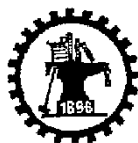


西安交通大学



## 编译原理实验报告

何宜晖  
计算机46  
2140504137  
电信学院  
heyihui@stu.xjtu.edu.cn

2016年11月

## 目录

<b>1 语法分析</b>	<b>3</b>
1.1 实验目的	3
1.2 实验内容	3
1.3 实验要求	3
1.4 功能描述	3
1.4.1 注释的跳过	3
1.5 程序结构描述	3
1.6 实验总结	4
<b>2 语法分析</b>	<b>6</b>
2.1 实验目的	6
2.2 实验内容	6
2.3 实验要求	6
2.4 功能描述	6
2.5 程序结构描述	7
2.5.1 ifelse	7
2.5.2 双目运算	7
2.5.3 单目运算	7
2.5.4 ++, --	7
2.5.5 $V_T$ & $V_N$	8
2.5.6 Abstract Tree	8
2.5.7 程序的缺陷	10
2.5.8 程序代码	10
2.6 实验总结	10
<b>3 参考文献</b>	<b>11</b>
<b>A lex code</b>	<b>12</b>
<b>B lex results</b>	<b>15</b>
<b>C yacc code</b>	<b>23</b>
<b>D yacc results</b>	<b>33</b>

# 1 语法分析

## 1.1 实验目的

1. 强化对系统软件综合工程实现能力的训练
2. 加强对词法分析原理、方法和基本实现技术的理解

## 1.2 实验内容

用C语言或者其他的高级语言作为宿主语言完成C1语言的词法分析器的设计和实现。

## 1.3 实验要求

1. 编写C0语言的词法分析器的源程序并调试通过。其中词法分析程序既可以自己手动去完成，也可以利用LEX自动生成。
2. 通过测试程序的验收；
3. 实验报告按照提供的模板填写

## 1.4 功能描述

该程序要实现的是一个读程序的过程，从输入的源程序中，识别出各种类型的单词(基本保留字、标识符、常数、运算符、分隔符)。输出并打印各个单词的类型以及本身。[7][1][6][2]。我编写了几个简单的c0语言程序，解析结果在附录B中

类型名按照实验指导书定义，部分未出现的，参照 ANSI C [3]

分析部分，可以开启yylineao，用于打开自动记录行号%option yylineao。匹配到的词可以用yytext直接获取。

主程序部分，yyin将读取到的文件传送给lex。yylex() 则开始词法分析，每个匹配到的词，都会执行后面动作。[5][4]

### 1.4.1 注释的跳过

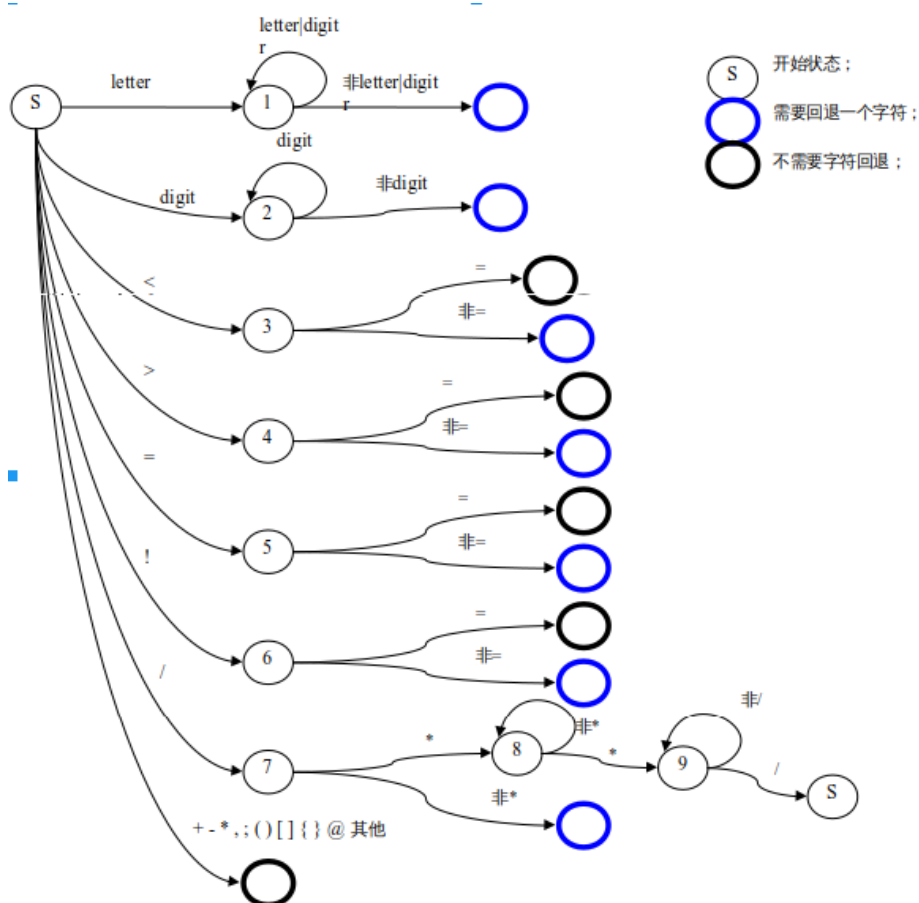
读到\\我们就吃掉整行。读到\\\*我们进入注释程序comment()。一直读取，直到读到\*/为止，否则报错。

## 1.5 程序结构描述

程序使用lex编写，按指导书给出的状态转换图进行正则匹配，状态转移图如图1所示。

程序中设计了一个关键的打印函数 printToken，该函数输入为当前识别的类型，输出为打印当前的行号，字符，以及类型。另一个函数是comment函数，用来判断当前注释进行的状态，如果注释出错，则需要报错，在章节1.4.1中已经详细解释了。另外则是主函数main，用于读取程序，启动yylex()程序解析。

具体lex的C语言实现，请见附录A，使用lex分析C0程序的结果，请见附录B。



## 1.6 实验总结

1. 你在编程过程中花时多少？我大概花了一个晚上。
2. 多少时间在纸上设计？花了半小时在纸上设计。
3. 多少时间上机输入和调试？3个小时左右。
4. 多少时间在思考问题？一个小时左右。
5. 遇到了哪些难题，你是怎么克服的？实验中还是遇到了很多难题。首先是如何使用lex，经过仔细阅读参考书目lex&yacc??，让我了解了lex的基

本用法。还有就是如何显示行号，如何获得当前的字符，我通过上网搜索了解到可以使用yylineao, yytext。以及如何解决有注释的问题，虽然实验指导书没有给出，我还是在参考书目中感悟到了解决方法??

6. 你对你的程序的评价？我的程序使用lex编写，token定义模仿标准的ANIS C。自己比较满意。
7. 你的收获有哪些？这次实验学会了使用lex，为后面利用yacc进行语法分析打下了坚实的基础。

## 2 语法分析

### 2.1 实验目的

1. 强化对系统软件综合工程实现能力的训练；
2. 加强对语法分析原理、方法和基本实现技术的理解；

### 2.2 实验内容

1. 用C语言或者其他的高级语言作为宿主语言完成C0语言的词法分析器的设计和实现.
2. 针对if语句的文法编写一个递归下降分析程序，输出结果为抽象语法树。注意，if语句文法中的表达式E采用四则运算表达式的文法；抽象语法树的格式自行设计，如果需要降低难度的话，也可用具体语法树而不用抽象语法树作为输出.

### 2.3 实验要求

1. 编写C0语言的语法分析器的源程序并调试通过。其中语法分析程序既可以自己手动去完成，也可以利用YACC自动生成。
2. 通过测试程序的验收；
3. 实验报告按照提供的模板填写；

### 2.4 功能描述

该程序要实现的是一个读程序的过程，从输入的源程序中生成一颗抽象语法树[7][1][6][2]，并将结果保存为xml。

我编写了一些简单的c0语言程序，输出结果见附录D.

大部分语法，终结符非终结符的定义，我都是参照实验指导书给出的c0语法如下。部分语法参照 ANSI C [3]

```
program → { var-declaration | fun-declaration }
var-declaration → int ID { , ID }
fun-declaration → ( int | void ) ID ( params ) compound-stmt
params → int ID { , int ID } | void | empty
compound-stmt → { { var-declaration } { statement } }
statement → expression-stmt compound-stmt if-stmt while-stmt
| return-stmt
expression-stmt → [ expression ] ;
if-stmt → if( expression ) statement [ else statement ]
while-stmt → while( expression ) statement
return-stmt → return [ expression ] ;
expression → ID = expression | simple-expression
simple-expression → additive-expression [ relop additive-expression ]
```

```

relop → < | <= | > | >= | == | !=
additive-expression → term [ ( + | - ) term ]
term → factor [ ( * | / ) factor ]
factor → ( expression ) | ID | call | NUM
call → ID( args )
args → expression { , expression } | empty
ID → ... ; 参见C语言标识符定义
NUM → ... ; 参见C语言数的定义

```

## 2.5 程序结构描述

### 2.5.1 ifelse

本程序有一个移进归约冲突：

```
IF '(' expression ')' statement _ ELSE statement
```

由于yacc默认的优先级是从上到下，只需要把if写在if else前面，这个冲突可以默认被消解。

### 2.5.2 双目运算

双目运算 $+$ ， $-$ ， $*$ ， $/$  需要具有左结合性，否则会产生歧义，并且乘除应当比加减先结合。具体到yacc如下：

```

%left PLUS MINUS
%left STAR SLASH

```

### 2.5.3 单目运算

单目运算 $+$ ， $-$ ，结合紧密型应当比乘除高，然而在前面已经定义了结合紧密性低于乘除，所以需要在单目运算中单独处理，具体到yacc时，使用prec语法，临时更换其结合紧密性。

```

additive_expression
...
...
| PLUS additive_expression %prec STAR {...}
| MINUS additive_expression %prec STAR {...}

```

### 2.5.4 ++, --

这是在c，c0，c++等语言中的特殊语法。如果在词法分析时，只单个提取 $+$ ， $-$ 。后面是无法区分 $-i$ 与 $-(i)$ 的，会有归约-归约冲突。故需要定义两个单独的token，与 $+$ ， $-$ 区别开来。

```
%token INC_OP DEC_OP
```

在词法分析时，就要单独识别：

```
"++" {return INC_OP; }
"--" {return DEC_OP; }
```

在语法分析时，就能轻松区别开了：

```
unary_expression
    : INC_OP ID {...}
    | DEC_OP ID {...}
    | postfix_expression {...}
    ;

postfix_expression
    : ID INC_OP {...}
    | ID DEC_OP {...}
    ;
```

### 2.5.5 $V_T$ & $V_N$

终结符直接用string表示，非终结符用语法树的节点表示。

---

```
%union {
    char* str;
    struct treeNode * ast;
}
```

---

在yacc中，需要分别定义类型：

```
%type<ast> atree program ...
%type<str> relop declaration_specifiers
```

### 2.5.6 Abstract Tree

语法树节点，便于输出打印，child便于递归打印：

---

```
struct treeNode{
    struct treeNode *child[MAXCHILD];
    char* nodeType;
    char* string;
    char* value;
    char* dataType;
    int lineNo;
    int Nchildren;
};
```

---

**递归生成语法树**，在yacc中  $$$, $1, $2, $3$  可以用来返回指针，以及获得下一级的指针。yacc会递归地，先按照需求计算对应位置非终结符的返回值。使用方法如下：

params



```

: params_list {$$=$1;}
| VOID {$$ = newnode(ylineno,"params", none, none, "VOID", 0);}
;

```

而newnode，是用来将节点穿起来的函数,利用了yacc递归的性质：

---

```

struct treeNode * newnode(int lineNo, char* nodeType, char* string,
    char* value, char* dataType, int Nchildren, ...){
    struct treeNode * node = (struct treeNode*) malloc(sizeof(struct
        treeNode));
    node->nodeType = nodeType;
    node->string = string;
    node->value = value;
    node->dataType = dataType;
    node->lineNo = lineNo;
    node->Nchildren = Nchildren;
    va_list ap;
    int i;
    va_start(ap, Nchildren);
    for (i=0;i<Nchildren;i++){
        node->child[i]=va_arg(ap, struct treeNode *);
    }
    va_end(ap);
    return node;
}

```

---

打印语法树，需要使用拓广文法。单独设定一个非终结符atree在程序开始，它没有任何语法意义，仅仅是为了开始节点有区分性，用来打印语法树。

```

%start atree
%%
atree:program {printNode($1);}

```

---

```

void printNode(struct treeNode* node){
    printf("%s<Tree lineNo=\"%d\" nodeType=\"%s\" string=\"%s\"
        value=\"%s\" dataType=\"%s\">\n",
        indent,
        node->lineNo,
        node->nodeType,
        node->string,
        node->value,
        node->dataType);
    int i;
    if (node->Nchildren > 0){
        printf("%s<Child>\n", indent);
        incIndent();
        for (i=0;i<node->Nchildren;i++){
            printNode(node->child[i]);
        }
    }
}

```

```

        decIndent();
        printf("%s</Child>\n", indent);
    }
    printf("%s</Tree>\n", indent);
}

```

---

### 2.5.7 程序的缺陷

本程序有一个缺陷，就是打印行号时，会打印出匹配到的非终结符的最后一行的行号，而不是样例中给出的第一行的行号。这是自下而上分析的栈读取的特性导致的，我暂时还不知道怎么解决。

### 2.5.8 程序代码

程序代码，见附录C

语法分析结果,见附录D

## 2.6 实验总结

1. 你在编程过程中花时多少？我大概花了两个晚上。
2. 多少时间在纸上设计？花了一小时在纸上设计。
3. 多少时间上机输入和调试？6个小时左右。
4. 多少时间在思考问题？3个小时左右。
5. 遇到了哪些难题，你是怎么克服的？实验中还是遇到了很多难题。首先是如何使用yacc，经过仔细阅读参考书目lex&yacc [5], 让我了解了yacc的基本用法。其他大部分问题都是通过上网查找相关资料解决的，具体困难和解决可以参考实验报告前面部分
6. 你对你的程序的评价？我的程序使用yacc和lex编写，token定义模仿标准的ANIS C。只有一个shift/reduce冲突，自己非常满意。
7. 你的收获有哪些？这次实验学会了使用yacc，以及如何将lex和yacc配合使用。这次实验后，我对编译原理产生了浓厚的兴趣。

### 3 参考文献

- [1] A. W. Appel. *Modern compiler implementation in C*. Cambridge university press, 2004.
- [2] A. W. Appel. 现代编译原理 c 语言描述, 2006.
- [3] J. Degener. Ansi c grammar, <http://www.quut.com/c/ansi-c-grammar-y.html>.
- [4] M. E. Lesk and E. Schmidt. Lex: A lexical analyzer generator, 1975.
- [5] J. R. Levine, T. Mason, and D. Brown. *Lex & yacc*. " O'Reilly Media, Inc.", 1992.
- [6] K. C. Loudon and 编译原理及实践. 冯博琴, 冯岚, 等译. 编译原理及实践. 北京: 机械工业出版社, 2000.
- [7] 陈火旺, 刘春林, 谭庆平, et al. 程序设计语言编译原理. 第三版). 北京: 国防工业出版社, 2000.

## A lex code

---

```
D  [0-9]
NZ [1-9]
L   [a-zA-Z_]
A   [a-zA-Z_0-9]
WS  [ \t\v\n\f]

%option yylineno

%{
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
int yywrap();

void printToken(char* type){
fprintf(yyout, " <token line=\"%d\" type=\"%s\" string=\"%s\" />\n",
        yylineno,
        type,
        yytext);
}
static void comment(void);
%}
%%

"/*"                                { comment(); }
"//" .*                             { /* consume //-comment */ }

"if"                                {printToken("IF"); }
"else"                              {printToken("ELSE");}
"while"                             {printToken("WHILE");}
"return"                            {printToken("RETURN");}
"void"                              {printToken("VOID");}
"int"                               {printToken("INT");}
"float"                             {printToken("FLOAT");}

"++"                                {printToken("INC_OP");}
"--"                                {printToken("DEC_OP");}
"+"                                 {printToken("PLUS");}
"-"                                 {printToken("MINUS");}
"*"                                 {printToken("STAR");}
"/"                                 {printToken("SLASH");}
"<"                                 {printToken("LT");}
"<="                               {printToken("LTEQ");}
">"                                 {printToken("GT");}
">="                               {printToken("GTEQ");}
"=="                               {printToken("EQ");}
```

```

"!="      {printToken("NEQ");}
"="      {printToken("ASSIGN");}

("[")     {printToken("LSQUAR");}
("]")     {printToken("RSQUAR");}
("{")     {printToken("LBRACE");}
("}")     {printToken("RBRACE");}
";"      {printToken("SEMI");}
","      {printToken("COMMA");}
"("      {printToken("LPAREN");}
")"      {printToken("RPAREN");}

{L}{A}*   {printToken("ID");}
{D}+      {printToken("NUMBER");}

{WS}+     {}
.         {}

%%
#include<stdio.h>
int yywrap() {
    return 1;
}

static void comment(void)
{
    int c;

    while ((c = input()) != 0)
        if (c == '*'')
        {
            while ((c = input()) == '*'')
                ;

            if (c == '/')
                return;

            if (c == 0)
                break;
        }
    printf("unterminated comment");
    exit(-1);
}

main(argc, argv)
int argc;
char** argv;

```

```
{
if (argc > 1)
{
    FILE *file;
    file = fopen(argv[1], "r");
    if (!file)
    {
        fprintf(stderr, "failed open");
        exit(1);
    }
    yyin=file;
}
printf("<?xml version=\"1.0\"?>\n<root>\n");
yylex();
printf("</root>\n");
return 0;
}
```

---

## B lex results

$c_0$  语言文件 orig.c

---

```
void main()
{
    int a=0;
    int b=2;
    while(a==b)
        ++a;
}
```

---

$c_0$  语言文件 orig.c的输出

---

```
<?xml version="1.0"?>
<root>
  <token line="1" type="VOID" string="void" />
  <token line="1" type="ID" string="main" />
  <token line="1" type="LPAREN" string="(" />
  <token line="1" type="RPAREN" string=")" />
  <token line="2" type="LBRACE" string="{ " />
  <token line="3" type="INT" string="int" />
  <token line="3" type="ID" string="a" />
  <token line="3" type="ASSIGN" string="=" />
  <token line="3" type="NUMBER" string="0" />
  <token line="3" type="SEMI" string=";" />
  <token line="4" type="INT" string="int" />
  <token line="4" type="ID" string="b" />
  <token line="4" type="ASSIGN" string="=" />
  <token line="4" type="NUMBER" string="2" />
  <token line="4" type="SEMI" string=";" />
  <token line="5" type="WHILE" string="while" />
  <token line="5" type="LPAREN" string="(" />
  <token line="5" type="ID" string="a" />
  <token line="5" type="EQ" string="==" />
  <token line="5" type="ID" string="b" />
  <token line="5" type="RPAREN" string=")" />
  <token line="6" type="INC_OP" string="++" />
  <token line="6" type="ID" string="a" />
  <token line="6" type="SEMI" string=";" />
  <token line="7" type="RBRACE" string="}" />
</root>
```

---

$c_0$  语言文件 simple.c

---

```
int a=0;
```

---

$c_0$  语言文件 simple.c的输出

---

```
<?xml version="1.0"?>
```

---

```

<root>
  <token line="1" type="INT" string="int" />
  <token line="1" type="ID" string="a" />
  <token line="1" type="ASSIGN" string="=" />
  <token line="1" type="NUMBER" string="0" />
  <token line="1" type="SEMI" string=";" />
</root>

```

---

$c_0$  语言文件 test.c

---

```

void main()
{
    int sum1=100;
    int a;
    int b;
    if (1 == 1+0){
        a=3;
    }
    else {
        b=5;
    }
}

```

---

$c_0$  语言文件 test.c 的输出

---

```

<?xml version="1.0"?>
<root>
  <token line="1" type="VOID" string="void" />
  <token line="1" type="ID" string="main" />
  <token line="1" type="LPAREN" string="(" />
  <token line="1" type="RPAREN" string=")" />
  <token line="2" type="LBRACE" string="{ " />
  <token line="3" type="INT" string="int" />
  <token line="3" type="ID" string="sum1" />
  <token line="3" type="ASSIGN" string="=" />
  <token line="3" type="NUMBER" string="100" />
  <token line="3" type="SEMI" string=";" />
  <token line="4" type="INT" string="int" />
  <token line="4" type="ID" string="a" />
  <token line="4" type="SEMI" string=";" />
  <token line="5" type="INT" string="int" />
  <token line="5" type="ID" string="b" />
  <token line="5" type="SEMI" string=";" />
  <token line="6" type="IF" string="if" />
  <token line="6" type="LPAREN" string="(" />
  <token line="6" type="NUMBER" string="1" />
  <token line="6" type="EQ" string="==" />
  <token line="6" type="NUMBER" string="1" />
  <token line="6" type="PLUS" string="+" />
  <token line="6" type="NUMBER" string="0" />

```



```

<token line="6" type="RPAREN" string=")" />
<token line="6" type="LBRACE" string="{" />
<token line="7" type="ID" string="a" />
<token line="7" type="ASSIGN" string="=" />
<token line="7" type="NUMBER" string="3" />
<token line="7" type="SEMI" string=";" />
<token line="8" type="RBRACE" string="}" />
<token line="9" type="ELSE" string="else" />
<token line="9" type="LBRACE" string="{" />
<token line="10" type="ID" string="b" />
<token line="10" type="ASSIGN" string="=" />
<token line="10" type="NUMBER" string="5" />
<token line="10" type="SEMI" string=";" />
<token line="11" type="RBRACE" string="}" />
<token line="12" type="RBRACE" string="}" />
</root>

```

---

$c_0$  语言文件 test2.c

---

```

int foo(int a,int b){
    return a+b;
}
void bar(int a){
    if (a==0){
        exit(-1);
    }
    else{
        exit(0);
    }
}
void main(){
    int yylineno;
    int t;
    int yytext;
    t = foo(3,4);
    bar(t);
}

```

---

$c_0$  语言文件 test2.c的输出

---

```

<?xml version="1.0"?>
<root>
  <token line="1" type="INT" string="int" />
  <token line="1" type="ID" string="foo" />
  <token line="1" type="LPAREN" string="(" />
  <token line="1" type="INT" string="int" />
  <token line="1" type="ID" string="a" />
  <token line="1" type="COMMA" string="," />
  <token line="1" type="INT" string="int" />
  <token line="1" type="ID" string="b" />

```

```

<token line="1" type="RPAREN" string=")" />
<token line="1" type="LBRACE" string="{" />
<token line="2" type="RETURN" string="return" />
<token line="2" type="ID" string="a" />
<token line="2" type="PLUS" string="+" />
<token line="2" type="ID" string="b" />
<token line="2" type="SEMI" string=";" />
<token line="3" type="RBRACE" string="}" />
<token line="4" type="VOID" string="void" />
<token line="4" type="ID" string="bar" />
<token line="4" type="LPAREN" string="(" />
<token line="4" type="INT" string="int" />
<token line="4" type="ID" string="a" />
<token line="4" type="RPAREN" string=")" />
<token line="4" type="LBRACE" string="{" />
<token line="5" type="IF" string="if" />
<token line="5" type="LPAREN" string="(" />
<token line="5" type="ID" string="a" />
<token line="5" type="EQ" string="==" />
<token line="5" type="NUMBER" string="0" />
<token line="5" type="RPAREN" string=")" />
<token line="5" type="LBRACE" string="{" />
<token line="6" type="ID" string="exit" />
<token line="6" type="LPAREN" string="(" />
<token line="6" type="MINUS" string="-" />
<token line="6" type="NUMBER" string="1" />
<token line="6" type="RPAREN" string=")" />
<token line="6" type="SEMI" string=";" />
<token line="7" type="RBRACE" string="}" />
<token line="8" type="ELSE" string="else" />
<token line="8" type="LBRACE" string="{" />
<token line="9" type="ID" string="exit" />
<token line="9" type="LPAREN" string="(" />
<token line="9" type="NUMBER" string="0" />
<token line="9" type="RPAREN" string=")" />
<token line="9" type="SEMI" string=";" />
<token line="10" type="RBRACE" string="}" />
<token line="11" type="RBRACE" string="}" />
<token line="12" type="VOID" string="void" />
<token line="12" type="ID" string="main" />
<token line="12" type="LPAREN" string="(" />
<token line="12" type="RPAREN" string=")" />
<token line="12" type="LBRACE" string="{" />
<token line="13" type="INT" string="int" />
<token line="13" type="ID" string="yylineno" />
<token line="13" type="SEMI" string=";" />
<token line="14" type="INT" string="int" />
<token line="14" type="ID" string="t" />
<token line="14" type="SEMI" string=";" />
<token line="15" type="INT" string="int" />

```

```

<token line="15" type="ID" string="yytext" />
<token line="15" type="SEMI" string=";" />
<token line="16" type="ID" string="t" />
<token line="16" type="ASSIGN" string="=" />
<token line="16" type="ID" string="foo" />
<token line="16" type="LPAREN" string="(" />
<token line="16" type="NUMBER" string="3" />
<token line="16" type="COMMA" string="," />
<token line="16" type="NUMBER" string="4" />
<token line="16" type="RPAREN" string=")" />
<token line="16" type="SEMI" string=";" />
<token line="17" type="ID" string="bar" />
<token line="17" type="LPAREN" string="(" />
<token line="17" type="ID" string="t" />
<token line="17" type="RPAREN" string=")" />
<token line="17" type="SEMI" string=";" />
<token line="18" type="RBRACE" string="}" />
</root>

```

---

$c_0$  语言文件 testlex.c

---

```

void f1(int a,int b) {
    a = 1;
    b = a+b;
}
void main()
{
    int a[100];
    int b;
    float c;
    a[b]=a;
    if(c<b){
        f1(a,b);
    }
}

```

---

$c_0$  语言文件 testlex.c的输出

---

```

<?xml version="1.0"?>
<root>
  <token line="1" type="VOID" string="void" />
  <token line="1" type="ID" string="f1" />
  <token line="1" type="LPAREN" string="(" />
  <token line="1" type="INT" string="int" />
  <token line="1" type="ID" string="a" />
  <token line="1" type="COMMA" string="," />
  <token line="1" type="INT" string="int" />
  <token line="1" type="ID" string="b" />
  <token line="1" type="RPAREN" string=")" />
  <token line="1" type="LBRACE" string="{" />

```

```

<token line="2" type="ID" string="a" />
<token line="2" type="ASSIGN" string="=" />
<token line="2" type="NUMBER" string="1" />
<token line="2" type="SEMI" string=";" />
<token line="3" type="ID" string="b" />
<token line="3" type="ASSIGN" string="=" />
<token line="3" type="ID" string="a" />
<token line="3" type="PLUS" string="+" />
<token line="3" type="ID" string="b" />
<token line="3" type="SEMI" string=";" />
<token line="4" type="RBRACE" string="}" />
<token line="5" type="VOID" string="void" />
<token line="5" type="ID" string="main" />
<token line="5" type="LPAREN" string="(" />
<token line="5" type="RPAREN" string=")" />
<token line="6" type="LBRACE" string="{" />
<token line="7" type="INT" string="int" />
<token line="7" type="ID" string="a" />
<token line="7" type="LSQUAR" string="[" />
<token line="7" type="NUMBER" string="100" />
<token line="7" type="RSQUAR" string="]" />
<token line="7" type="SEMI" string=";" />
<token line="8" type="INT" string="int" />
<token line="8" type="ID" string="b" />
<token line="8" type="SEMI" string=";" />
<token line="9" type="FLOAT" string="float" />
<token line="9" type="ID" string="c" />
<token line="9" type="SEMI" string=";" />
<token line="10" type="ID" string="a" />
<token line="10" type="LSQUAR" string="[" />
<token line="10" type="ID" string="b" />
<token line="10" type="RSQUAR" string="]" />
<token line="10" type="ASSIGN" string="=" />
<token line="10" type="ID" string="a" />
<token line="10" type="SEMI" string=";" />
<token line="11" type="IF" string="if" />
<token line="11" type="LPAREN" string="(" />
<token line="11" type="ID" string="c" />
<token line="11" type="LT" string="<" />
<token line="11" type="ID" string="b" />
<token line="11" type="RPAREN" string=")" />
<token line="11" type="LBRACE" string="{" />
<token line="12" type="ID" string="f1" />
<token line="12" type="LPAREN" string="(" />
<token line="12" type="ID" string="a" />
<token line="12" type="COMMA" string="," />
<token line="12" type="ID" string="b" />
<token line="12" type="RPAREN" string=")" />
<token line="12" type="SEMI" string=";" />
<token line="13" type="RBRACE" string="}" />

```

```
<token line="14" type="RBRACE" string="}" />
</root>
```

---

c<sub>0</sub> 语言文件 testparser.c

---

```
int a;
int b;
int d,e,f;

void main()
{
    int a=0;
    int b=2;
    while(a==b)
        ++a;
}
```

---

c<sub>0</sub> 语言文件 testparser.c的输出

---

```
<?xml version="1.0"?>
<root>
  <token line="1" type="INT" string="int" />
  <token line="1" type="ID" string="a" />
  <token line="1" type="SEMI" string=";" />
  <token line="2" type="INT" string="int" />
  <token line="2" type="ID" string="b" />
  <token line="2" type="SEMI" string=";" />
  <token line="3" type="INT" string="int" />
  <token line="3" type="ID" string="d" />
  <token line="3" type="COMMA" string="," />
  <token line="3" type="ID" string="e" />
  <token line="3" type="COMMA" string="," />
  <token line="3" type="ID" string="f" />
  <token line="3" type="SEMI" string=";" />
  <token line="5" type="VOID" string="void" />
  <token line="5" type="ID" string="main" />
  <token line="5" type="LPAREN" string="(" />
  <token line="5" type="RPAREN" string=")" />
  <token line="6" type="LBRACE" string="{" />
  <token line="7" type="INT" string="int" />
  <token line="7" type="ID" string="a" />
  <token line="7" type="ASSIGN" string="=" />
  <token line="7" type="NUMBER" string="0" />
  <token line="7" type="SEMI" string=";" />
  <token line="8" type="INT" string="int" />
  <token line="8" type="ID" string="b" />
  <token line="8" type="ASSIGN" string="=" />
  <token line="8" type="NUMBER" string="2" />
  <token line="8" type="SEMI" string=";" />
  <token line="9" type="WHILE" string="while" />
```

```
<token line="9" type="LPAREN" string="(" />
<token line="9" type="ID" string="a" />
<token line="9" type="EQ" string="==" />
<token line="9" type="ID" string="b" />
<token line="9" type="RPAREN" string=")" />
<token line="10" type="INC_OP" string="++" />
<token line="10" type="ID" string="a" />
<token line="10" type="SEMI" string=";" />
<token line="11" type="RBRACE" string="}" />
</root>
```

---

## C yacc code

yacc 文件: q2.y

---

```
%{

//#include "y.tab.h"
#include <ctype.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <stdarg.h>

//typedef char* string;
//#define YYSTYPE string
#define STR(VAR) (#VAR)
#define release 1
#define MAXCHILD 10

extern void yyerror(const char *); /* prints grammar violation message */
extern int yylex(void);
extern FILE *yyin;
extern FILE *yyout;
extern int yylineno;

char* tab=" ";
char indent[100]="";

char* integer="INT";
char* floating="float";
char* none = "none";
char* assign = "=";

void incIndent(){
    strcat(indent, tab);
}
void decIndent(){
    int len = strlen(indent);
    indent[len-2]='\0';
}

struct treeNode{
    struct treeNode *child[MAXCHILD];
    char* nodeType;
    char* string;
    char* value;
    char* dataType;
    int lineNo;
    int Nchildren;
};
```

```

void printNode(struct treeNode* node){
    printf("%s<Tree lineNo=\"%d\" nodeType=\"%s\" string=\"%s\"
        value=\"%s\" dataType=\"%s\">\n",
        indent,
        node->lineNo,
        node->nodeType,
        node->string,
        node->value,
        node->dataType);
    int i;
    if (node->Nchildren > 0){
        printf("%s<Child>\n", indent);
        incIndent();
        for (i=0;i<node->Nchildren;i++){
            printNode(node->child[i]);
        }
        decIndent();
        printf("%s</Child>\n", indent);
    }
    printf("%s</Tree>\n", indent);
}

struct treeNode * newnode(int lineNo, char* nodeType, char* string,
    char* value, char* dataType, int Nchildren, ...){
    struct treeNode * node = (struct treeNode*) malloc(sizeof(struct
        treeNode));
    node->nodeType = nodeType;
    node->string = string;
    node->value = value;
    node->dataType = dataType;
    node->lineNo = lineNo;
    node->Nchildren = Nchildren;
    va_list ap;
    int i;
    va_start(ap, Nchildren);
    for (i=0;i<Nchildren;i++){
        node->child[i]=va_arg(ap, struct treeNode *);
    }
    va_end(ap);
    return node;
}
%}
%code requires {

}

%union {
    char* str;
    struct treeNode * ast;
}

```



```

%token IF ELSE WHILE RETURN VOID INT FLOAT
%token INC_OP DEC_OP PLUS MINUS STAR SLASH LT LTEQ GT GTEQ EQ NEQ ASSIGN
%token SEMI COMMA LPAREN RPAREN LSQUAR RSQUAR LBRACE RBRACE LCOMMENT
      RCOMMENT
%token <str> ID NUM
%token LETTER DIGIT
%token NONTOKEN ERROR ENDFILE

%left PLUS MINUS
%left STAR SLASH

%type<ast> atree program external_declaration var_declaration
      init_declarator_list fun_declaration params_list compound_stmt
      declarator params block_item_list block_item factor call term
      additive_expression simple_expression unary_expression
      postfix_expression assignment_expression return_stmt while_stmt
      if_stmt expression statement args expression_stmt
%type<str> relop declaration_specifiers

%start atree
%%

atree:program {printNode($1);}

program
: external_declaration {$$=$1;}
| program external_declaration {$$=newnode(yylineno, STR(program),
      none, none, none, 2, $1, $2); }
;

external_declaration
: var_declaration {$$=$1;}
| fun_declaration {$$=$1;}
;

var_declaration
: declaration_specifiers init_declarator_list SEMI
{$$=newnode(yylineno, "var_declaration", none, none, $1, 1, $2); }
;

init_declarator_list
: ID {$$ = newnode(yylineno, "init_declarator_list", $1, none, none,
      0);}
| ID ASSIGN expression {$$ =
      newnode(yylineno, "init_declarator_list", $1, none, none, 1, $3);}
| init_declarator_list COMMA ID {$$ =
      newnode(yylineno, "init_declarator_list", $3, none, none, 1, $1);}
;

```

```

declarator
: LPAREN RPAREN {$$ = newnode(yylineno,"declarator", none, none,
    none, 0);}
| LPAREN params RPAREN {$$ = newnode(yylineno,"declarator", none,
    none, none, 1, $2);}
;

fun_declaration
: declaration_specifiers ID declarator compound_stmt
  {$$=newnode(yylineno,STR(fun_declaration), $2, none, $1, 1, $4);}
;

declaration_specifiers
: INT {$$=integer;}
| VOID {$$="VOID";}
| FLOAT {$$="VOID";}
;

params_list
: INT ID {$$ = newnode(yylineno,"params_list", $2, none, integer,
    0);}
| FLOAT ID {$$ = newnode(yylineno,"params_list", $2, none, floating,
    0);}
| params_list COMMA INT ID {$$ = newnode(yylineno,"params_list", $4,
    none, integer, 1, $1);}
| params_list COMMA FLOAT ID {$$ = newnode(yylineno,"params_list",
    $4, none, floating, 1, $1);}
;

params
: params_list {$$=$1;}
| VOID {$$ = newnode(yylineno,"params", none, none, "VOID", 0);}
;

compound_stmt
: LBRACE RBRACE {$$ = newnode(yylineno,"compound_stmt", none, none,
    none, 0);}
| LBRACE block_item_list RBRACE {$$ = $2;}
;

block_item_list
: block_item {$$ = $1;}
| block_item_list block_item {$$ =
    newnode(yylineno,"block_item_list", none, none, none, 2, $1,
    $2);}
;

block_item
: var_declaration {$$=$1;}
| statement {$$=$1;}

```

```

;

statement
: expression_stmt {$$=$1;}
| compound_stmt {$$=$1;}
| if_stmt {$$=$1;}
| while_stmt {$$=$1;}
| return_stmt {$$=$1;}
;

expression_stmt
: SEMI {$$ = newnode(yylineno,"expression_stmt", none, none, none,
0);}
| expression SEMI {$$=$1;}
;

if_stmt
: IF LPAREN expression RPAREN statement ELSE statement {$$ =
newnode(yylineno,"if_stmt", none, none, none, 3, $3, $5, $7);}
| IF LPAREN expression RPAREN statement {$$ =
newnode(yylineno,"if_stmt", none, none, none, 2, $3, $5);}
;

while_stmt
: WHILE LPAREN expression RPAREN statement {$$ =
newnode(yylineno,"while_stmt", none, none, none, 2, $3, $5);}
;

return_stmt
: RETURN SEMI {$$ = newnode(yylineno,"return_stmt", none, none,
none, 0);}
| RETURN expression SEMI {$$ = newnode(yylineno,"return_stmt", none,
none, none, 1, $2);}
;

expression
: assignment_expression {$$=$1;}
| simple_expression {$$=$1;}
;

assignment_expression
: ID ASSIGN expression {$$ =
newnode(yylineno,"assignment_expression", $1, none, none, 1,
$3);}
| unary_expression {$$=$1;} ;

unary_expression
: INC_OP ID {$$ = newnode(yylineno,"unary_expression", $2, none,
"++", 0);}
| DEC_OP ID {$$ = newnode(yylineno,"unary_expression", $2, none,

```

```

        "--", 0);}
    | postfix_expression {$$=$1;}
    ;

postfix_expression
: ID INC_OP {$$ = newnode(yylineno,"postfix_expression", $1, none,
    "+", 0);}
| ID DEC_OP {$$ = newnode(yylineno,"postfix_expression", $1, none,
    "--", 0);}
;

simple_expression
: additive_expression {$$=$1;}
| additive_expression relop additive_expression {$$ =
    newnode(yylineno,"simple_expression", none, none, $2, 2, $1,
    $3);}
;

relop
: LT {$$ = "<";}
| LTEQ {$$ = "<=";}
| GT {$$ = ">";}
| GTEQ {$$ = ">=";}
| EQ {$$ = "==";}
| NEQ {$$ = "!=";}
;

additive_expression
: term {$$=$1;}
| additive_expression PLUS term {$$ =
    newnode(yylineno,"additive_expression", none, none, "+", 2, $1,
    $3);}
| additive_expression MINUS term {$$ =
    newnode(yylineno,"additive_expression", none, none, "-", 2, $1,
    $3);}
| PLUS additive_expression %prec STAR {$$ =
    newnode(yylineno,"additive_expression", none, none, "+", 1, $2);}
| MINUS additive_expression %prec STAR {$$ =
    newnode(yylineno,"additive_expression", none, none, "-", 1, $2);}
;

term
: factor {$$=$1;}
| term STAR factor {$$ = newnode(yylineno,"term", none, none, "*",
    2, $1, $3);}
| term SLASH factor {$$ = newnode(yylineno,"term", none, none, "/",
    2, $1, $3);}
;

factor

```

```

: LPAREN expression RPAREN {$$=$2;}
| ID {$$ = newnode(yylineno,"factor", $1, none, none, 0);}
| call {$$=$1;}
| NUM {$$ = newnode(yylineno,"factor", none, $1, none, 0);}
;

call
: ID LPAREN RPAREN {$$ = newnode(yylineno,"call", $1, none, none,
    0);}
| ID LPAREN args RPAREN {$$ = newnode(yylineno,"call", $1, none,
    none, 1, $3);}
;

args
: expression {$$=$1;}
| expression COMMA args {$$ = newnode(yylineno,"args", none, none,
    none, 2, $1, $3);}
;

%%
#include <stdio.h>
main(argc, argv)
int argc;
char** argv;
{
if (argc > 1)
{
FILE *file;
file = fopen(argv[1], "r");
if (!file)
{
fprintf(stderr, "failed open");
exit(1);
}
yyin=file;
//printf("success open %s\n", argv[1]);
}
else
{
printf("no input file\n");
exit(1);
}
printf("<?xml version=\"1.0\"?>\n<root>\n");
yyparse();
printf("</root>\n");
return 0;
}

void yyerror(const char *s)
{

```

```

    fflush(stdout);
    fprintf(stderr, "*** %s\n", s);
}

```

---

yacc文件对应的lex文件: q2.l

---

```

%e 1019
%p 2807
%n 371
%k 284
%a 1213
%o 1117

```

```

D [0-9]
NZ [1-9]
L [a-zA-Z_]
A [a-zA-Z_0-9]
WS [ \t\v\n\f]

```

```
%option yylineno
```

```

%{
#define ifprint 0

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include "y.tab.h"
//extern char* yylval;

extern void yyerror(const char *); /* prints grammar violation message */
extern int sym_type(const char *); /* returns type from symbol table */

#define sym_type(identifier) IDENTIFIER /* with no symbol table, fake it
*/

static void comment(void);

//if (ifprint) {ECHO;fprintf(yyout, " ");}
%}

%%
/*"                                { comment(); }
//".*                             { /* consume //-comment */ }

"if"                             {if (ifprint) {ECHO;fprintf(yyout, " ");}; return(IF); }
"else"                           {if (ifprint) {ECHO;fprintf(yyout, " ");};

```

```

        return(ELSE); }
"while"      {if (ifprint) {ECHO;fprintf(yyout, " ");};
              return(WHILE); }
"return"     {if (ifprint) {ECHO;fprintf(yyout, " ");};
              return(RETURN); }
"void"       {yyval.str = strdup(yytext);
              return(VOID); }
"int"        {yyval.str = strdup(yytext);
              return(INT); }
"float"      {yyval.str = strdup(yytext);
              return(FLOAT); }

"++"         {if (ifprint) {ECHO;fprintf(yyout, " ");}; return INC_OP; }
"--"         {if (ifprint) {ECHO;fprintf(yyout, " ");}; return DEC_OP; }
"+"          {if (ifprint) {ECHO;fprintf(yyout, " ");}; return PLUS; }
"-"          {if (ifprint) {ECHO;fprintf(yyout, " ");}; return MINUS; }
"*"          {if (ifprint) {ECHO;fprintf(yyout, " ");}; return STAR; }
"/"          {if (ifprint) {ECHO;fprintf(yyout, " ");}; return SLASH; }
"<"          {if (ifprint) {ECHO;fprintf(yyout, " ");}; return LT; }
"<="        {if (ifprint) {ECHO;fprintf(yyout, " ");}; return LTEQ; }
">"          {if (ifprint) {ECHO;fprintf(yyout, " ");}; return GT; }
">="        {if (ifprint) {ECHO;fprintf(yyout, " ");}; return GTEQ; }
"=="         {if (ifprint) {ECHO;fprintf(yyout, " ");}; return EQ; }
"!="         {if (ifprint) {ECHO;fprintf(yyout, " ");}; return NEQ; }
"="          {if (ifprint) {ECHO;fprintf(yyout, " ");}; return ASSIGN; }

("[")        {if (ifprint) {ECHO;fprintf(yyout, " ");}; return LSQUAR; }
("]")        {if (ifprint) {ECHO;fprintf(yyout, " ");}; return RSQUAR; }
("{")        {if (ifprint) {ECHO;fprintf(yyout, " ");}; return LBRACE; }
("}")        {if (ifprint) {ECHO;fprintf(yyout, " ");}; return RBRACE; }
";"          {if (ifprint) {ECHO;fprintf(yyout, " ");}; return SEMI; }
","          {if (ifprint) {ECHO;fprintf(yyout, " ");}; return COMMA; }
"("          {if (ifprint) {ECHO;fprintf(yyout, " ");}; return LPAREN; }
")"          {if (ifprint) {ECHO;fprintf(yyout, " ");}; return RPAREN; }

{L}{A}*      { yyval.str = strdup(yytext); return ID; }
{D}+         {if (ifprint) {ECHO;fprintf(yyout, " ");};yyval.str =
              strdup(yytext); return NUM; }

{WS}+        {if (ifprint) {ECHO;fprintf(yyout, " ");}; /*
              whitespace separates tokens */ }
.            {if (ifprint) {ECHO;fprintf(yyout, " ");}; /* discard bad
              characters */ }

%%

int yywrap(void) /* called at end of input */
{
    return 1;     /* terminate now */
}

```

```
}

static void comment(void)
{
    int c;

    while ((c = input()) != 0)
        if (c == '/*')
        {
            while ((c = input()) == '/*')
                ;

            if (c == '/')
                return;

            if (c == 0)
                break;
        }
    yyerror("unterminated comment");
}
```

---



## D yacc results

c<sub>0</sub> 语言文件 orig.c

---

```
void main()
{
    int a=0;
    int b=2;
    while(a==b)
        ++a;
}
```

---

c<sub>0</sub> 语言文件 orig.c的输出

---

```
<?xml version="1.0"?>
<root>
  <Tree dataType="VOID" lineNo="7" nodeType="fun_declaration"
    string="main" value="none">
    <Child>
      <Tree dataType="none" lineNo="6" nodeType="block_item_list"
        string="none" value="none">
        <Child>
          <Tree dataType="none" lineNo="4" nodeType="block_item_list"
            string="none" value="none">
            <Child>
              <Tree dataType="INT" lineNo="3" nodeType="var_declaration"
                string="none" value="none">
                <Child>
                  <Tree dataType="none" lineNo="3"
                    nodeType="init_declarator_list" string="a"
                    value="none">
                    <Child>
                      <Tree dataType="none" lineNo="3" nodeType="factor"
                        string="none" value="0"></Tree>
                    </Child>
                  </Tree>
                </Child>
              <Tree dataType="INT" lineNo="4" nodeType="var_declaration"
                string="none" value="none">
                <Child>
                  <Tree dataType="none" lineNo="4"
                    nodeType="init_declarator_list" string="b"
                    value="none">
                    <Child>
                      <Tree dataType="none" lineNo="4" nodeType="factor"
                        string="none" value="2"></Tree>
                    </Child>
                  </Tree>
                </Child>
              </Tree>
            </Child>
          </Tree>
        </Child>
      </Tree>
    </Child>
  </Tree>
</root>
```

```

    </Tree>
  </Child>
</Tree>
<Tree dataType="none" lineNo="6" nodeType="while_stmt"
  string="none" value="none">
  <Child>
    <Tree dataType="==" lineNo="5" nodeType="simple_expression"
      string="none" value="none">
      <Child>
        <Tree dataType="none" lineNo="5" nodeType="factor"
          string="a" value="none"></Tree>
        <Tree dataType="none" lineNo="5" nodeType="factor"
          string="b" value="none"></Tree>
      </Child>
    </Tree>
    <Tree dataType="++" lineNo="6" nodeType="unary_expression"
      string="a" value="none"></Tree>
  </Child>
</Tree>
</Child>
</Tree>
</Child>
</Tree>
</root>

```

---

$c_0$  语言文件 simple.c

---

```
int a=0;
```

---

$c_0$  语言文件 simple.c 的输出

---

```

<?xml version="1.0"?>
<root>
  <Tree dataType="INT" lineNo="1" nodeType="var_declaration"
    string="none" value="none">
    <Child>
      <Tree dataType="none" lineNo="1" nodeType="init_declarator_list"
        string="a" value="none">
        <Child>
          <Tree dataType="none" lineNo="1" nodeType="factor"
            string="none" value="0"></Tree>
        </Child>
      </Tree>
    </Child>
  </Tree>
</root>

```

---

$c_0$  语言文件 test.c

---

```

void main()
{
    int sum1=100;
    int a;
    int b;
    if (1 == 1+0){
        a=3;
    }
    else {
        b=5;
    }
}

```

---

c<sub>0</sub> 语言文件 test.c的输出

---

```

<?xml version="1.0"?>
<root>
  <Tree dataType="VOID" lineNo="12" nodeType="fun_declaration"
    string="main" value="none">
    <Child>
      <Tree dataType="none" lineNo="11" nodeType="block_item_list"
        string="none" value="none">
        <Child>
          <Tree dataType="none" lineNo="5" nodeType="block_item_list"
            string="none" value="none">
            <Child>
              <Tree dataType="none" lineNo="4" nodeType="block_item_list"
                string="none" value="none">
                <Child>
                  <Tree dataType="INT" lineNo="3"
                    nodeType="var_declaration" string="none"
                    value="none">
                    <Child>
                      <Tree dataType="none" lineNo="3"
                        nodeType="init_declarator_list" string="sum1"
                        value="none">
                        <Child>
                          <Tree dataType="none" lineNo="3"
                            nodeType="factor" string="none"
                            value="100"></Tree>
                        </Child>
                      </Tree>
                    </Tree>
                  </Tree>
                </Tree>
              <Tree dataType="INT" lineNo="4"
                nodeType="var_declaration" string="none"
                value="none">
                <Child>
                  <Tree dataType="none" lineNo="4"
                    nodeType="init_declarator_list" string="a"

```

```

        value="none"></Tree>
    </Child>
</Tree>
</Child>
</Tree>
<Tree dataType="INT" lineNo="5" nodeType="var_declaration"
    string="none" value="none">
    <Child>
        <Tree dataType="none" lineNo="5"
            nodeType="init_declarator_list" string="b"
            value="none"></Tree>
    </Child>
</Tree>
</Child>
</Tree>
<Tree dataType="none" lineNo="11" nodeType="if_stmt"
    string="none" value="none">
    <Child>
        <Tree dataType="==" lineNo="6" nodeType="simple_expression"
            string="none" value="none">
            <Child>
                <Tree dataType="none" lineNo="6" nodeType="factor"
                    string="none" value="1"></Tree>
                <Tree dataType="+" lineNo="6"
                    nodeType="additive_expression" string="none"
                    value="none">
                    <Child>
                        <Tree dataType="none" lineNo="6" nodeType="factor"
                            string="none" value="1"></Tree>
                        <Tree dataType="none" lineNo="6" nodeType="factor"
                            string="none" value="0"></Tree>
                    </Child>
                </Tree>
            </Child>
        </Tree>
    </Child>
</Tree>
<Tree dataType="none" lineNo="7"
    nodeType="assignment_expression" string="a"
    value="none">
    <Child>
        <Tree dataType="none" lineNo="7" nodeType="factor"
            string="none" value="3"></Tree>
    </Child>
</Tree>
<Tree dataType="none" lineNo="10"
    nodeType="assignment_expression" string="b"
    value="none">
    <Child>
        <Tree dataType="none" lineNo="10" nodeType="factor"
            string="none" value="5"></Tree>
    </Child>

```

```

        </Tree>
      </Child>
    </Tree>
  </Child>
</Tree>
</root>

```

---

$c_0$  语言文件 test2.c

---

```

int foo(int a,int b){
    return a+b;
}
void bar(int a){
    if (a==0){
        exit(-1);
    }
    else{
        exit(0);
    }
}
void main(){
    int yylineno;
    int t;
    int yytext;
    t = foo(3,4);
    bar(t);
}

```

---

$c_0$  语言文件 test2.c的输出

---

```

<?xml version="1.0"?>
<root>
  <Tree dataType="none" lineNo="18" nodeType="program" string="none"
    value="none">
    <Child>
      <Tree dataType="none" lineNo="11" nodeType="program" string="none"
        value="none">
        <Child>
          <Tree dataType="INT" lineNo="3" nodeType="fun_declaration"
            string="foo" value="none">
            <Child>
              <Tree dataType="none" lineNo="2" nodeType="return_stmt"
                string="none" value="none">
                <Child>
                  <Tree dataType="+" lineNo="2"
                    nodeType="additive_expression" string="none"
                    value="none">
                    <Child>

```

```

        <Tree dataType="none" lineNo="2" nodeType="factor"
            string="a" value="none"></Tree>
        <Tree dataType="none" lineNo="2" nodeType="factor"
            string="b" value="none"></Tree>
    </Child>
</Tree>
</Child>
</Tree>
</Child>
</Tree>
<Tree dataType="VOID" lineNo="11" nodeType="fun_declaration"
    string="bar" value="none">
    <Child>
        <Tree dataType="none" lineNo="10" nodeType="if_stmt"
            string="none" value="none">
            <Child>
                <Tree dataType="==" lineNo="5"
                    nodeType="simple_expression" string="none"
                    value="none">
                    <Child>
                        <Tree dataType="none" lineNo="5" nodeType="factor"
                            string="a" value="none"></Tree>
                        <Tree dataType="none" lineNo="5" nodeType="factor"
                            string="none" value="0"></Tree>
                    </Child>
                </Tree>
            <Tree dataType="none" lineNo="6" nodeType="call"
                string="exit" value="none">
                <Child>
                    <Tree dataType="-" lineNo="6"
                        nodeType="additive_expression" string="none"
                        value="none">
                        <Child>
                            <Tree dataType="none" lineNo="6"
                                nodeType="factor" string="none"
                                value="1"></Tree>
                        </Child>
                    </Tree>
                </Child>
            </Tree>
        </Child>
    </Tree>
    <Tree dataType="none" lineNo="9" nodeType="call"
        string="exit" value="none">
        <Child>
            <Tree dataType="none" lineNo="9" nodeType="factor"
                string="none" value="0"></Tree>
        </Child>
    </Tree>
</Child>
</Tree>

```

```

    </Tree>
  </Child>
</Tree>
<Tree dataType="VOID" lineNo="18" nodeType="fun_declaration"
  string="main" value="none">
  <Child>
    <Tree dataType="none" lineNo="17" nodeType="block_item_list"
      string="none" value="none">
      <Child>
        <Tree dataType="none" lineNo="16"
          nodeType="block_item_list" string="none" value="none">
          <Child>
            <Tree dataType="none" lineNo="15"
              nodeType="block_item_list" string="none"
              value="none">
              <Child>
                <Tree dataType="none" lineNo="14"
                  nodeType="block_item_list" string="none"
                  value="none">
                  <Child>
                    <Tree dataType="INT" lineNo="13"
                      nodeType="var_declaration" string="none"
                      value="none">
                      <Child>
                        <Tree dataType="none" lineNo="13"
                          nodeType="init_declarator_list"
                          string="yylineno" value="none"></Tree>
                      </Child>
                    </Tree>
                  </Tree>
                <Tree dataType="INT" lineNo="14"
                  nodeType="var_declaration" string="none"
                  value="none">
                  <Child>
                    <Tree dataType="none" lineNo="14"
                      nodeType="init_declarator_list"
                      string="t" value="none"></Tree>
                  </Child>
                </Tree>
              </Child>
            </Tree>
          </Child>
        </Tree>
      </Child>
    </Tree>
  <Tree dataType="INT" lineNo="15"
    nodeType="var_declaration" string="none"
    value="none">
    <Child>
      <Tree dataType="none" lineNo="15"
        nodeType="init_declarator_list"
        string="yytext" value="none"></Tree>
    </Child>
  </Tree>
</Child>

```

```

</Tree>
<Tree dataType="none" lineNo="16"
  nodeType="assignment_expression" string="t"
  value="none">
  <Child>
    <Tree dataType="none" lineNo="16" nodeType="call"
      string="foo" value="none">
      <Child>
        <Tree dataType="none" lineNo="16"
          nodeType="args" string="none" value="none">
          <Child>
            <Tree dataType="none" lineNo="16"
              nodeType="factor" string="none"
              value="3"></Tree>
            <Tree dataType="none" lineNo="16"
              nodeType="factor" string="none"
              value="4"></Tree>
          </Child>
        </Tree>
      </Child>
    </Tree>
  </Child>
</Tree>
</Child>
</Tree>
</Child>
</Tree>
</Child>
</Tree>
</Child>
</Tree>
</Child>
</Tree>
</Child>
</Tree>
</Child>
</Tree>
</root>

```

---

c<sub>0</sub> 语言文件 testlex.c

---

```

void f1(int a,int b) {
  a = 1;
  b = a+b;
}
void main()
{
  int a[100];
  int b;

```



```

float c;
a[b]=a;
if(c<b){
    fl(a,b);
}
}

```

---

$c_0$  语言文件 testlex.c的输出

---

```

<?xml version="1.0"?>
<root></root>

```

---

$c_0$  语言文件 testparser.c

---

```

int a;
int b;
int d,e,f;

void main()
{
    int a=0;
    int b=2;
    while(a==b)
        ++a;
}

```

---

$c_0$  语言文件 testparser.c的输出

---

```

<?xml version="1.0"?>
<root>
  <Tree dataType="none" lineNo="11" nodeType="program" string="none"
    value="none">
    <Child>
      <Tree dataType="none" lineNo="3" nodeType="program" string="none"
        value="none">
        <Child>
          <Tree dataType="none" lineNo="2" nodeType="program"
            string="none" value="none">
            <Child>
              <Tree dataType="INT" lineNo="1" nodeType="var_declaration"
                string="none" value="none">
                <Child>
                  <Tree dataType="none" lineNo="1"
                    nodeType="init_declarator_list" string="a"
                    value="none"></Tree>
                </Child>
              </Tree>
            </Child>
          </Tree>
        <Tree dataType="INT" lineNo="2" nodeType="var_declaration"
          string="none" value="none">

```

```

    <Child>
      <Tree dataType="none" lineNo="2"
        nodeType="init_declarator_list" string="b"
        value="none"></Tree>
    </Child>
  </Tree>
</Child>
</Tree>
<Tree dataType="INT" lineNo="3" nodeType="var_declaration"
  string="none" value="none">
  <Child>
    <Tree dataType="none" lineNo="3"
      nodeType="init_declarator_list" string="f" value="none">
      <Child>
        <Tree dataType="none" lineNo="3"
          nodeType="init_declarator_list" string="e"
          value="none">
          <Child>
            <Tree dataType="none" lineNo="3"
              nodeType="init_declarator_list" string="d"
              value="none"></Tree>
          </Child>
        </Tree>
      </Child>
    </Tree>
  </Child>
</Tree>
</Child>
</Tree>
<Tree dataType="VOID" lineNo="11" nodeType="fun_declaration"
  string="main" value="none">
  <Child>
    <Tree dataType="none" lineNo="10" nodeType="block_item_list"
      string="none" value="none">
    <Child>
      <Tree dataType="none" lineNo="8" nodeType="block_item_list"
        string="none" value="none">
      <Child>
        <Tree dataType="INT" lineNo="7"
          nodeType="var_declaration" string="none"
          value="none">
        <Child>
          <Tree dataType="none" lineNo="7"
            nodeType="init_declarator_list" string="a"
            value="none">
          <Child>
            <Tree dataType="none" lineNo="7"
              nodeType="factor" string="none"
              value="0"></Tree>
          </Child>
        </Child>
      </Child>
    </Tree>
  </Child>
</Tree>

```

```

        </Tree>
    </Child>
</Tree>
<Tree dataType="INT" lineNo="8"
    nodeType="var_declaration" string="none"
    value="none">
    <Child>
        <Tree dataType="none" lineNo="8"
            nodeType="init_declarator_list" string="b"
            value="none">
            <Child>
                <Tree dataType="none" lineNo="8"
                    nodeType="factor" string="none"
                    value="2"></Tree>
            </Child>
        </Tree>
    </Child>
</Tree>
</Child>
</Tree>
</Child>
</Tree>
<Tree dataType="none" lineNo="10" nodeType="while_stmt"
    string="none" value="none">
    <Child>
        <Tree dataType="==" lineNo="9"
            nodeType="simple_expression" string="none"
            value="none">
            <Child>
                <Tree dataType="none" lineNo="9" nodeType="factor"
                    string="a" value="none"></Tree>
                <Tree dataType="none" lineNo="9" nodeType="factor"
                    string="b" value="none"></Tree>
            </Child>
        </Tree>
        <Tree dataType="++" lineNo="10"
            nodeType="unary_expression" string="a"
            value="none"></Tree>
    </Child>
</Tree>
</Child>
</Tree>
</Child>
</Tree>
</Child>
</Tree>
</root>

```

---