说明：

实验环境：Ubuntu18.04

我的虚拟机的名字：`liuqingshuai@liuqingshuai-VirtualBox:`

实验一、配环境和HelloWorld

1.1-下载安装工具

下载flex和bison-> `sudo apt-get install flex bison`

```
liuqingshuai@liuqingshuai-VirtualBox:~$ sudo apt-get install flex bison
```

检验安装是否成功，通过查看版本

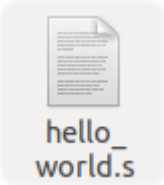
```
liuqingshuai@liuqingshuai-VirtualBox:~$ flex --version
flex 2.6.4
liuqingshuai@liuqingshuai-VirtualBox:~$ bison --version
```

1.2-编译hello_world程序

编译以后， `examples` 文件夹会多出一个 `hello_world.s` 的文件，

```
./coolc ../examples/hello_world.cl
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/bin$ ./coolc ../examples/hello_world.cl
```



`hello_world.s` 的文件里边装着MIPS汇编代码，需要在spim下运行

```
./spim -trap_file ../lib/trap.handler -file ../examples/hello_world.s
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/bin$ ./spim -trap_file ../lib/trap.
handler -file ../examples/hello_world.s
SPIM Version 6.5 of January 4, 2003
Copyright 1990-2003 by James R. Larus (larus@cs.wisc.edu).
All Rights Reserved.
See the file README for a full copyright notice.
Loaded: ../lib/trap.handler
Hello, World.
COOL program successfully executed
```

1.3-使用分析器编译cl文件

1.用标准的词法分析程序，编译一个Cool语言程序

```
./reference-lexer ../examples/hello_world.cl
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/bin$ ./reference-lexer ../examples/
hello_world.cl
#name "../examples/hello_world.cl"
#1 CLASS
#1 TYPEID Main
#1 INHERITS
#1 TYPEID IO
#1 '{'
#2 OBJECTID main
#2 '('
#2 ')'
#2 ':'
#2 TYPEID SELF_TYPE
#2 '{'
#3 OBJECTID out_string
#3 '('
#3 STR_CONST "Hello, World.\n"
#3 ')'
#4 '}'
#4 ';'
#5 '}'
#5 ';'
```

2.用标准的词法分析程序和语法分析程序，编译一个Cool语言程序(通过管道流的方式)

```
./reference-lexer ../examples/hello_world.cl|./reference-parser
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/bin$ ./reference-le
xer ../examples/hello_world.cl|./reference-parser
#5
_program
  #5
  _class
    Main
    IO
    "../examples/hello_world.cl"
    (
    #4
    _method
      main
      SELF_TYPE
      #3
      _dispatch
        #3
        _object
          self
        : _no_type
        out_string
        (
        #3
        _string
          "Hello, World.\n"
        : _no_type
        )
      : _no_type
    )
```

3.用标准的词法分析程序，语法分析程序和语义分析程序编译一个Cool语言程序

```
./reference-lexer ../examples/hello_world.cl|./reference-parser|./reference-semant
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/bin$ ./reference-le
xer ../examples/hello_world.cl|./reference-parser|./reference-semant
#5
_program
  #5
  _class
    Main
    IO
    "../examples/hello_world.cl"
    (
    #4
    _method
      main
      SELF_TYPE
      #3
      _dispatch
        #3
        _object
          self
        : SELF_TYPE
        out_string
        (
        #3
        _string
          "Hello, World.\n"
        : String
        )
      : SELF_TYPE
    )
```

4.用标准的词法分析程序，语法分析程序，语义分析程序和代码生成程序共同编译Cool语言程序，生成最终的汇编代码

```
./reference-lexer ../examples/hello_world.cl | ./reference-parser | ./reference-semant | ./reference-cgen
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/bin$ ./reference-le
xer ../examples/hello_world.cl | ./reference-parser | ./reference-semant | ./referen
ce-cgen
        .data
        .align  2
        .globl  class_nameTab
        .globl  Main_protObj
        .globl  Int_protObj
        .globl  String_protObj
        .globl  bool_const0
        .globl  bool_const1
        .globl  _int_tag
        .globl  _bool_tag
        .globl  _string_tag
_int_tag:
        .word   3
_bool_tag:
        .word   4
_string_tag:
        .word   5
        .globl  _MemMgr_INITIALIZER
_MemMgr_INITIALIZER:
        .word   _NoGC_Init
        .globl  _MemMgr_COLLECTOR
_MemMgr_COLLECTOR:
        .word   _NoGC_Collect
        .globl  _MemMgr_TEST
_MemMgr_TEST:
```

5.将得到的汇编代码输出到 `code.s` 文件中，使用输出重定向符’ >’

```
./reference-lexer ../examples/hello_world.cl | ./reference-parser | ./reference-semant | ./reference-cgen > code.s
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/bin$ ./reference-le
xer ../examples/hello_world.cl | ./reference-parser | ./reference-semant | ./referen
ce-cgen > code.s
```

发现多了一个 `code.s`

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/bin$ ls
aps2c++    coolc           jlex              reference-parser  test.cl~
aps2java   dispatch.SKEL   reference-cgen    reference-semant  xspim
code.s     java_cup        reference-lexer   spim
```

6.将生成的汇编代码在spim上运行

```
./spim -trap_file ../lib/trap.handler -file code.s
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/bin$ ./spim -trap_f
ile ../lib/trap.handler -file code.s
SPIM Version 6.5 of January 4, 2003
Copyright 1990-2003 by James R. Larus (larus@cs.wisc.edu).
All Rights Reserved.
See the file README for a full copyright notice.
Loaded: ../lib/trap.handler
Hello, World.
COOL program successfully executed
```

1.4-extra部分

add.cl：计算1到100的和

```
class Main inherits IO{
  i:Int <- 1;
  ans:Int <- 0;
  main(): SELF_TYPE{{

    while(i<=100) loop{
      ans <- ans+i;
      i <- i+1;
    }pool;
    out_string("sum from 1 to 100 is : ");

    out_int(ans).out_string("\n");

  }};
};
```

打开(O) add.cl ~/桌面/编译器实验/cool/cool/examples

```
class Main inherits IO{
  i:Int <- 1;
  ans:Int <- 0;
  main(): SELF_TYPE{{

    while(i<=100) loop{
      ans <- ans+i;
      i <- i+1;
    }pool;
    out_string("sum from 1 to 100 is : ");

    out_int(ans).out_string("\n");

  }};
};
```

编译并运行程序

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/bin$ ./coolc ..
/examples/add.cl
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/bin$ ./spim -tr
ap_file ../lib/trap.handler -file ../examples/add.s
SPIM Version 6.5 of January 4, 2003
Copyright 1990-2003 by James R. Larus (larus@cs.wisc.edu).
All Rights Reserved.
See the file README for a full copyright notice.
Loaded: ../lib/trap.handler
sum from 1 to 100 is : 5050
COOL program successfully executed
```

实验二、Cool堆栈机

2.1-修改makefile

CLASSDIR由 `~/cool/cool` 修改为 `/home/liuqingshuai/桌面/编译器实验/cool/cool`

SRC由 `demo.cl README.SKEL` 修改为 `stack.cl README.SKEL`

demo、test、run里面的demo均修改为stack

修改后如下

```
#######################################
# 编辑这里
# 把CLASSDIR设置成cool文件的位置
# 以便让Makefile通过 ${CLASSDIR}/bin 可以找到coolc
# 下面是我的电脑上cool文件夹的位置
CLASSDIR= /home/liuqingshuai/桌面/编译器实验/cool/cool
#######################################

ASSN = 1
CLASS= cs-compiler
SRC= stack.cl README.SKEL
LSRC= Makefile

CC=gcc
CFLAGS=-g

default: source compile test

.c.o:
        ${CC} ${CFLAGS} -c $<

source : lsource
        ${CLASSDIR}/etc/copy-skel ${ASSN} ${SRC}

lsource:
        ${CLASSDIR}/etc/link-shared ${ASSN} ${LSRC}

compile: demo

demo: stack.cl
        @echo create stack.s
        ${CLASSDIR}/bin/coolc stack.cl

test:   compile
        @echo test stack.s
        ${CLASSDIR}/bin/spim -trap_file ${CLASSDIR}/lib/trap.handler -file stack.s

run:    compile
        @echo run stack.s
        ${CLASSDIR}/bin/spim -trap_file ${CLASSDIR}/lib/trap.handler -file stack.s

clean :
        rm -f *.s core *~
~
-- 插入 --                                          43,19-26      全部
```

`stack.cl` 代码如下

```
class A2I {

    c2i(char : String) : Int {
  if char = "0" then 0 else
  if char = "1" then 1 else
  if char = "2" then 2 else
        if char = "3" then 3 else
        if char = "4" then 4 else
        if char = "5" then 5 else
        if char = "6" then 6 else
        if char = "7" then 7 else
        if char = "8" then 8 else
```

```
        if char = "9" then 9 else
        { abort(); 0; }  -- the 0 is needed to satisfy the typchecker
        fi fi fi fi fi fi fi fi fi fi
    };

    i2c(i : Int) : String {
if i = 0 then "0" else
if i = 1 then "1" else
if i = 2 then "2" else
if i = 3 then "3" else
if i = 4 then "4" else
if i = 5 then "5" else
if i = 6 then "6" else
if i = 7 then "7" else
if i = 8 then "8" else
if i = 9 then "9" else
{ abort(); ""; }  -- the "" is needed to satisfy the typchecker
        fi fi fi fi fi fi fi fi fi fi
    };

    a2i(s : String) : Int {
        if s.length() = 0 then 0 else
if s.substr(0,1) = "-" then ~a2i_aux(s.substr(1,s.length()-1)) else
        if s.substr(0,1) = "+" then a2i_aux(s.substr(1,s.length()-1)) else
           a2i_aux(s)
        fi fi fi
    };

    a2i_aux(s : String) : Int {
(let int : Int <- 0 in
          {
              (let j : Int <- s.length() in
            (let i : Int <- 0 in
        while i < j loop
      {
          int <- int * 10 + c2i(s.substr(i,1));
          i <- i + 1;
      }
        pool
      )
         );
              int;
      }
        )
    };

   i2a(i : Int) : String {
if i = 0 then "0" else
        if 0 < i then i2a_aux(i) else
```

```
          "-".concat(i2a_aux(i * ~1))
        fi fi
    };

    i2a_aux(i : Int) : String {
        if i = 0 then "" else
      (let next : Int <- i / 10 in
    i2a_aux(next).concat(i2c(i - next * 10))
      )
        fi
    };

};

class List inherits IO
{
  isNil() : Bool
  {
    {
      --out_string("list\n");
      true;
    }
  };

  head() : String
  {
    {
      abort();
      "";
    }
  };

  tail() : List
  {
    {
      abort();
      self;
    }
  };
  cons(i : String) : List
  {
    (new Cons).init(i, self)
  };
};

class Cons inherits List
{
  first : String;
  rest :  List;
```

```
  isNil() : Bool
  {
    {
      --out_string("cons\n");
      false;
    }
  };
  head() : String
  {
    first
  };
  tail() : List
  {
    rest
  };
  init(head : String, next : List) : List
  {
    {
      first <- head;
      rest  <- next;
      self;
    }
  };
};


class Main inherits IO
{
  stack : List;

  newline() : Object
  {
    out_string("\n")
  };

  prompt() : String
  {
    {
      out_string(">");
      in_string();
    }
  };

  display_stack(s : List) : Object
  {
    {
      --out_string("hello\n");
      if s.isNil() then out_string("")
          else
```

```
          {
            out_string(s.head());
            out_string("\n");
            display_stack(s.tail());
          }
    fi;
    }
  };

  main():Object
  {
    ( let z : A2I <- new A2I  , stack : List <- new List in
      while true loop
      ( let s : String <- prompt() in
        if s = "x" then
          abort()
        else
          if s = "d"  then
            display_stack(stack)
          else
              if s = "e"  then
              {
                if stack.isNil() then out_string("")

                else
                if stack.head() = "+" then
                  {
                    stack <- stack.tail();
                    (let a : Int <- new Int, b : Int <- new Int in
                      {
                        --out_string(stack.head());
                        a  <- z.a2i(stack.head());
                        stack <- stack.tail();
                        b  <- z.a2i(stack.head());
                        stack <- stack.tail();
                        a <- a + b;
                        --out_string(z.i2a(a));
                        stack <- stack.cons(z.i2a(a));
                      }
                    );
                  }
                else
                  if stack.head() = "s" then
                    {
                      stack <- stack.tail();
                      (let a : String <- new String , b : String <- new String in
                        {
                          a  <- stack.head();
```

```
                        stack <- stack.tail();
                        b  <- stack.head();
                        stack <- stack.tail();
                        stack <- stack.cons(a);
                        stack <- stack.cons(b);
                      }
                    );
                  }
                else
                  out_string("")
                fi
                fi
              fi;
            }
          else
            stack <- stack.cons(s)
          fi
        fi
      fi
    )
    pool
  )
 };
};
```

2.2-编译测试

先把1、+、2、s压入栈

输入d展示一下栈

输入两个e，先把s弹出，然后计算出3

输入d，此时栈只有一个3

输入x，退出了

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA1$ make
/home/liuqingshuai/桌面/编译器实验/cool/cool/etc/link-shared 1 Makefile
Makefile already exists. Skipping Makefile.
/home/liuqingshuai/桌面/编译器实验/cool/cool/etc/copy-skel 1 stack.cl README.SKEL
stack.cl already exists. Skipping stack.cl.
README.SKEL already exists. Skipping README.SKEL.
create stack.s
/home/liuqingshuai/桌面/编译器实验/cool/cool/bin/coolc stack.cl
test stack.s
/home/liuqingshuai/桌面/编译器实验/cool/cool/bin/spim -trap_file /home/liuqingshuai/桌面/编译器实验/coo
l/cool/lib/trap.handler -file stack.s
SPIM Version 6.5 of January 4, 2003
Copyright 1990-2003 by James R. Larus (larus@cs.wisc.edu).
All Rights Reserved.
See the file README for a full copyright notice.
Loaded: /home/liuqingshuai/桌面/编译器实验/cool/cool/lib/trap.handler
>1
>+
>2
>s
>d
s
2
+
1
>e
>e
>d
3
>x
Abort called from class Main
```

实验三、词法分析(上)

3.1-实现打印输入文字的行数，字数，字符数

`LexSamp1.l` 如下

```
%{
    int numChar = 0;
    int numLine = 0;
    int numWord = 0;
%}

%%
[ \t] /*匹配到tab或者空格，不用管*/

\n {numLine++;} /*匹配到换行符，numLine加1*/

[^ \t\n]+ {numChar+=yyleng;numWord++;}  /*匹配到一个不包括tab、空格、换行符的字，numWord加1，numChar加上字符长度*/
%%

int yywrap(){}

int main(){
```

```
  yylex();
  printf("numChar=%d\nnumWord=%d\nnumLine=%d\n",numChar,numWord,numLine);
  return 0;
}
```

LexSamp1.l
~/桌面/编译器实验/cool/cool/assignments/PA2

```
%{
    int numChar = 0;
    int numLine = 0;
    int numWord = 0;
%}

%%
[ \t]   /*匹配到tab或者空格，不用管*/

\n {numLine++;} /*匹配到换行符，numLine加1*/

[^ \t\n]+ {numChar+=yyleng;numWord++;}  /*匹配到一个不包括tab、空格、换行符的字，numWord加1，numChar加上字符长度*/
%%

int yywrap(){}

int main(){
  yylex();
  printf("numChar=%d\nnumWord=%d\nnumLine=%d\n",numChar,numWord,numLine);
  return 0;
```

将 `LexSamp1.l` 转换为C语言文件 `lex.yy.c` 然后编译执行

```
flex LexSamp1.l
cc -o LexSamp1 lex.yy.c -ll
./LexSamp1
```

按 `ctrl+d` 结束

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ flex LexSamp1.l
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ cc -o LexSamp1 lex.yy.c -ll
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ ./LexSamp1
nihao
123
abcd
numChar=12
numWord=3
numLine=3
```

3.2-统计给定程序文件的行数，字数，以及关键字的个数

`LexSamp2.l` 如下

打开(O) LexSamp2.l ~/桌面/编译器实验/cool/cool/assignments/PA2 保存(S)

```
%{
#include<stdio.h>
int numChar, numWord, numLine, numInclude, numDefine,numInt,numCChar,numMain,numPrintf,numIf,numElse,numReturn;
%}
%option yylineno
%%
[ \t]   /*匹配到空格或tab键*/
\n      {numLine++;}    /*匹配到换行符*/
#include|#[ *]include {numInclude++;numWord++;numChar+=yyleng;} /*匹配include*/
#define|#[ *]define     {numDefine++;numWord++;numChar+=yyleng;}/*匹配define*/
int {numInt++;numWord++;numChar+=yyleng;}/*匹配int*/
char {numCChar++;numWord++;numChar+=yyleng;}/*匹配char*/
main {numMain++;numWord++;numChar+=yyleng;}/*匹配main*/
printf  {numPrintf++;numWord++;numChar+=yyleng;}/*匹配printf*/
if      {numIf++;numWord++;numChar+=yyleng;}/*匹配if*/
else {numElse++;numWord++;numChar+=yyleng;}/*匹配else*/
return  {numReturn++;numWord++;numChar+=yyleng;}/*匹配return*/
[^ \t\n]+       {numWord++;numChar+=yyleng;}/*匹配到一个不包括空格、tab、换行符的字*/
%%
int main(int argc,char* argv[]){
  printf("按ctrl+d退出\n");
  printf("请输入文件名:");
  char fileName[64];
  scanf("%s",fileName);
  yyin = fopen(fileName,"r");
  yylex();
  printf("Information:\nnumChar=%d\tnumWord=%d\tnumLine=%d\t",numChar,numWord,numLine);
  printf("numInclude=%d\tnumDefine=%d\tnumInt=%d\tnumCChar=%d\n",numInclude,numDefine,numInt,numCChar);
  printf("numMain=%d\tnumPrintf=%d\tnumIf=%d\tnumElse=%d\tnumReturn=%d\n",numMain,numPrintf,numIf,numElse,numReturn);
  return 0;
}
```

```
%{
#include<stdio.h>
int numChar, numWord, numLine, numInclude,
numDefine,numInt,numCChar,numMain,numPrintf,numIf,numElse,numReturn;
%}
%option yylineno
%%
[ \t] /*匹配到空格或tab键*/
\n  {numLine++;}  /*匹配到换行符*/
#include|#[ *]include {numInclude++;numWord++;numChar+=yyleng;} /*匹配include*/
#define|#[ *]define {numDefine++;numWord++;numChar+=yyleng;}/*匹配define*/
int {numInt++;numWord++;numChar+=yyleng;}/*匹配int*/
char {numCChar++;numWord++;numChar+=yyleng;}/*匹配char*/
main {numMain++;numWord++;numChar+=yyleng;}/*匹配main*/
printf  {numPrintf++;numWord++;numChar+=yyleng;}/*匹配printf*/
if  {numIf++;numWord++;numChar+=yyleng;}/*匹配if*/
else {numElse++;numWord++;numChar+=yyleng;}/*匹配else*/
return  {numReturn++;numWord++;numChar+=yyleng;}/*匹配return*/
[^ \t\n]+ {numWord++;numChar+=yyleng;}/*匹配到一个不包括空格、tab、换行符的字*/
%%
int main(int argc,char* argv[]){
  printf("按ctrl+d退出\n");
  printf("请输入文件名:");
  char fileName[64];
  scanf("%s",fileName);
  yyin = fopen(fileName,"r");
```

```
  yylex();
  printf("Information:\nnumChar=%d\tnumWord=%d\tnumLine=%d\t",numChar,numWord,numLine);
  printf("numInclude=%d\tnumDefine=%d\tnumInt=%d\tnumCChar=%d\n",numInclude,numDefine,numInt,numCChar);
  printf("numMain=%d\tnumPrintf=%d\tnumIf=%d\tnumElse=%d\tnumReturn=%d\n",numMain,numPrintf,numIf,numElse,numReturn);
  return 0;
}
```

test2.c如下

打开(O) test2.c ~/桌面/编译器实验/cool/cool/assignments/PA2

```
#include <stdio.h>
#include <stdlib.h>
int main () {
        int a = 1, b = 2;
        int result = a + b;
        if ( result > 100 )     printf ("result > 100\n");

        char word = 'A';
        printf ("word is %c\n",word);

        return 0;
}
```

```
#include <stdio.h>
#include <stdlib.h>
int main () {
  int a = 1, b = 2;
  int result = a + b;
  if ( result > 100 ) printf ("result > 100\n");

  char word = 'A';
  printf ("word is %c\n",word);

  return 0;
}
```

将 `LexSamp2.l` 转换为C语言文件 `lex.yy.c` 然后编译执行

```
flex LexSamp2.l
cc -o LexSamp2 lex.yy.c -;;
./LexSamp2
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ flex LexSamp2.l
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ cc -o LexSamp2 lex.yy.c -ll
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ ./LexSamp2
按ctrl+d退出
请输入文件名:test2.c
Information:
numChar=155     numWord=42      numLine=12      numInclude=2    numDefine=0     numInt=3        numCChar=1
numMain=1       numPrintf=2     numIf=1 numElse=0       numReturn=1
```

3.3-实现多重入口

LexSamp4.l 如下

```
{%
#include <stdio.h>
%}
%x AA BB CC
%%
^a    {ECHO; BEGIN AA;}
^b    {ECHO; BEGIN BB;}
^c    {ECHO; BEGIN CC;}
\n|(\t)+|" "+ {ECHO; BEGIN 0;}
<AA>magin   {printf("first"); BEGIN 0;}
<AA>magin   {printf("second"); BEGIN 0;}
<AA>magin   {printf("third"); BEGIN 0;}
magic   {printf("zero");}
%%

int yywrap(){}

int main(){
    printf("按 ctrl+d 退出\n");
    yyLex();
    return 0;
}
```

```
flex -o LexSamp4.c LexSamp4.l
gcc -o LexSamp4 LexSamp4.c
./LexSamp4
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ flex -o LexSamp4.c LexSamp4.l
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ gcc -o LexSamp4 LexSamp4.c
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ ./LexSamp4
按 ctrl+d 退出
amagic
afirst
bmagic
bsecond
cmagic
cthird
ojkbmagic
ojkbzero
lqsmagic
lqszero
magic
zero
ff
ff
```

实验四、词法分析(下)

4.1-修改makefile

CLASSDIR由 `/home/os/cool/cool` 修改为 `/home/liuqingshuai/桌面/编译器实验/cool/cool`

```
终端
文件(F)  编辑(E)  查看(V)  搜索(S)  终端(T)  帮助(H)
#########################################
#    将这里的CLASSDIR改成你机子上cool所在的目录
#    以便Makefile可以找到cool/bin所在的位置
CLASSDIR= /home/liuqingshuai/桌面/编译器实验/cool/cool
#########################################
#作业号，用来判断需要链接的头文件和源文件的目录
ASSN = 2
#没有用,表示这个作业是用来干嘛的
CLASS= xjtucomplier
#表示lib的位置，这里不用lib，暂时没有用
LIB= -L/usr/sww/lib

#make依赖的文件列表
SRC= cool.flex test.cl README
#make需要的源文件列表
CSRC= lextest.cc utilities.cc stringtab.cc handle_flags.cc
#一个shell脚本程序
TSRC= mycoolc
HSRC=
#需要生成的文件
CGEN= cool-lex.cc
HGEN=
#一个完整的编译过程
LIBS= parser semant cgen
CFIL= ${CSRC} ${CGEN}
LSRC= Makefile
```

4.2-补充 `cool.flex`

`cool.flex`(修改如下最开始两个词法分析器的输出是不同的，这里就不贴图了，直接修改 `cool.flex`)

```
 /*
  *  这个文件用来生成一个COOL语言的词法分析程序.
  */

 /*
  *  lex文件的第一个部分，也就是包含在“%{”和“ %}”之间的部分，是用来像未来的词法分析程序输出代
  *  码的，也就是说这里的需要include头文件，extern外部变量，因为这部分是要直接照搬到以后的.c文
  *  件中去的
  */
%{

#include <cool-parse.h> //记号的定义放在cool-parse.h文件中
#include <stringtab.h>
#include <utilities.h>
#include <stdint.h>

/* 词法分析程序需要的宏定义 */
#define yylval cool_yylval
#define yylex  cool_yylex

/* 字符串常量的最大长度 */
#define MAX_STR_CONST 1025
#define YY_NO_UNPUT   /* 让g++的编译结果变得友好 */

extern FILE *fin; /* 从这个文件指针读取记号 */

/* 定义YY_INPUT以后我们就可以从fin中读取记号了:
 */
#undef YY_INPUT
#define YY_INPUT(buf,result,max_size) \
  if ( (result = fread( (char*)buf, sizeof(char), max_size, fin)) < 0) \
    YY_FATAL_ERROR( "read() in flex scanner failed");

char string_buf[MAX_STR_CONST]; /* 记录字符串的字符数组*/
char *string_buf_ptr;

extern int curr_lineno;
extern int verbose_flag;

extern YYSTYPE cool_yylval;

/*
 *  在这里添加你自己的头文件和变量
 */

char string_const[MAX_STR_CONST];
```

```
int string_const_len;
bool str_contain_null_char;

%}

 /*
  * 定义正则表达式的名字
  */

%option noyywrap
%x LINE_COMMENT BLOCK_COMMENT STRING

DARROW      =>
ASSIGN      <-
LE        <=

%%

\n        { curr_lineno++; }
[ \t\r\v\f]+  {}

/*
 * 第二部分用来定义正则表达式需要的“元素”
 */

"--"      { BEGIN LINE_COMMENT; }
"(\*"     { BEGIN BLOCK_COMMENT; }
"\*)"     {
  strcpy(cool_yylval.error_msg, "Unmatched *)");
  return (ERROR);
}

<LINE_COMMENT>\n    { BEGIN 0; curr_lineno++; }
<BLOCK_COMMENT>\n   { curr_lineno++; }
<BLOCK_COMMENT>"\*)"  { BEGIN 0; }
<BLOCK_COMMENT><<EOF>>  {
  strcpy(cool_yylval.error_msg, "EOF in comment");
  BEGIN 0; return (ERROR);
}

<LINE_COMMENT>.     {}
<BLOCK_COMMENT>.    {}

 /*
  *  多字符操作符
  */

{DARROW}    { return (DARROW); }
{ASSIGN}    { return (ASSIGN); }
```

```
{LE}      { return (LE); }

 /*
  *  单字符操作符
  */

"{"     { return '{'; }
"}"     { return '}'; }
"("     { return '('; }
")"     { return ')'; }
"~"     { return '~'; }
","     { return ','; }
";"     { return ';'; }
":"     { return ':'; }
"+"     { return '+'; }
"-"     { return '-'; }
"*"     { return '*'; }
"/"     { return '/'; }
"%"     { return '%'; }
"."     { return '.'; }
"<"     { return '<'; }
"="     { return '='; }
"@"     { return '@'; }

 /*
  * 关键字
  */

(?i:CLASS)    { return (CLASS); }
(?i:ELSE)   { return (ELSE); }
(?i:FI)     { return (FI); }
(?i:IF)     { return (IF); }
(?i:IN)     { return (IN); }
(?i:INHERITS) { return (INHERITS); }
(?i:LET)    { return (LET); }
(?i:LOOP)   { return (LOOP); }
(?i:POOL)   { return (POOL); }
(?i:THEN)   { return (THEN); }
(?i:WHILE)    { return (WHILE); }
(?i:CASE)   { return (CASE); }
(?i:ESAC)   { return (ESAC); }
(?i:OF)     { return (OF); }
(?i:NEW)    { return (NEW); }
(?i:LE)     { return (LE); }
(?i:NOT)    { return (NOT); }
(?i:ISVOID)   { return (ISVOID); }

t[rR][uU][eE]   {
  cool_yylval.boolean = 1;
```

```
  return (BOOL_CONST);
}

f[aA][lL][sS][eE] {
  cool_yylval.boolean = 0;
  return (BOOL_CONST);
}

 /*
  *  字符串
  *
  */

\"  {
  memset(string_const, 0, sizeof string_const);
  string_const_len = 0; str_contain_null_char = false;
  BEGIN STRING;
}

<STRING><<EOF>> {
  strcpy(cool_yylval.error_msg, "EOF in string constant");
  BEGIN 0; return (ERROR);
}

<STRING>\\.   {
  if (string_const_len ≥ MAX_STR_CONST) {
    strcpy(cool_yylval.error_msg, "String constant too long");
    BEGIN 0; return (ERROR);
  }
  switch(yytext[1]) {
    case '\"': string_const[string_const_len++] = '\"'; break;
    case '\\': string_const[string_const_len++] = '\\'; break;
    case 'b' : string_const[string_const_len++] = '\b'; break;
    case 'f' : string_const[string_const_len++] = '\f'; break;
    case 'n' : string_const[string_const_len++] = '\n'; break;
    case 't' : string_const[string_const_len++] = '\t'; break;
    case '0' : string_const[string_const_len++] = 0;
         str_contain_null_char = true; break;
    default  : string_const[string_const_len++] = yytext[1];
  }
}

<STRING>\\\n  { curr_lineno++; }
<STRING>\n    {
  curr_lineno++;
  strcpy(cool_yylval.error_msg, "Unterminated string constant");
  BEGIN 0; return (ERROR);
}

```

```
<STRING>\"    {
  if (string_const_len > 1 && str_contain_null_char) {
    strcpy(cool_yylval.error_msg, "String contains null character");
    BEGIN 0; return (ERROR);
  }
  cool_yylval.symbol = stringtable.add_string(string_const);
  BEGIN 0; return (STR_CONST);
}

<STRING>.   {
  if (string_const_len ≥ MAX_STR_CONST) {
    strcpy(cool_yylval.error_msg, "String constant too long");
    BEGIN 0; return (ERROR);
  }
  string_const[string_const_len++] = yytext[0];
}

 /*
  *  数字和标识符
  */

[0-9]+        {
  cool_yylval.symbol = inttable.add_string(yytext);
  return (INT_CONST);
}

[A-Z][A-Za-z0-9_]*  {
  cool_yylval.symbol = idtable.add_string(yytext);
  return (TYPEID);
}

[a-z][A-Za-z0-9_]*  {
  cool_yylval.symbol = idtable.add_string(yytext);
  return (OBJECTID);
}

 /*
  *  其他错误
  */

. {
  strcpy(cool_yylval.error_msg, yytext);
  return (ERROR);
}

%%
```

4.3-使用make指令生成的lexer进行词法分析

```
make lexer
ls
make dotest
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ make lexer
flex -d -ocool-lex.cc cool.flex
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA2 -I/home/liuqingshuai/桌面/编译器实验/coo
l/cool/src/PA2 cool-lex.cc | sed '\''s/\(cool-lex\.o\)[ :]*/\1 cool-lex.d : /g'\'' > cool-lex.d'
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA2 -I/home/liuqingshuai/桌面/编译器实验/coo
l/cool/src/PA2 handle_flags.cc | sed '\''s/\(handle_flags\.o\)[ :]*/\1 handle_flags.d : /g'\'' > handle_flags.d'
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA2 -I/home/liuqingshuai/桌面/编译器实验/coo
l/cool/src/PA2 stringtab.cc | sed '\''s/\(stringtab\.o\)[ :]*/\1 stringtab.d : /g'\'' > stringtab.d'
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA2 -I/home/liuqingshuai/桌面/编译器实验/coo
l/cool/src/PA2 utilities.cc | sed '\''s/\(utilities\.o\)[ :]*/\1 utilities.d : /g'\'' > utilities.d'
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA2 -I/home/liuqingshuai/桌面/编译器实验/coo
l/cool/src/PA2 lextest.cc | sed '\''s/\(lextest\.o\)[ :]*/\1 lextest.d : /g'\'' > lextest.d'
g++ -g -Wall -Wno-unused -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA2 -I/home/liuqingshuai/桌面/编译器实验
/cool/cool/src/PA2 -c cool-lex.cc
g++ -g -Wall -Wno-unused -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA2 -I/home/liuqingshuai/桌面/编译器实验
/cool/cool/src/PA2 lextest.o utilities.o stringtab.o handle_flags.o cool-lex.o -L/usr/sww/lib -o lexer
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ ls
cool.flex        handle_flags.cc  LexSamp1.l  LexSamp4.l  Makefile         stringtab.cc  test.cl.SKEL
cool.flex.SKEL   handle_flags.d   LexSamp2    lextest.cc  mycoolc          stringtab.d   utilities.cc
cool-lex.cc      handle_flags.o   LexSamp2.l  lextest.d   README           stringtab.o   utilities.d
cool-lex.d       lexer            LexSamp4    lextest.o   README.SKEL      test2.c       utilities.o
cool-lex.o       LexSamp1         LexSamp4.c  lex.yy.c    reference-lexer  test.cl
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ make dotest
./lexer test.cl
#name "test.cl"
#5 CLASS
#5 TYPEID CellularAutomaton
#5 INHERITS
#5 TYPEID IO
#5 '{'
#6 OBJECTID population_map
#6 ':'
#6 TYPEID String
#6 ';'
#8 OBJECTID init
#8 '('
#8 OBJECTID map
#8 ':'
#8 TYPEID String
#8 ')'
#8 ':'
#8 TYPEID SELF_TYPE
#8 '{'
#9 '{'
#10 OBJECTID population_map
#10 ASSIGN
#10 OBJECTID map
#10 ';'
#11 OBJECTID self
#11 ';'
#12 '}'
#13 '}'
#13 ';'
#15 OBJECTID print
#15 '('
#15 ')'
#15 ':'
#15 TYPEID SELF_TYPE
#15 '{'
```

```
#85 '('
#85 LET
#85 OBJECTID countdown
#85 ':'
#85 TYPEID Int
#85 ASSIGN
#85 INT_CONST 20
#85 IN
#86 WHILE
#86 OBJECTID countdown
#86 ERROR ">"
#86 INT_CONST 0
#86 LOOP
#87 '{'
#88 OBJECTID cells
#88 '.'
#88 OBJECTID evolve
#88 '('
#88 ')'
#88 ';'
#89 OBJECTID cells
#89 '.'
#89 OBJECTID print
#89 '('
#89 ')'
#89 ';'
#90 OBJECTID countdown
#90 ASSIGN
#90 OBJECTID countdown
#90 '-'
#90 INT_CONST 1
#90 ';'
#92 POOL
#93 ')'
#93 ';'
#98 ERROR "EOF in comment"
```

4.4-使用标准词法分析器进行分析

```
./reference-lexer test.cl
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ ./reference-lexer test.cl
#name "test.cl"
#5 CLASS
#5 TYPEID CellularAutomaton
#5 INHERITS
#5 TYPEID IO
#5 '{'
#6 OBJECTID population_map
#6 ':'
#6 TYPEID String
#6 ';'
#8 OBJECTID init
#8 '('
#8 OBJECTID map
#8 ':'
#8 TYPEID String
#8 ')'
#8 ':'
#8 TYPEID SELF_TYPE
#8 '{'
#9 '{'
#10 OBJECTID population_map
#10 ASSIGN
#10 OBJECTID map
#10 ';'
#11 OBJECTID self
#11 ';'
#12 '}'
#13 '}'
#13 ';'
#15 OBJECTID print
#15 '('
#15 ')'
#15 ':'
#15 TYPEID SELF_TYPE
#15 '{'
```

```
#85 '('
#85 LET
#85 OBJECTID countdown
#85 ':'
#85 TYPEID Int
#85 ASSIGN
#85 INT_CONST 20
#85 IN
#86 WHILE
#86 OBJECTID countdown
#86 ERROR ">"
#86 INT_CONST 0
#86 LOOP
#87 '{'
#88 OBJECTID cells
#88 '.'
#88 OBJECTID evolve
#88 '('
#88 ')'
#88 ';'
#89 OBJECTID cells
#89 '.'
#89 OBJECTID print
#89 '('
#89 ')'
#89 ';'
#90 OBJECTID countdown
#90 ASSIGN
#90 OBJECTID countdown
#90 '-'
#90 INT_CONST 1
#90 ';'
#92 POOL
#93 ')'
#93 ';'
#98 ERROR "EOF in comment"
```

4.5-对比

对比上面两个词法分析器，二者输出结果相同，都对目标代码进行了词法分析。

4.6-错误处理

由于 `test.cl` 实际上有问题，因此修改一下 `test.cl` ，将93行的注释补齐如下，左侧为原本，右侧为修改后

```
class Main {
    cells : CellularAutomaton;

    main() : SELF_TYPE {
        {
            cells <- (new CellularAutomaton).init("         X         ");
            cells.print();
            (let countdown : Int <- 20 in
                while countdown > 0 loop
                    {
                        cells.evolve();
                        cells.print();
                        countdown <- countdown - 1;

                    pool
            );  (* end let countdown
            self;
        }
    };
};
```

```
class Main {
    cells : CellularAutomaton;

    main() : SELF_TYPE {
        {
            cells <- (new CellularAutomaton).init("         X         ");
            cells.print();
            (let countdown : Int <- 20 in
                while countdown > 0 loop
                    {
                        cells.evolve();
                        cells.print();
                        countdown <- countdown - 1;

                    pool
            );  (* end let countdown *)
            self;
        }
    };
};
```

然后再次执行

```
make dotest
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA2$ make dotest
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA2 -I/home/liuqingshuai/桌
cool/cool/src/PA2 cool-lex.cc | sed '\''s/\(cool-lex\.o\)[ :]*/\1 cool-lex.d : /g'\'' > cool-lex.d'
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA2 -I/home/liuqingshuai/桌
cool/cool/src/PA2 handle_flags.cc | sed '\''s/\(handle_flags\.o\)[ :]*/\1 handle_flags.d : /g'\'' > handle_
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA2 -I/home/liuqingshuai/桌
cool/cool/src/PA2 stringtab.cc | sed '\''s/\(stringtab\.o\)[ :]*/\1 stringtab.d : /g'\'' > stringtab.d'
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA2 -I/home/liuqingshuai/桌
cool/cool/src/PA2 utilities.cc | sed '\''s/\(utilities\.o\)[ :]*/\1 utilities.d : /g'\'' > utilities.d'
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA2 -I/home/liuqingshuai/桌
cool/cool/src/PA2 lextest.cc | sed '\''s/\(lextest\.o\)[ :]*/\1 lextest.d : /g'\'' > lextest.d'
./lexer test.cl
#name "test.cl"
#5 CLASS
#5 TYPEID CellularAutomaton
#5 INHERITS
#5 TYPEID IO
#5 '{'
#6 OBJECTID population_map
#6 ':'
#6 TYPEID String
#6 ';'
#8 OBJECTID init
#8 '('
#8 OBJECTID map
#8 ':'
```

```
#86 LOOP
#87 '{'
#88 OBJECTID cells
#88 '.'
#88 OBJECTID evolve
#88 '('
#88 ')'
#88 ';'
#89 OBJECTID cells
#89 '.'
#89 OBJECTID print
#89 '('
#89 ')'
#89 ';'
#90 OBJECTID countdown
#90 ASSIGN
#90 OBJECTID countdown
#90 '-'
#90 INT_CONST 1
#90 ';'
#92 POOL
#93 ')'
#93 ';'
#94 OBJECTID self
#94 ';'
#95 '}'
#96 '}'
#96 ';'
#97 '}'
#97 ';'
```

这次便没有了之前的 `ERROR "EOF IN COMMENT"`

实验五、语义分析和语法制导

5.1&5.2-编写一个简单的.y文件，能实现一个简单的一位数十进制计算器，包括加减乘除，并能识别负数

`token.l` 文件如下

```
%{
#include "y.tab.h"
%}

%%
[0-9]+ {yylval=atoi(yytext); return T_NUM;}
[-/+*()\n] {return yytext[0];}
. {return 0;}
%%

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

`parser1.y` 文件如下

```
%{
#include<stdio.h>
extern int yylex();
```

```
extern int yyparse();
void yyerror(const char* msg){}
%}

%token T_NUM
%left '+' '-'
%left '*' '/'
%right uminus

%%
S: S E '\n' {printf("ans=%d\n",$2);}
 |          {  }
 ;

E: E '+' E {$$=$1+$3;}
 | E '-' E {$$=$1-$3;}
 | E '*' E {$$=$1*$3;}
 | E '/' E {$$=$1/$3;}
 | T_NUM {$$=$1;}
 | '(' E ')' {$$=$2;}
 | '-' E %prec uminus {$$=-$2;}
 ;
%%

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

token.l

```
%{
#include "y.tab.h"
%}

%%
[0-9]+ {yylval=atoi(yytext); return T_NUM;}
[-/+*()\n] {return yytext[0];}
. {return 0;}
%%

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

parser1.y

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

%token T_NUM
%left '+' '-'
%left '*' '/'
%right uminus

%%
S: S E '\n' {printf("ans=%d\n",$2);}
 |          {  }
 ;

E: E '+' E {$$=$1+$3;}
 | E '-' E {$$=$1-$3;}
 | E '*' E {$$=$1*$3;}
 | E '/' E {$$=$1/$3;}
 | T_NUM {$$=$1;}
 | '(' E ')' {$$=$2;}
 | '-' E %prec uminus {$$=-$2;}
 ;
%%

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

```
bison -vtdy parser1.y | flex token.l
gcc -o calculate1 lex.yy.c y.tab.c
./calculate1
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA3$ bison -vtdy parser1.y | flex token.l
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA3$ gcc -o calculate1 lex.yy.c y.tab.c
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA3$ ./calculate1
1+2
ans=3
1+2*3
ans=7
(2+3)/(5)
ans=1
-1+2
ans=1
```

5.3-在任务2的基础上实现多位数字的处理，并增加报错功能（选做）

`parser2.y` 如下

parser2.y
~/桌面/编译器实验/cool/cool/assignments...

```
%{
// 加减乘除括号 多位数  a-z符号
#include <stdio.h>
#include <string.h>
int regs[26];
void yyerror(char *s);
int yylex();
%}

%token DIGIT ID

%left '+' '-'
%left '*' '/'
%right uminus

%%
S    :   S STAT '\n'          { printf("ans = %d\n", $2); }
     |   /* empty */      { /* empty */ }
     ;

STAT:    ID '=' E     { regs[$1] = $3; $$ = $3; }
     |   E                 { $$ = $1;}
     ;

E    :   E '+' E               { $$ = $1 + $3;}
     |   E '-' E               { $$ = $1 - $3; }
     |   E '*' E               { $$ = $1 * $3; }
     |   E '/' E               { $$ = $1 / $3; }
     |   ID                    { $$ = regs[$1]; }
     |   '-' E %prec uminus    { $$ = -$2; }
     |   number                { $$ = $1;}
     |   '(' E ')'             { $$ = $2; }
     |   error                 { yyerror("expr: error"); }
     ;

number
     :   DIGIT            { $$ = $1; }
     |   number DIGIT     { $$ = $1*10 + $2;}

%%

int yylex() {
    int c;
    do{
        c = getchar();
    }while(c==' ');
```

```
bison -d parser2.y
gcc -o calculate2 parser2.tab.c
./calculate2
```

实现了赋值和报错

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA3$ bison -d parser2.y
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA3$ gcc -o calculate2 parser2.tab.c
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA3$ ./calculate2
1++3
syntax error
expr: error
ans = 5
a = 1
ans = 1
1*2+3
ans = 5
```

实验六、语法分析

6.1-修改makefile

修改 `CLASSDIR`

```
终端
文件(F)  编辑(E)  查看(V)  搜索(S)  终端(T)  帮助(H)
#######################################
# 编辑这里
# 将CLASSDIR设置成你电脑上cool项目所在的位置
CLASSDIR= /home/liuqingshuai/桌面/编译器实验/cool/cool
#######################################

#作业序号，第三次作业
ASSN = 3
#没有用
CLASS= xjtucompiler
#链接库，暂时不用管
LIB= -L/usr/sww/lib
```

6.2-编写一个cool.y文件

`cool.y` 文件如下(去掉了注释)

```
%{
#include <iostream>
#include "cool-tree.h"
#include "stringtab.h"
#include "utilities.h"

extern char *curr_filename;

void yyerror(char *s);        /*  defined below; called for each parse error */
extern int yylex();           /*  the entry point to the lexer  */

```

```
Program ast_root;       /* the result of the parse  */
Classes parse_results;        /* for use in semantic analysis */
int omerrs = 0;               /* number of errors in lexing and parsing */
%}

%union {
  Boolean boolean;
  Symbol symbol;
  Program program;
  Class_ class_;
  Classes classes;
  Feature feature;
  Features features;
  Formal formal;
  Formals formals;
  Case case_;
  Cases cases;
  Expression expression;
  Expressions expressions;
  char *error_msg;
}

%token CLASS 258 ELSE 259 FI 260 IF 261 IN 262
%token INHERITS 263 LET 264 LOOP 265 POOL 266 THEN 267 WHILE 268
%token CASE 269 ESAC 270 OF 271 DARROW 272 NEW 273 ISVOID 274
%token <symbol>  STR_CONST 275 INT_CONST 276
%token <boolean> BOOL_CONST 277
%token <symbol>  TYPEID 278 OBJECTID 279
%token ASSIGN 280 NOT 281 LE 282 ERROR 283

%type <program> program
%type <classes> class_list
%type <class_> class

%type <features> dummy_feature_list


%%
program : class_list  { ast_root = program($1); }
        ;

class_list
  : class     /* single class */
    { $$ = single_Classes($1);
                  parse_results = $$; }
  | class_list class  /* several classes */
    { $$ = append_Classes($1,single_Classes($2));
                  parse_results = $$; }
  ;
```

```
class : CLASS TYPEID '{' dummy_feature_list '}' ';'
    { $$ = class_($2,idtable.add_string("Object"),$4,
            stringtable.add_string(curr_filename)); }
  | CLASS TYPEID INHERITS TYPEID '{' dummy_feature_list '}' ';'
    { $$ = class_($2,$4,$6,stringtable.add_string(curr_filename)); }
  ;

dummy_feature_list:   /* empty */
                {  $$ = nil_Features(); }
  ;

%%

void yyerror(char *s)
{
  extern int curr_lineno;

  cerr << "\"" << curr_filename << "\", line " << curr_lineno << ": " \
    << s << " at or near ";
  print_cool_token(yychar);
  cerr << endl;c
  omerrs++;

  if(omerrs>50) {fprintf(stdout, "More than 50 errors\n"); exit(1);}
}
```

6.3-根据cool语言的标准文法完成cool语言语法分析，输出语法分析树结果

```
make
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA3$ make
bison -d -v -y -b cool --debug -p cool_yy cool.y
cool.y: 警告: 18 shift/reduce conflicts [-Wconflicts-sr]
mv -f cool.tab.c cool-parse.cc
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA3 -I/home/liuqingshuai/桌面/编译器实验/cool/cool/s
src/PA3 cool-parse.cc | sed '\''s/\(cool-parse\.o\)[ :]*/\1 cool-parse.d : /g'\'' > cool-parse.d'
g++ -g -Wall -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA3 -I/home/liuqingshuai/桌面/编译器实验/cool/cool/src/PA3 -
c cool-parse.cc
cool.y: In function ‘int cool_yyparse()’:
cool.y:123:77: warning: ISO C++ forbids converting a string constant to ‘char*’ [-Wwrite-strings]
     { $$ = class_($2,idtable.add_string("Object"),$4,
                                                      ^
cool.y:190:69: warning: ISO C++ forbids converting a string constant to ‘char*’ [-Wwrite-strings]
     { $$ = dispatch(object(idtable.add_string("self")), $1, $3); }
                                                                 ^
cool.tab.c:1796:35: warning: ISO C++ forbids converting a string constant to ‘char*’ [-Wwrite-strings]
cool.tab.c:1940:35: warning: ISO C++ forbids converting a string constant to ‘char*’ [-Wwrite-strings]
echo "start parser"
start parser
g++ -g -Wall -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA3 -I/home/liuqingshuai/桌面/编译器实验/cool/cool/src/PA3 p
arser-phase.o utilities.o stringtab.o dumptype.o tree.o cool-tree.o tokens-lex.o handle_flags.o cool-parse.o -L/usr/sww/lib -o parse
r
```

```
../../bin/reference-lexer good.cl | ../../bin/reference-parser
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA3$ ../../bin/reference-lexer good.cl | ../../bin/reference-parser
#5
_program
  #2
  _class
    A
    Object
    "good.cl"
    (
    )
  #5
  _class
    BB__
    A
    "good.cl"
    (
    )
```

```
../../bin/reference-lexer good.cl | ./parser
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA3$ ../../bin/reference-lexer good.cl | ./parser
#5
_program
  #2
  _class
    A
    Object
    "good.cl"
    (
    )
  #5
  _class
    BB__
    A
    "good.cl"
    (
    )
```

`make` 生成的 `parser` 和标准语法分析器二者对 `good.cl` 的分析树结果是相同的

6.4-对bad.cl也进行语法分析

```
../../bin/reference-lexer bad.cl | ../../bin/reference-parser
../../bin/reference-lexer bad.cl | ./parser
```

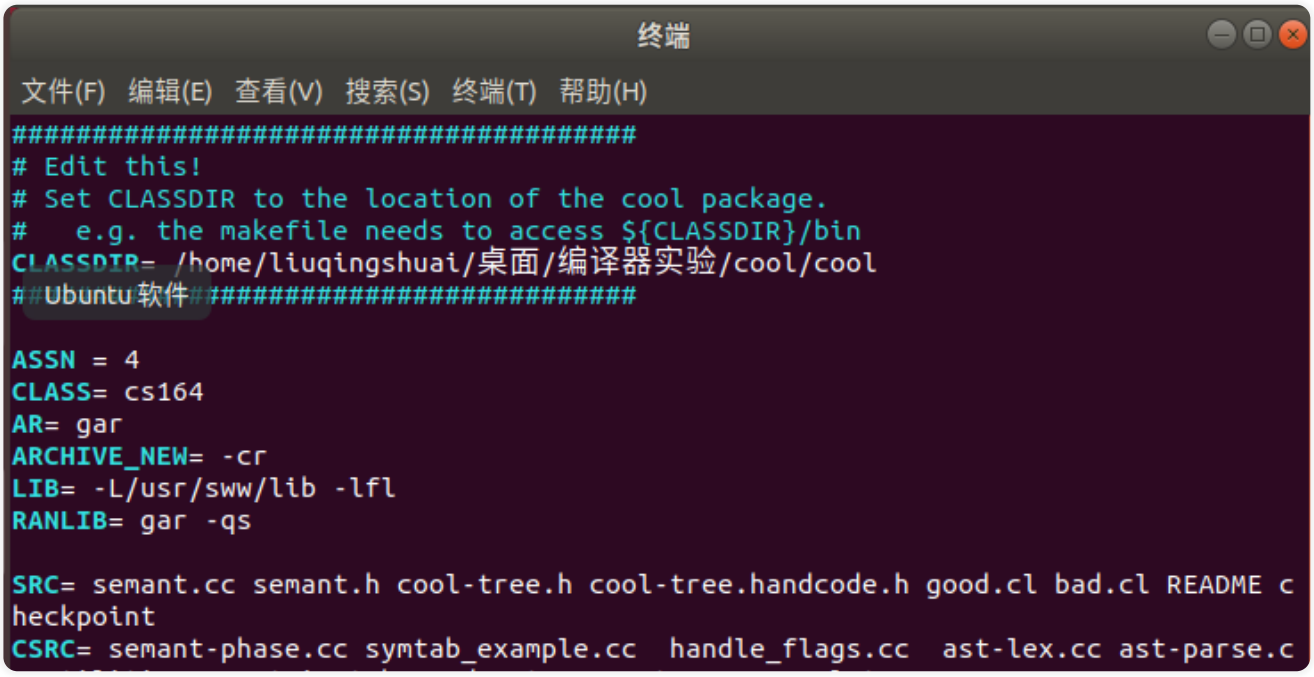
```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA3$ ../../bin/reference-lexer bad.cl | ../../bin/refer
ence-parser
"bad.cl", line 15: parse error at or near OBJECTID = b
"bad.cl", line 19: parse error at or near OBJECTID = a
"bad.cl", line 23: parse error at or near OBJECTID = inherts
"bad.cl", line 28: parse error at or near ';'
Compilation halted due to lex and parse errors
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA3$ ../../bin/referen
"bad.cl", line 15: syntax error at or near OBJECTID = b
"bad.cl", line 19: syntax error at or near OBJECTID = a
"bad.cl", line 23: syntax error at or near OBJECTID = inherts
"bad.cl", line 28: syntax error at or near ';'
Compilation halted due to lex and parse errors
```

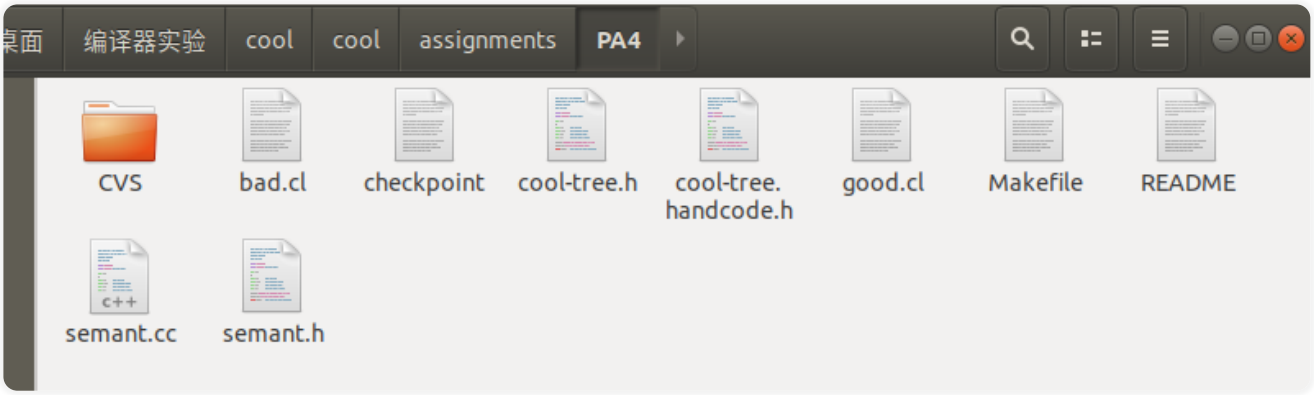
两个分析器对 `bad.cl` 的语法分析结果也是相同的

实验七、语义分析

7.1-修改makefile



7.2-删掉只包含路径的文件，只剩下下列文件，编译器运行



执行下面操作

```
make
./lexer good.cl
./lexer good.cl | ./parser
./lexer good.cl | ./parser | ./semant
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA4$ make
ln -s /home/liuqingshuai/桌面/编译器实验/cool/cool/src/PA4/cool-tree.cc cool-tree.cc
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA4 -I/home/liuqings
huai/桌面/编译器实验/cool/cool/src/PA4 cool-tree.cc | sed '\''s/\(cool-tree\.o\)[ :]*/\1 cool-tree.d
 : /g'\'' > cool-tree.d'
ln -s /home/liuqingshuai/桌面/编译器实验/cool/cool/src/PA4/tree.cc tree.cc
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA4 -I/home/liuqings
huai/桌面/编译器实验/cool/cool/src/PA4 tree.cc | sed '\''s/\(tree\.o\)[ :]*/\1 tree.d : /g'\'' > tre
e.d'
ln -s /home/liuqingshuai/桌面/编译器实验/cool/cool/src/PA4/dumptype.cc dumptype.cc
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA4 -I/home/liuqings
huai/桌面/编译器实验/cool/cool/src/PA4 dumptype.cc | sed '\''s/\(dumptype\.o\)[ :]*/\1 dumptype.d :
/g'\'' > dumptype.d'
ln -s /home/liuqingshuai/桌面/编译器实验/cool/cool/src/PA4/stringtab.cc stringtab.cc
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA4 -I/home/liuqings
huai/桌面/编译器实验/cool/cool/src/PA4 stringtab.cc | sed '\''s/\(stringtab\.o\)[ :]*/\1 stringtab.d
 : /g'\'' > stringtab.d'
ln -s /home/liuqingshuai/桌面/编译器实验/cool/cool/src/PA4/utilities.cc utilities.cc
/bin/sh -ec 'g++ -MM -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA4 -I/home/liuqings
huai/桌面/编译器实验/cool/cool/src/PA4 utilities.cc | sed '\''s/\(utilities\.o\)[ :]*/\1 utilities.d
 : /g'\'' > utilities.d'
ln -s /home/liuqingshuai/桌面/编译器实验/cool/cool/src/PA4/ast-parse.cc ast-parse.cc
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA4$ ./lexer good.cl
#name "good.cl"
#1 CLASS
#1 TYPEID C
#1 '{'
#2 OBJECTID a
#2 ':'
#2 TYPEID Int
#2 ';'
#3 OBJECTID b
#3 ':'
#3 TYPEID Bool
#3 ';'
#4 OBJECTID init
#4 '('
#4 OBJECTID x
#4 ':'
#4 TYPEID Int
#4 ','
#4 OBJECTID y
#4 ':'
#4 TYPEID Bool
#4 ')'
#4 ':'
#4 TYPEID C
#4 '{'
#5 '{'
#6 OBJECTID a
#6 ASSIGN
#6 OBJECTID x
#6 ';'
#7 OBJECTID b
#7 ASSIGN
#7 OBJECTID y
#7 ';'
#8 OBJECTID self
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA4$ ./lexer good.cl | ./parser
#1
_program
  #1
  _class
    C
    Object
    "good.cl"
    (
    #1
    _attr
      a
      Int
      #1
      _no_expr
      : _no_type
    #1
    _attr
      b
      Bool
      #1
      _no_expr
      : _no_type
    #1
    _method
      init
      #1
      _formal
        x
        Int
      #1
      _formal
        y
        Bool
      C
      #1
      _block
        #1
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA4$ ./lexer good.cl | ./parser | ./semant
#1
_program
  #1
  _class
    C
    Object
    "good.cl"
    (
    #1
    _attr
      a
      Int
      #1
      _no_expr
      : _no_type
    #1
    _attr
      b
      Bool
      #1
      _no_expr
      : _no_type
    #1
    _method
      init
      #1
      _formal
        x
        Int
      #1
      _formal
        y
        Bool
      C
      #1
      _block
```

```
./lexer bad.cl
./lexer bad.cl | ./parser
./lexer bad.cl | ./parser | ./semant
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA4$ ./lexer bad.cl
#name "bad.cl"
#1 CLASS
#1 TYPEID C
#1 '{'
#2 OBJECTID a
#2 ':'
#2 TYPEID Int
#2 ';'
#3 OBJECTID b
#3 ':'
#3 TYPEID Bool
#3 ';'
#4 OBJECTID init
#4 '('
#4 OBJECTID x
#4 ':'
#4 TYPEID Int
#4 ','
#4 OBJECTID y
#4 ':'
#4 TYPEID Bool
#4 ')'
#4 ':'
#4 TYPEID C
#4 '{'
#5 '{'
#6 OBJECTID a
#6 ASSIGN
#6 OBJECTID x
#6 ';'
#7 OBJECTID b
#7 ASSIGN
#7 OBJECTID y
#7 ';'
#8 OBJECTID self
#8 ';'
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA4$
./lexer bad.cl | ./parser
#1
_program
  #1
  _class
    C
    Object
    "bad.cl"
    (
    #1
    _attr
      a
      Int
      #1
      _no_expr
      : _no_type
    #1
    _attr
      b
      Bool
      #1
      _no_expr
      : _no_type
    #1
    _method
      init
      #1
      _formal
        x
        Int
      #1
      _formal
        y
        Bool
      C
      #1
      _block
        #1
        _assign
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA4$
./lexer bad.cl | ./parser | ./semant
bad.cl:1:In call of method init,type Int of parameter ydoes not conform to declared type Bool.
bad.cl:1:Method init called with wrong number of arguments.
bad.cl:1:Dispatch to undefined method iinit.
Compilation halted due to static semantic errors.
```

7.3-测试符号表结构

```
make symtab_example
./symtab_example
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA4$
make symtab_example
g++ -g -Wall -Wno-unused -Wno-write-strings -Wno-deprecated -I. -I/home/liuqingshuai/桌面/编译器实验/cool/cool/include/PA4 -I/home/liuqingshuai/桌面/编译器实验/cool/cool/src/PA4 -DDEBUG symtab_example.cc -L/usr/pubsw/lib -lfl  -o symtab_example
```

```
liuqingshuai@liuqingshuai-VirtualBox:~/桌面/编译器实验/cool/cool/assignments/PA4$ ./symtab_example
No
Yes
23
Yes
25
Yes
No
```

7.4-遍历classes实例

`semant.cc` 如下

```
#include <stdlib.h>
#include <stdio.h>
#include <stdarg.h>
#include "semant.h"
#include "utilities.h"


extern int semant_debug;
extern char *curr_filename;
extern int node_lineno;
//////////////////////////////////////////////////////////////////////
//
// Symbols
//
// For convenience, a large number of symbols are predefined here.
// These symbols include the primitive type and method names, as well
// as fixed names used by the runtime system.
//
//////////////////////////////////////////////////////////////////////
static Symbol
    arg,
    arg2,
    Bool,
    concat,
    cool_abort,
    copy,
    Int,
    in_int,
    in_string,
    IO,
    length,
    Main,
    main_meth,
    No_class,
    No_type,
    Object,
    out_int,
    out_string,
    prim_slot,
    self,
    SELF_TYPE,
                                                        1,1           顶端
```