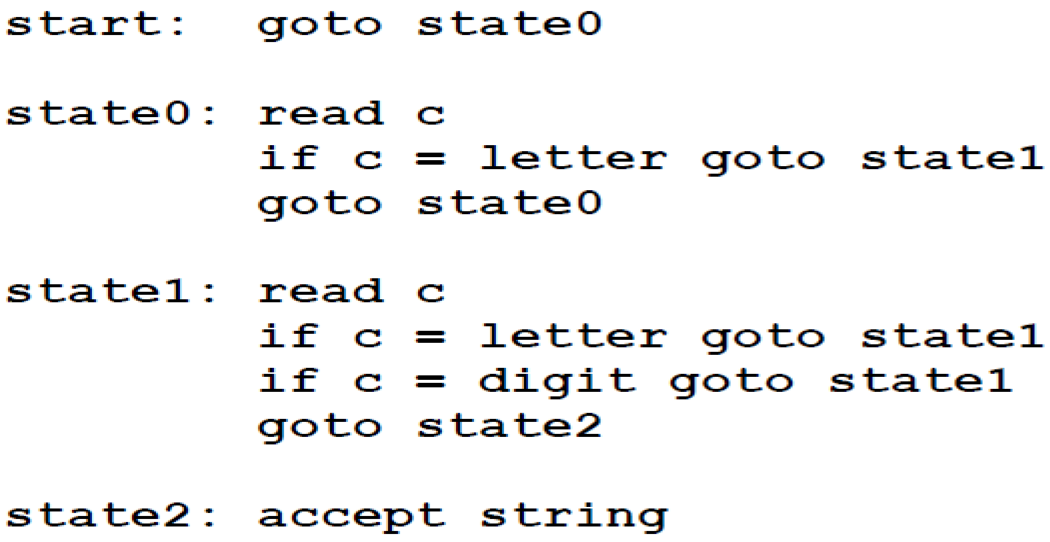
Lex

  - A simple pattern: **letter(letter|digit)***

- Regular expressions are translated by lex to a computer program that mimics an FSA.
- This pattern matches a string of characters that begins with a single letter followed by zero or more letters or digits.



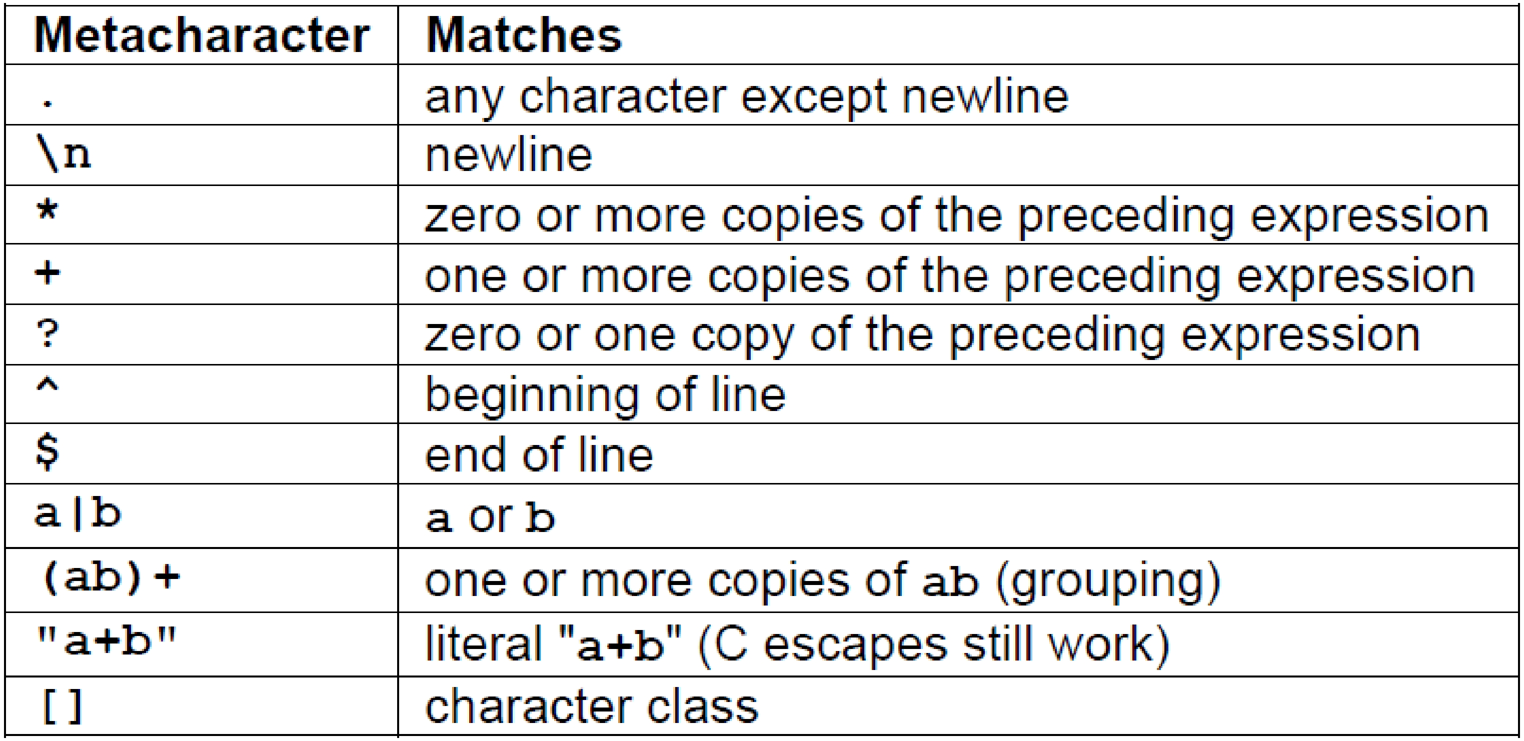
Lex



```
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
```

- Some limitations, Lex cannot be used to recognize nested structures such as parentheses, since it only has states and transitions between states.
- So, Lex is good at pattern matching, while Yacc is for more challenging tasks.

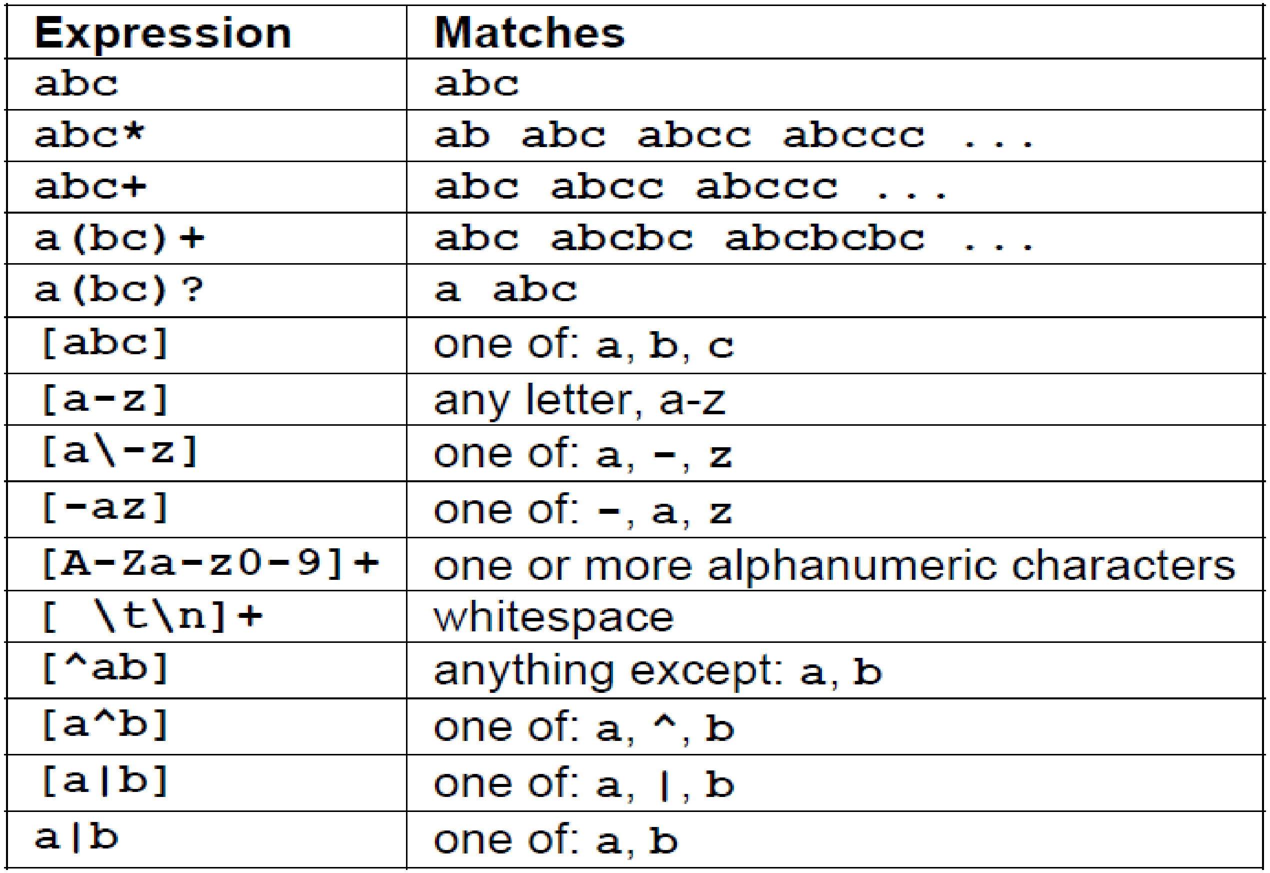
Lex



Metacharacter	Matches
.	any character except newline
\n	newline
*	zero or more copies of the preceding expression
+	one or more copies of the preceding expression
?	zero or one copy of the preceding expression
^	beginning of line
$	end of line
a|b	a or b
(ab)+	one or more copies of ab (grouping)
"a+b"	literal "a+b" (C escapes still work)
[]	character class

Pattern Matching Primitives

Lex



Expression	Matches
abc	abc
abc*	ab abc abcc abccc ...
abc+	abc abcc abccc ...
a(bc)+	abc abcbc abcbcbc ...
a(bc)?	a abc
[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
a|b	one of: a, b

- Pattern Matching examples.

Lex

……..Definitions section……

%%

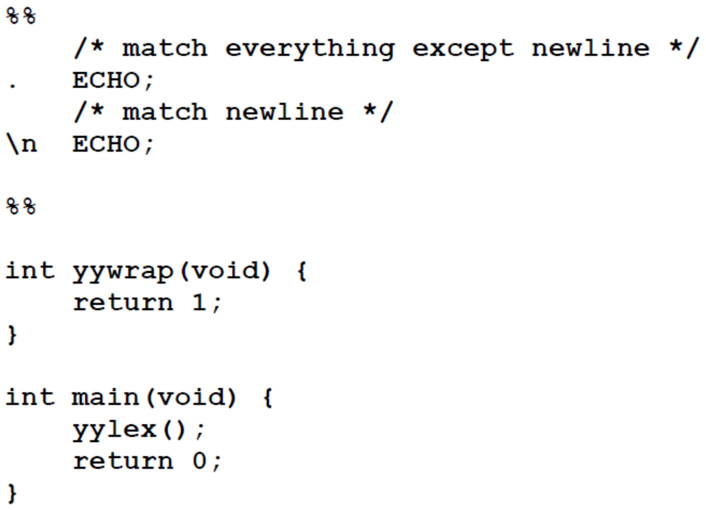
……Rules section……..

%%

……….C code section (subroutines)……..

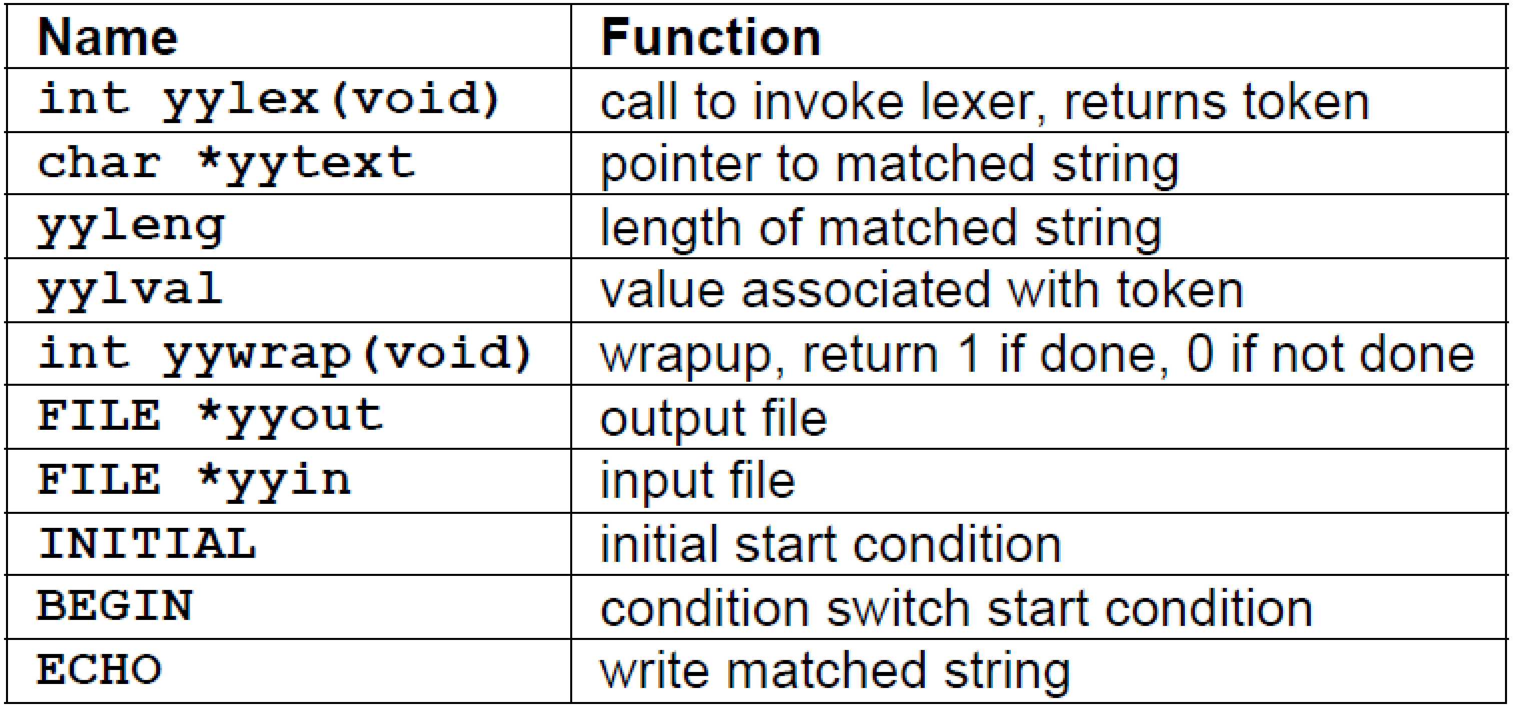
- The input structure to Lex.

•Echo is an action and predefined macro in lex that writes code matched by the pattern.



```
%%
    /* match everything except newline */
.   ECHO;
    /* match newline */
\n  ECHO;

%%

int yywrap(void) {
    return 1;
}

int main(void) {
    yylex();
    return 0;
}
```

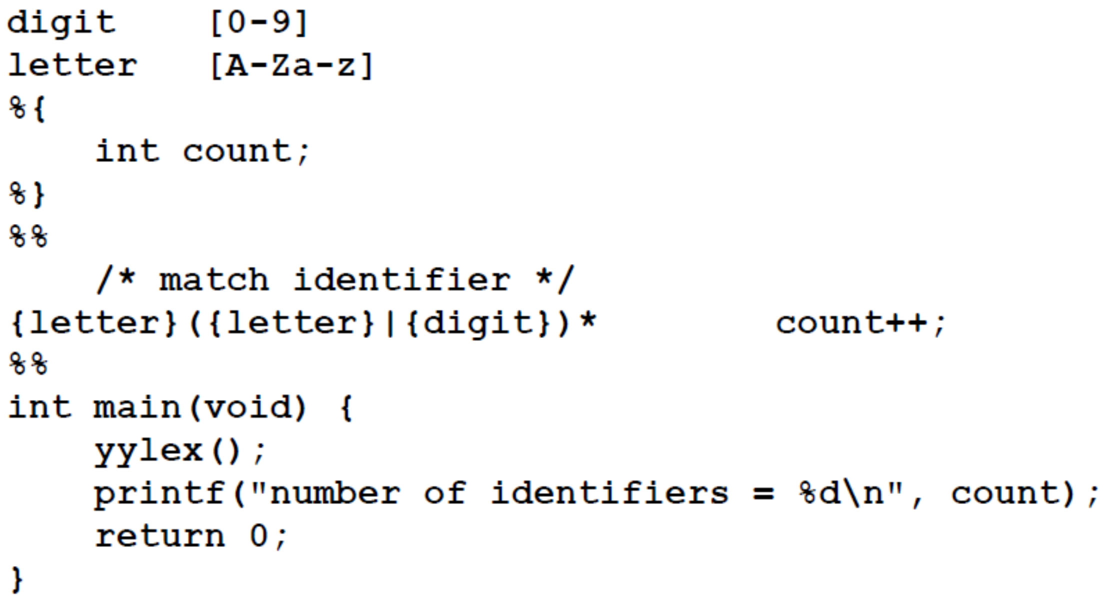
Lex



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

Lex predefined variables.

Lex



```
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.
- 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 in the rules section are surrounded by braces ({letter}) to distinguish them from literals.

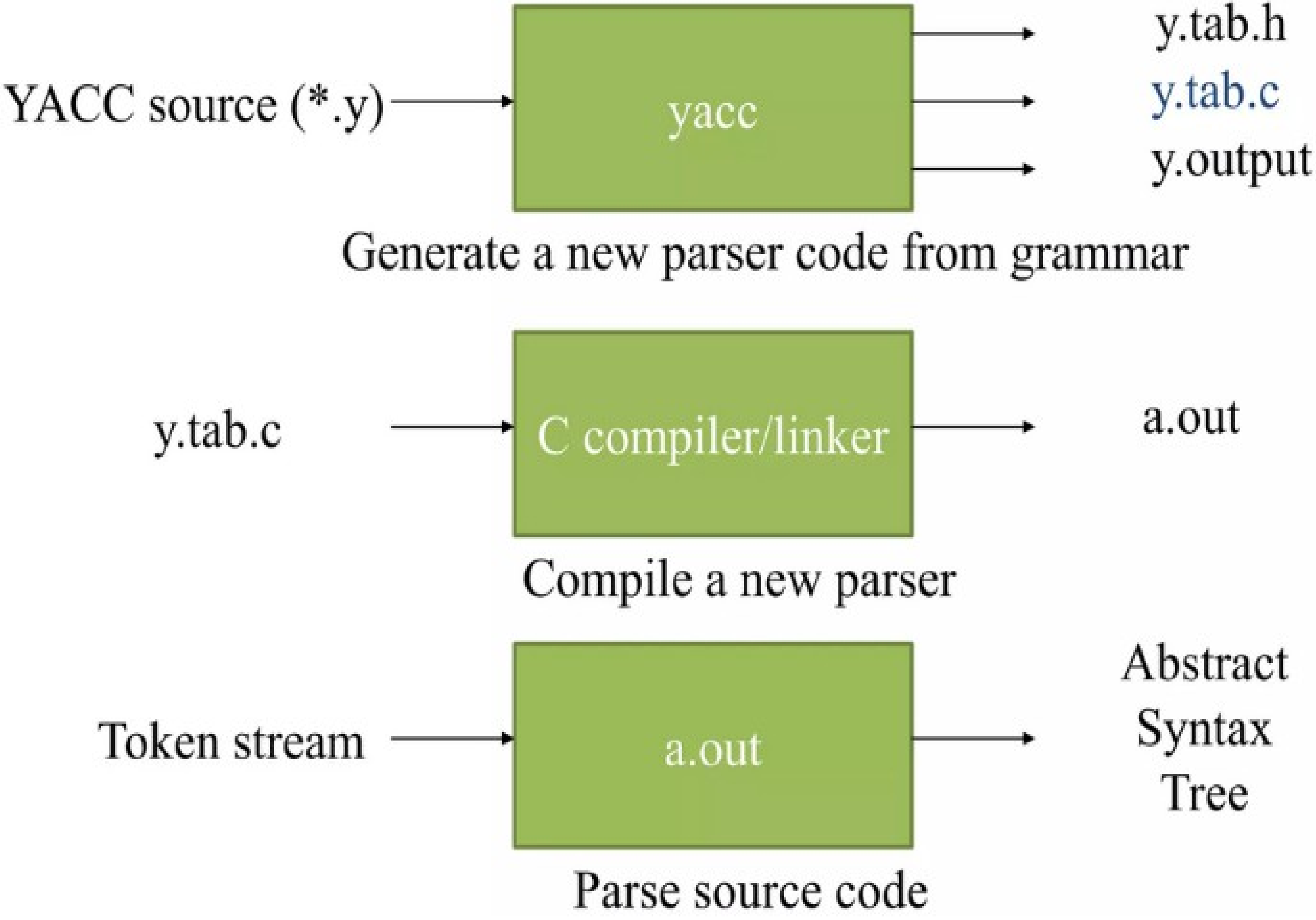
Yacc

- Theory:
  - Yacc reads the grammar and generate C code for a parser .
  - Grammars written in Backus Naur Form (BNF) .
  - BNF grammar used to express *context-free languages .*
  - e.g. to parse an expression , do reverse operation(reducing the expression)
  - This known as *bottom-up or shift-reduce parsing .*
  - *Using* stack for storing (LIFO).

YACC: Yet Another Compiler-Compiler

- Yacc generates C code for syntax analyzer, of **parser.**
- Yacc uses grammar rules that allow it to analyze tokens from **LEX** and create a **syntax tree.**
- Yacc provides a general tool for describing the **input** to a computer program.
- The Yacc user specifies the structures of his input, together with code to be invoked as each such structure is recognized.
- Yacc is written in **portable C**.
- The class of specifications accepted is a very general one: **LALR grammars** with disambiguating rules.
- In addition to compilers for **C, APL, Pascal, RATFOR**, etc., Yacc has also been used for less conventional languages, including a phototypesetter language, several desk calculator languages, a document retrieval system, and a Fortran debugging system.

How Does YACC Work?



Generate a new parser code from grammar

Compile a new parser

Parse source code

Yacc

- Input to yacc is divided into three sections.

... definitions ...

%%

... rules ...

%%

... subroutines ...

Yacc

- **The definitions section consists of:**
  - token declarations .
  - C code bracketed by **“%{“** and **“%}”.**

  - **the rules section consists of**:
 BNF grammar .

- **the subroutines section** consists of:
  - user subroutines .

yacc& lex in Together

- **The grammar:**

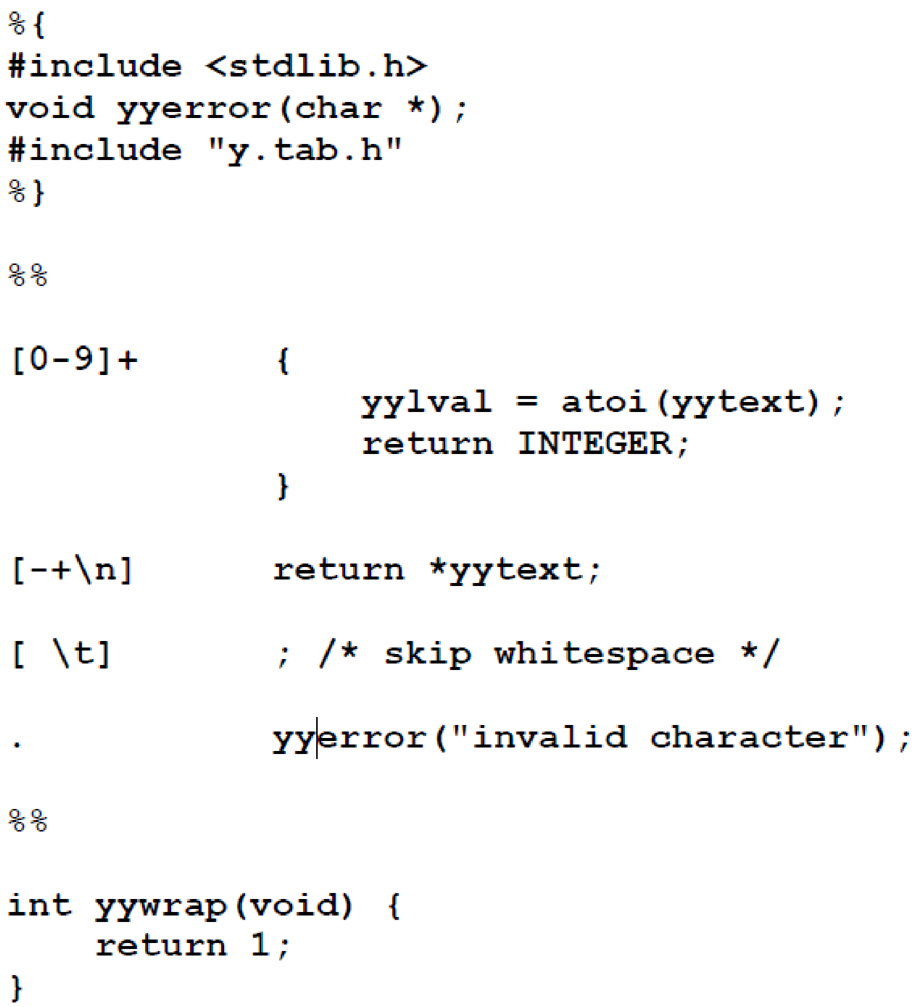
  program -> program expr | ε

  expr -> expr + expr | expr - expr | id

- **Program and expr are nonterminals.**
- **Id are terminals (**tokens returned by lex**) .**

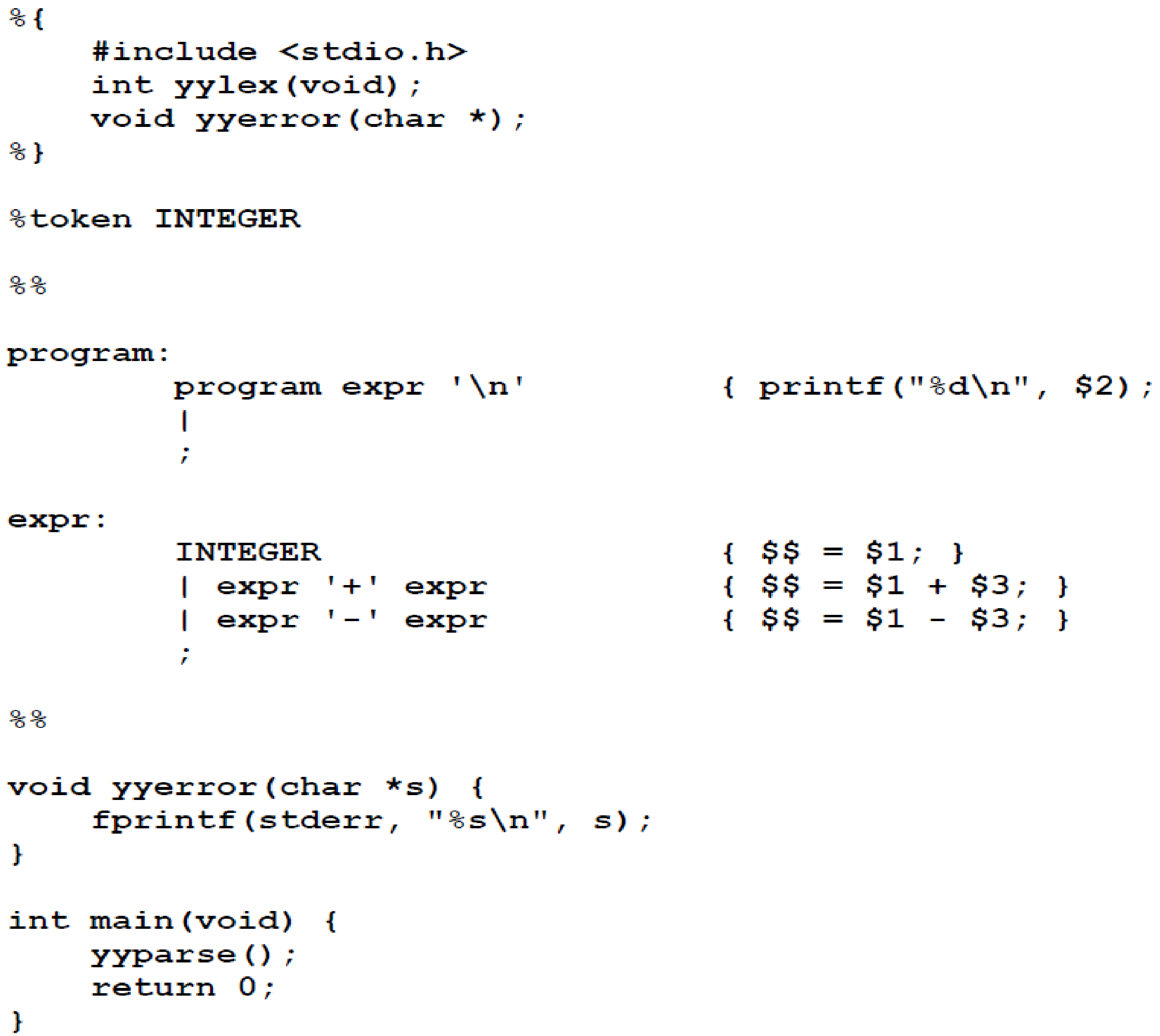
- **expression may be :**
  - sum of two expressions .
  - product of two expressions .
  - Or an identifiers

Lex file



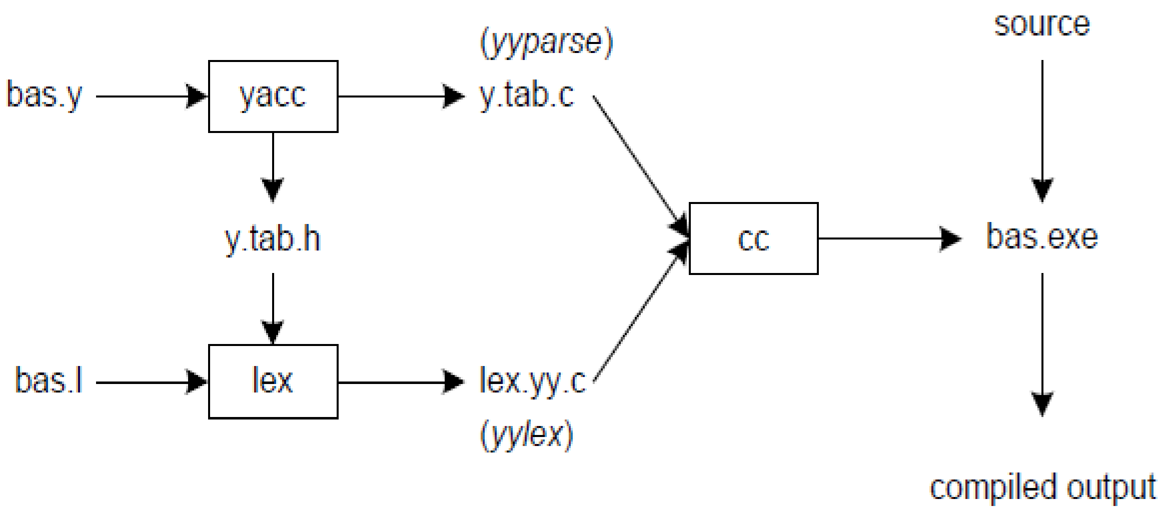
```
%{
#include <stdlib.h>
void yyerror(char *);
#include "y.tab.h"
%}

%%

[0-9]+      {
                yylval = atoi(yytext);
                return INTEGER;
            }

[-+\n]      return *yytext;

[ \t]       ; /* skip whitespace */

.           yyerror("invalid character");

%%

int yywrap(void) {
    return 1;
}
```

Yacc file



```
%{
    #include <stdio.h>
    int yylex(void);
    void yyerror(char *);
%}

%token INTEGER

%%

program:
        program expr '\n'         { printf("%d\n", $2);
        |
        ;

expr:
        INTEGER                   { $$ = $1; }
        | expr '+' expr           { $$ = $1 + $3; }
        | expr '-' expr           { $$ = $1 - $3; }
        ;

%%

void yyerror(char *s) {
    fprintf(stderr, "%s\n", s);
}

int main(void) {
    yyparse();
    return 0;
}
```

Linking lex&yacc



Compiling YACC Program:

```
$ lex file.l
$ yacc file.y
$ cc lex.yy.c y.tab.h -ll
$ ./a.out
```

```
%token INTEGER VARIABLE
%left '+' '-'
%left '*' '/'

%{
    void yyerror(char *);
    int yylex(void);
    int sym[26];
%}

%%

program:
        program statement '\n'
        |
        ;

statement:
        expr                      { printf("%d\n", $1); }
        | VARIABLE '=' expr       { sym[$1] = $3; }
        ;

expr:
        INTEGER
        | VARIABLE                { $$ = sym[$1]; }
        | expr '+' expr           { $$ = $1 + $3; }
        | expr '-' expr           { $$ = $1 - $3; }
        | expr '*' expr           { $$ = $1 * $3; }
        | expr '/' expr           { $$ = $1 / $3; }
        | '(' expr ')'            { $$ = $2; }
        ;

%%

void yyerror(char *s) {
    fprintf(stderr, "%s\n", s);
    return 0;
}

int main(void) {
    yyparse();
    return 0;
}
```