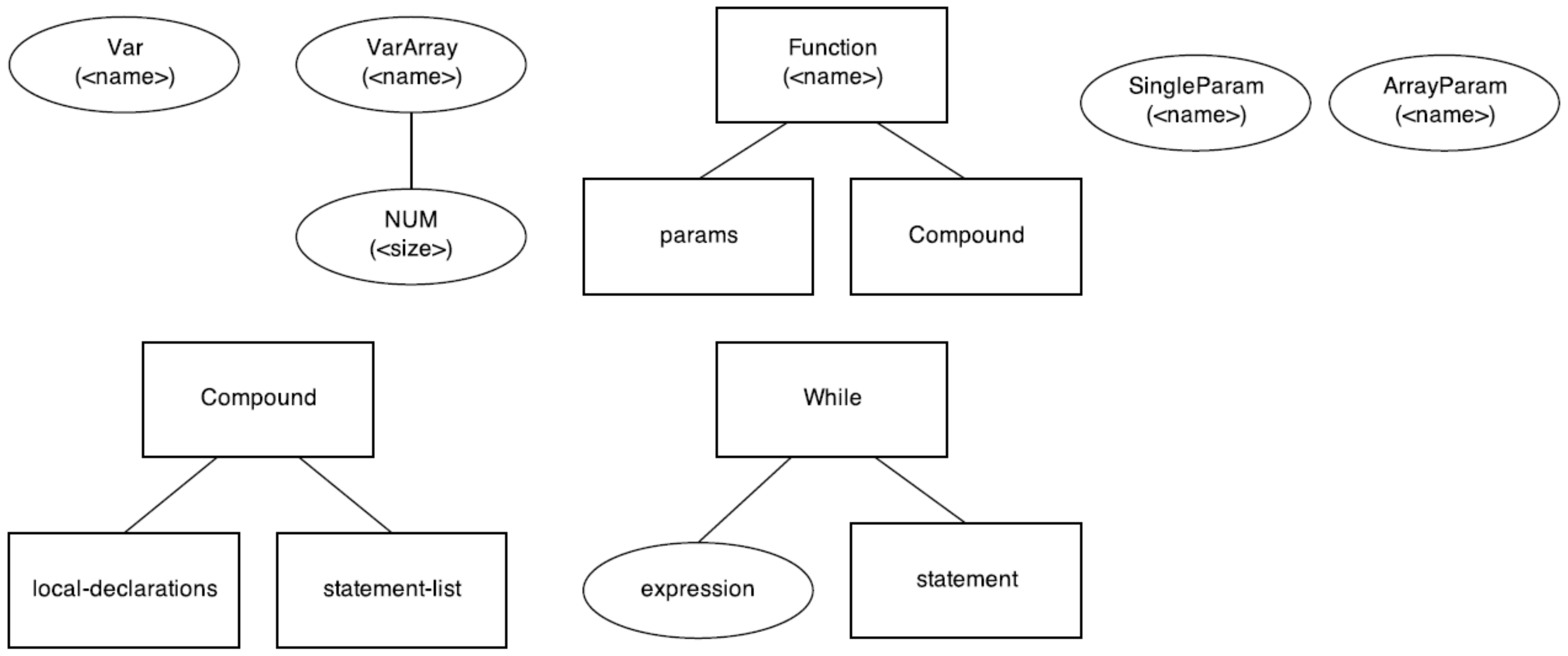
Project #2. Parser

Parser

- **C-Minus Parser Implementation**
  - **Implement the parser using Yacc (bison)**
    - C-Minus Scanner with Flex should be used.
    - Some source code should be obtained using Yacc (bison)

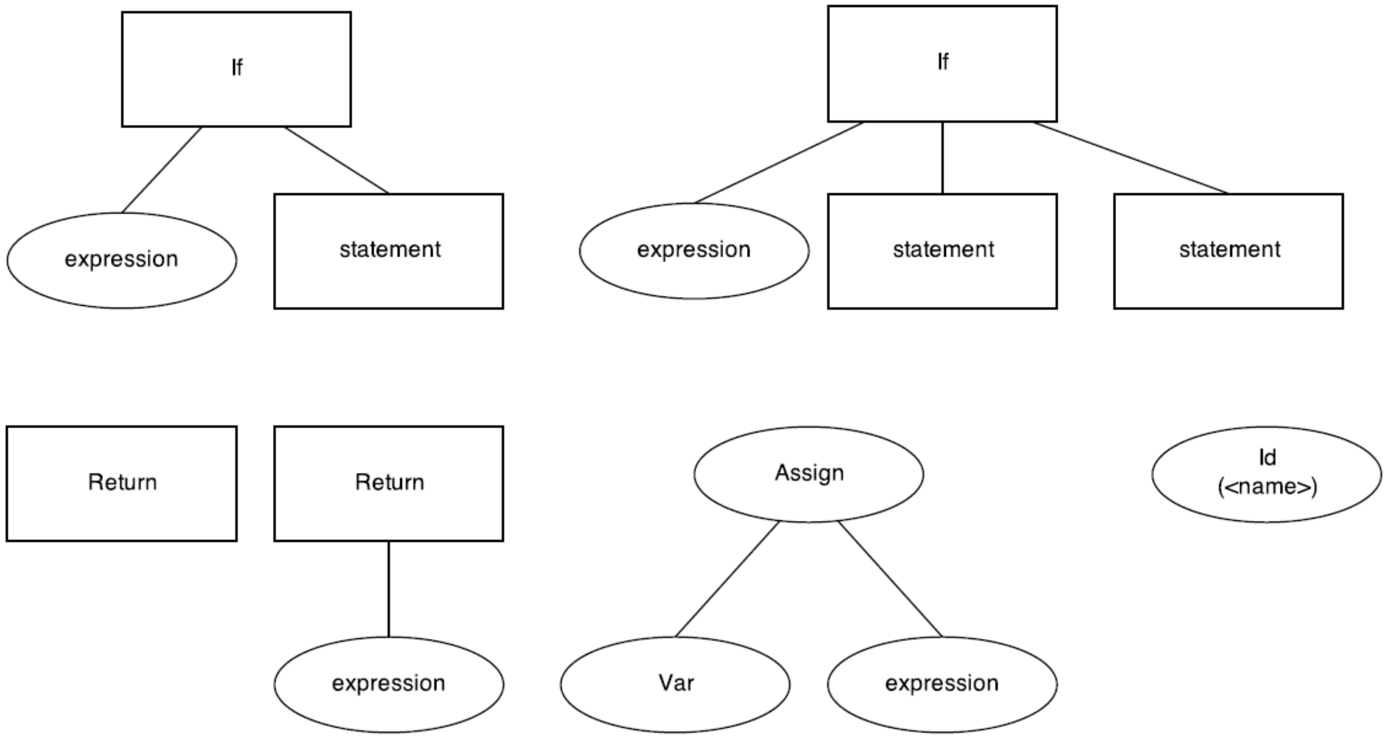
Parser Goal

- **Syntax Tree Definition**



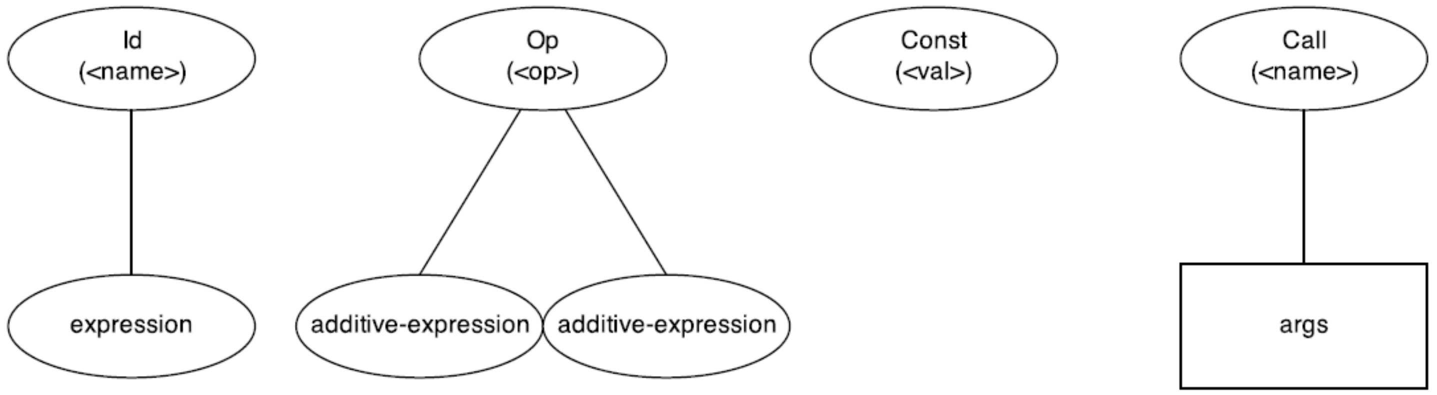
Parser Goal

- **Syntax Tree Definition**



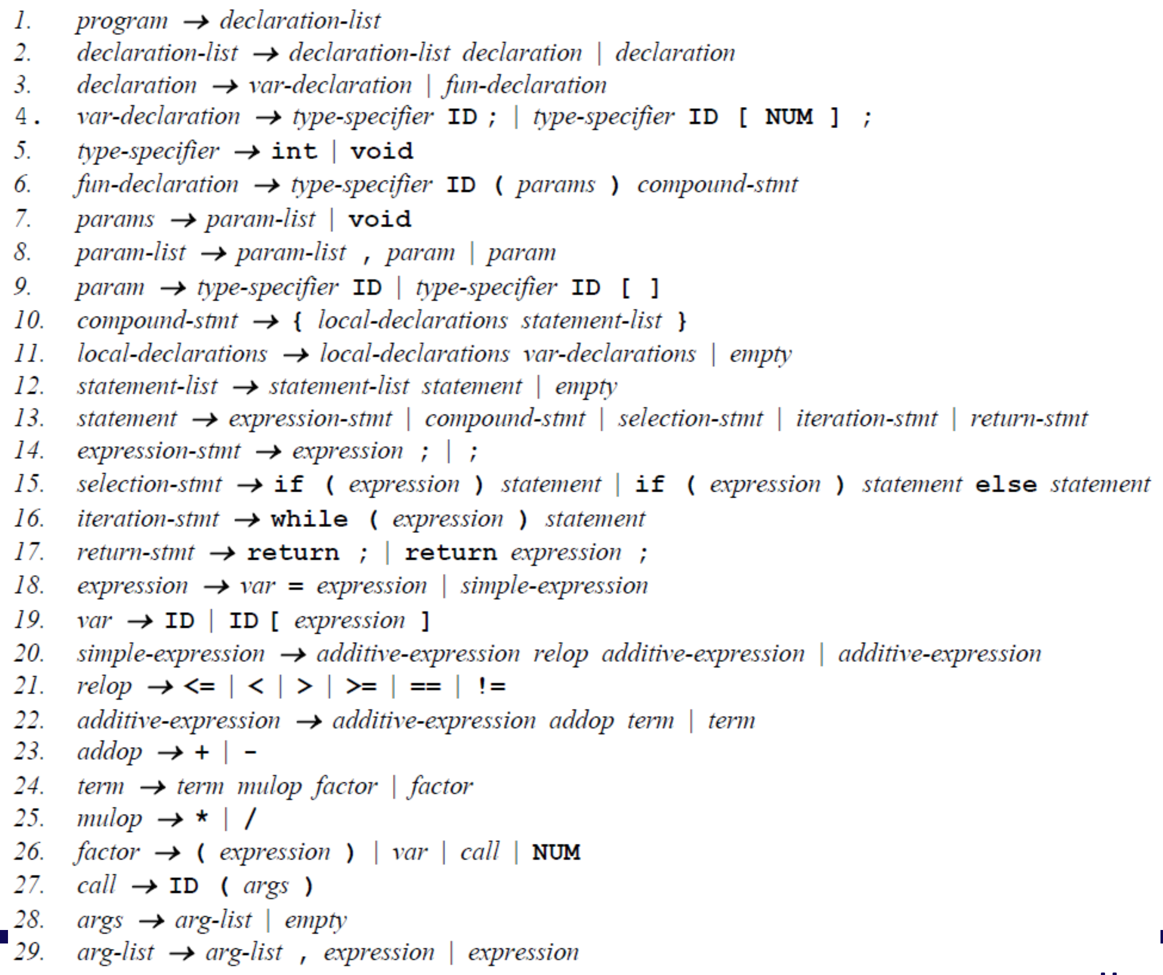
Parser Goal

- **Syntax Tree Definition**



BNF Grammar for C-Minus

- **Appendix A.2**



1. *program* → *declaration-list*
2. *declaration-list* → *declaration-list declaration* | *declaration*
3. *declaration* → *var-declaration* | *fun-declaration*
4. *var-declaration* → *type-specifier* `ID` `;` | *type-specifier* `ID` `[` `NUM` `]` `;`
5. *type-specifier* → `int` | `void`
6. *fun-declaration* → *type-specifier* `ID` `(` *params* `)` *compound-stmt*
7. *params* → *param-list* | `void`
8. *param-list* → *param-list* `,` *param* | *param*
9. *param* → *type-specifier* `ID` | *type-specifier* `ID` `[` `]`
10. *compound-stmt* → `{` *local-declarations statement-list* `}`
11. *local-declarations* → *local-declarations var-declarations* | *empty*
12. *statement-list* → *statement-list statement* | *empty*
13. *statement* → *expression-stmt* | *compound-stmt* | *selection-stmt* | *iteration-stmt* | *return-stmt*
14. *expression-stmt* → *expression* `;` | `;`
15. *selection-stmt* → `if` `(` *expression* `)` *statement* | `if` `(` *expression* `)` *statement* `else` *statement*
16. *iteration-stmt* → `while` `(` *expression* `)` *statement*
17. *return-stmt* → `return` `;` | `return` *expression* `;`
18. *expression* → *var* `=` *expression* | *simple-expression*
19. *var* → `ID` | `ID` `[` *expression* `]`
20. *simple-expression* → *additive-expression relop additive-expression* | *additive-expression*
21. *relop* → `<=` | `<` | `>` | `>=` | `==` | `!=`
22. *additive-expression* → *additive-expression addop term* | *term*
23. *addop* → `+` | `-`
24. *term* → *term mulop factor* | *factor*
25. *mulop* → `*` | `/`
26. *factor* → `(` *expression* `)` | *var* | *call* | `NUM`
27. *call* → `ID` `(` *args* `)`
28. *args* → *arg-list* | *empty*
29. *arg-list* → *arg-list* `,` *expression* | *expression*

Dangling Else Problem

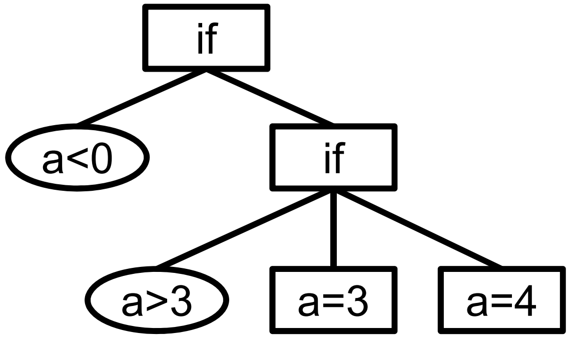
- Ambiguous(Conflict) in 13, 15

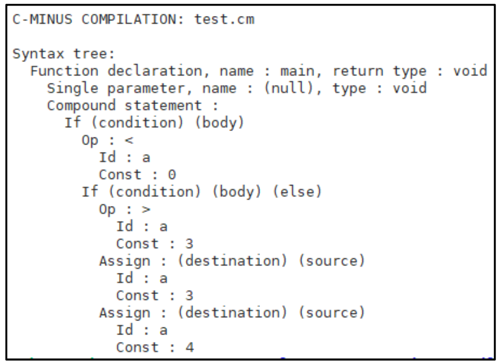
```
/* dangling else example */
void main(void) { if( a < 0 )   if ( a > 3 ) a = 3;   else a = 4; }
```

```
(1)    void main(void) { if( a < 0 )   if ( a > 3 ) a = 3;   else a = 4; }
(2)    void main(void) { if( a < 0 )   if ( a > 3 ) a = 3;   else a = 4; }
```

(2)

- Rule: Associate the else with the nearest if

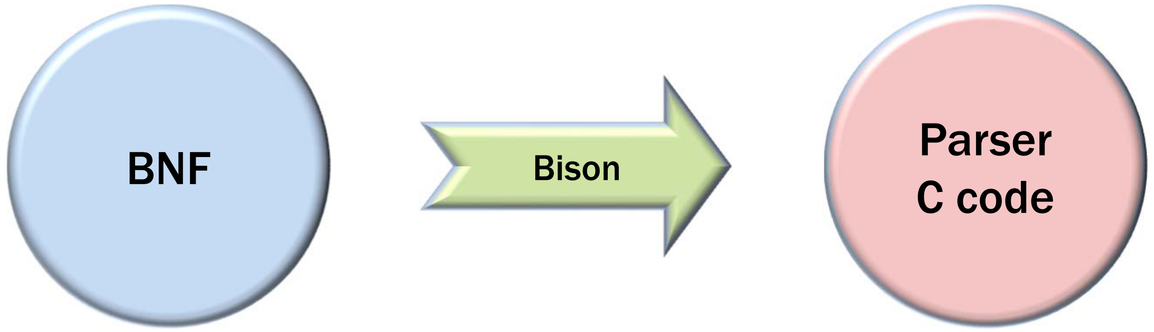




```
C-MINUS COMPILATION: test.cm

Syntax tree:
  Function declaration, name : main, return type : void
    Single parameter, name : (null), type : void
    Compound statement :
      If (condition) (body)
        Op : <
          Id : a
          Const : 0
        If (condition) (body) (else)
          Op : >
            Id : a
            Const : 3
          Assign : (destination) (source)
            Id : a
            Const : 3
          Assign : (destination) (source)
            Id : a
            Const : 4
```

Yacc (bison)

- Yacc: Parser generator for UNIX
  - Yet Another Compiler Compiler
  - Bison: GNU Project parser generator (yacc replacement)
- Input BNF
- Output: C-code of parser for the input BNF



Yacc (bison) source description

Definitions

%%

Rules (BNF syntax)

%%

~~Subroutines~~

(You don’t need to modify this part)

Yacc (bison) source example - tiny

- **definitions**

```
%token IF THEN ELSE END REPEAT UNTIL READ WRITE
%token ID NUM
%token ASSIGN EQ LT PLUS MINUS TIMES OVER LPAREN RPAREN SEMI
%token ERROR
```

- **rules**

```
  $$          $1  $2  $3      $4     $5
if_stmt      : IF exp THEN stmt_seq END
                  { $$ = newStmtNode(IfK);
                    $$->child[0] = $2;
                    $$->child[1] = $4;
                  }
             | IF exp THEN stmt_seq ELSE stmt_seq END
                  { $$ = newStmtNode(IfK);
                    $$->child[0] = $2;
                    $$->child[1] = $4;
                    $$->child[2] = $6;
                  }
             ;
```

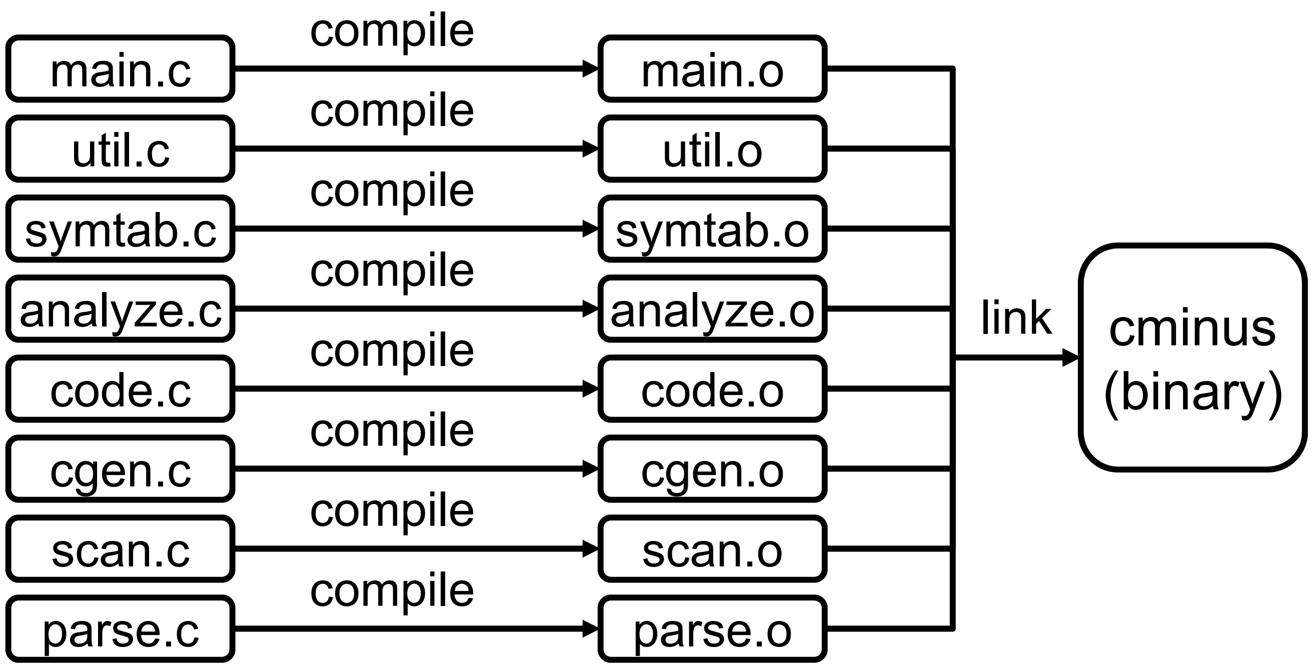
Yacc (bison) Usage & Manual

```
Usage: yacc [options] filename

Options:
  -d                  write definitions (y.tab.h)
  -o output_file      (default "y.tab.c")
  -t                  add debugging support
  -v                  write description (y.output)
```

- **Manual**
  http://www.gnu.org/software/bison/manual/ (English)

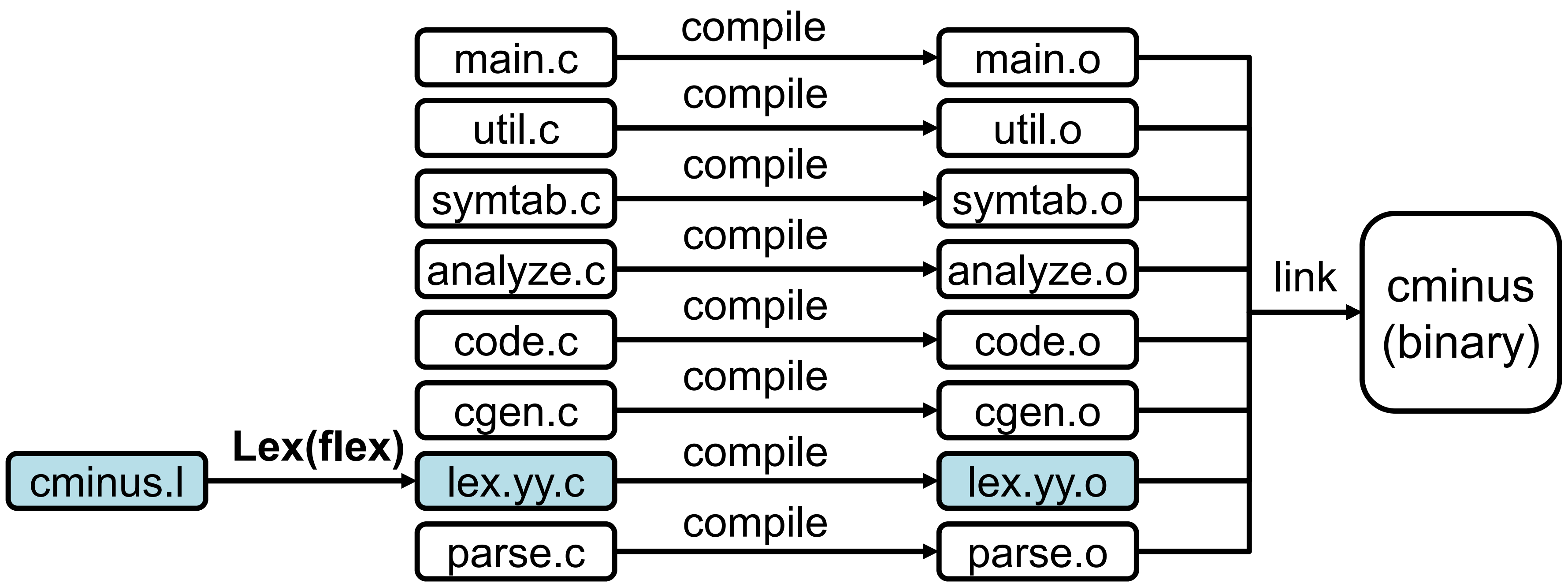
Hint: How to build?

- **Using c-implementation (= original tiny compiler build structure)**



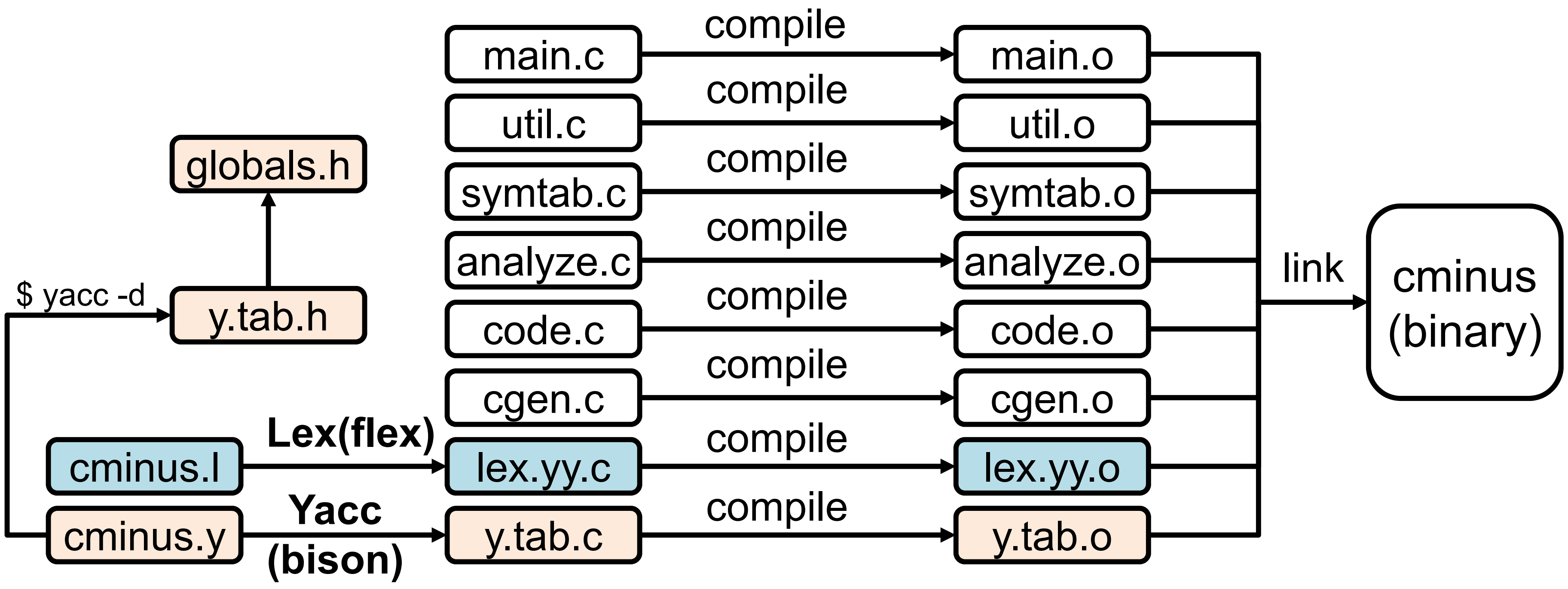
Hint: How to build?

- **Using Lex for scanner**

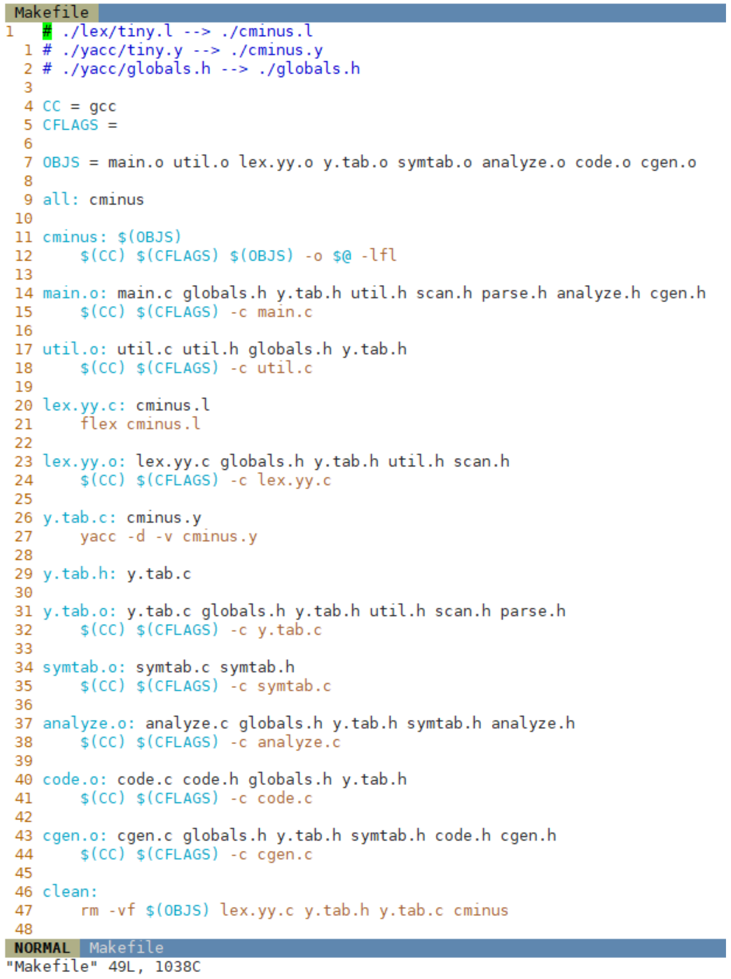


Hint: How to build?

- **Using Yacc for parser(this project)**



Hint: Build with Makefile

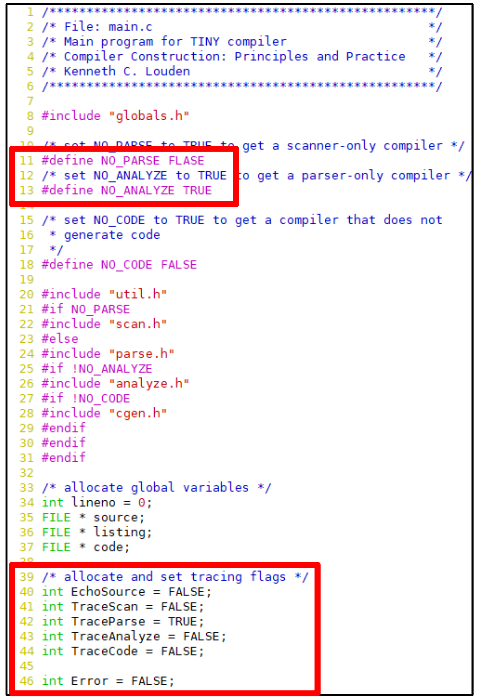


```makefile
# ./lex/tiny.l --> ./cminus.l
# ./yacc/tiny.y --> ./cminus.y
# ./yacc/globals.h --> ./globals.h

CC = gcc
CFLAGS =

OBJS = main.o util.o lex.yy.o y.tab.o symtab.o analyze.o code.o cgen.o

all: cminus

cminus: $(OBJS)
	$(CC) $(CFLAGS) $(OBJS) -o $@ -lfl

main.o: main.c globals.h y.tab.h util.h scan.h parse.h analyze.h cgen.h
	$(CC) $(CFLAGS) -c main.c

util.o: util.c util.h globals.h y.tab.h
	$(CC) $(CFLAGS) -c util.c

lex.yy.c: cminus.l
	flex cminus.l

lex.yy.o: lex.yy.c globals.h y.tab.h util.h scan.h
	$(CC) $(CFLAGS) -c lex.yy.c

y.tab.c: cminus.y
	yacc -d -v cminus.y

y.tab.h: y.tab.c

y.tab.o: y.tab.c globals.h y.tab.h util.h scan.h parse.h
	$(CC) $(CFLAGS) -c y.tab.c

symtab.o: symtab.c symtab.h
	$(CC) $(CFLAGS) -c symtab.c

analyze.o: analyze.c globals.h y.tab.h symtab.h analyze.h
	$(CC) $(CFLAGS) -c analyze.c

code.o: code.c code.h globals.h y.tab.h
	$(CC) $(CFLAGS) -c code.c

cgen.o: cgen.c globals.h y.tab.h symtab.h code.h cgen.h
	$(CC) $(CFLAGS) -c cgen.c

clean:
	rm -vf $(OBJS) lex.yy.c y.tab.h y.tab.c cminus

```

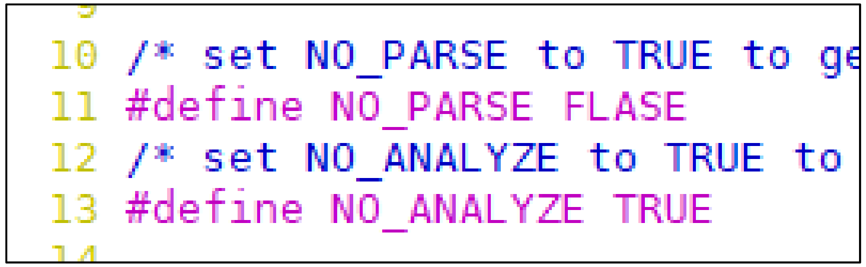
```
"Makefile" 49L, 1038C
```

Hint: where to see?

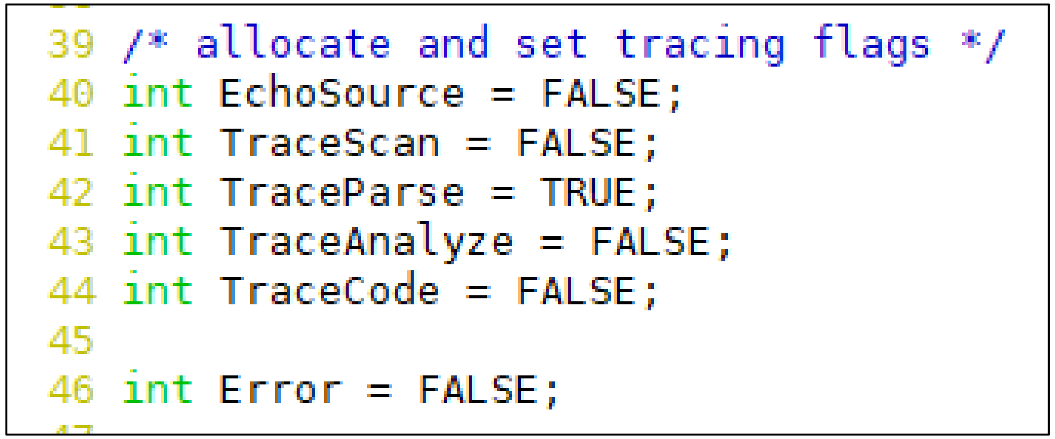
- **main.c**
  - To modify code to print *only* Syntax Tree
  - NO_ANALYZE, TraceParser



```c
/***********************************************************/
/* File: main.c                                            */
/* Main program for TINY compiler                          */
/* Compiler Construction: Principles and Practice          */
/* Kenneth C. Louden                                       */
/***********************************************************/

#include "globals.h"

/* set NO_PARSE to TRUE to get a scanner-only compiler */
#define NO_PARSE FLASE
/* set NO_ANALYZE to TRUE to get a parser-only compiler */
#define NO_ANALYZE TRUE

/* set NO_CODE to TRUE to get a compiler that does not
 * generate code
 */
#define NO_CODE FALSE

#include "util.h"
#if NO_PARSE
#include "scan.h"
#else
#include "parse.h"
#if !NO_ANALYZE
#include "analyze.h"
#if !NO_CODE
#include "cgen.h"
#endif
#endif
#endif

/* allocate global variables */
int lineno = 0;
FILE * source;
FILE * listing;
FILE * code;

/* allocate and set tracing flags */
int EchoSource = FALSE;
int TraceScan = FALSE;
int TraceParse = TRUE;
int TraceAnalyze = FALSE;
int TraceCode = FALSE;

int Error = FALSE;
```



```c
/* set NO_PARSE to TRUE to ge
#define NO_PARSE FLASE
/* set NO_ANALYZE to TRUE to
#define NO_ANALYZE TRUE
```



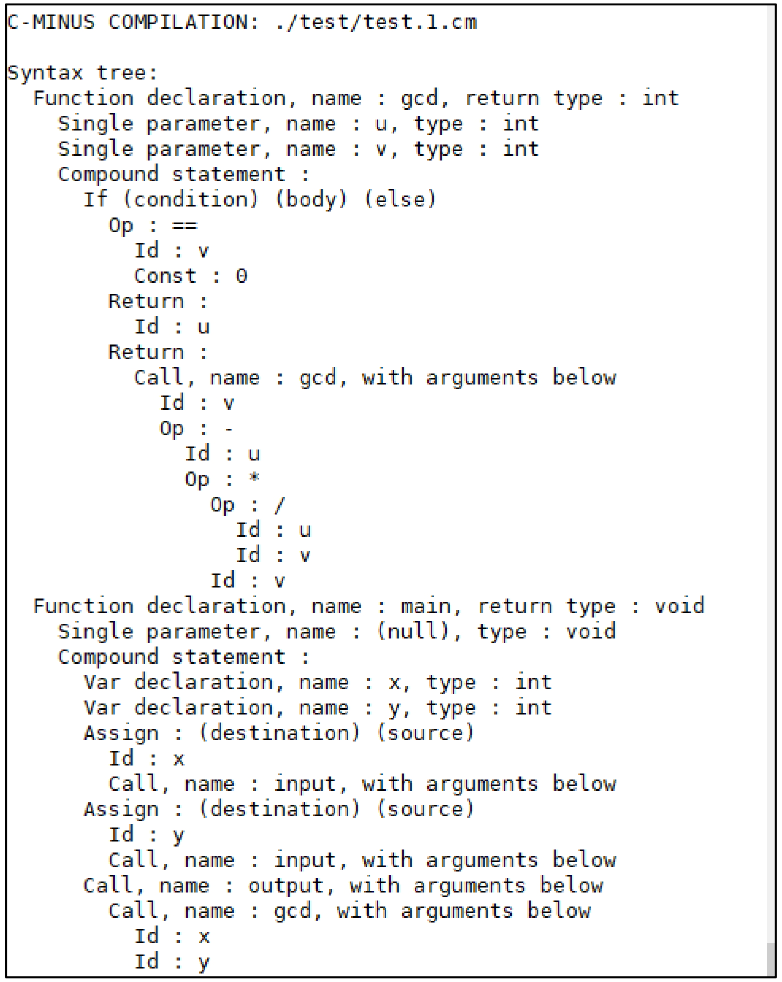
```c
/* allocate and set tracing flags */
int EchoSource = FALSE;
int TraceScan = FALSE;
int TraceParse = TRUE;
int TraceAnalyze = FALSE;
int TraceCode = FALSE;

int Error = FALSE;
```

Hint: where to see?

- **util.c**
  - printTree function should be updated to print C-Minus Syntax Tree
- **globals.h**
  - Overwrite your globals.h with yacc/globals.h
  - “Syntax tree for parsing” should be updated to meet C-Minus Spec
- **yacc/tiny.y**
  - Baseline of cminus.y
- **Other files(analyze.c, cgen.c, …)**
  - If need

Example (Syntax tree)

```
/* A program to perform Euclid's
   Algorithm to computer gcd */

int gcd (int u, int v)
{
    if (v == 0) return u;
    else return gcd(v,u-u/v*v);
    /* u-u/v*v == u mod v */
}

void main(void)
{
    int x; int y;
    x = input(); y = input();
    output(gcd(x,y));
}
```



```
C-MINUS COMPILATION: ./test/test.1.cm

Syntax tree:
  Function declaration, name : gcd, return type : int
    Single parameter, name : u, type : int
    Single parameter, name : v, type : int
    Compound statement :
      If (condition) (body) (else)
        Op : ==
          Id : v
          Const : 0
        Return :
          Id : u
        Return :
          Call, name : gcd, with arguments below
            Id : v
            Op : -
              Id : u
              Op : *
                Op : /
                  Id : u
                  Id : v
                Id : v
  Function declaration, name : main, return type : void
    Single parameter, name : (null), type : void
    Compound statement :
      Var declaration, name : x, type : int
      Var declaration, name : y, type : int
      Assign : (destination) (source)
        Id : x
        Call, name : input, with arguments below
      Assign : (destination) (source)
        Id : y
        Call, name : input, with arguments below
      Call, name : output, with arguments below
        Call, name : gcd, with arguments below
          Id : x
          Id : y
```

Some Comments

- You don’t need to generate exactly same output. If you generate the right result, it will be okay.

- You don’t need to care about Semantics, just Syntax analyzer will be okay.

Some Comments

```
/* Semantic Error Example */
/* (1) uninitialized variables a and b (2) undefined variable c */
void main ( void )
{
    int a;
    int b;
    c = a + b;
}
```

- **For this example, this code will be parsed correctly even though the code has some semantic error.**

Report

- **Guideline**
  - Compilation method and environment
  - Explanation about how to implement and how to operate
  - Some explanation about the modified code
  - Example and Result Screenshot

- **File format**
  - MS Word, HWP, PDF, …
  - GitLab Wiki Not Allowed
    (If you want, write report in markdown and **take screenshot** and submit in other formats(PDF, JPEG, …))

Submission

- Submission directory in repository: **2_Parser**

  (Please submit all your codes and reports into the submission directory)

- Questions

  compiler.teachingassistant@gmail.com

- Parser submission deadline
  - 11/24(Sun) 23:59:59

Contact (Prof. Yongjun Park)

- **Submission**
  - Where: Using GitLab
    - https://hconnect.hanyang.ac.kr
    - Git Project: **https://hconnect.hanyang.ac.kr/2019_ELE4029_12214/2019_ELE4029_Student#.git**
    - Example URL: https://hconnect.hanyang.ac.kr/2019_ELE4029_12214/2019_ELE4029_2019000000.git
    - The Submission Directory is in Repo: 1_Scanner, 2_Parser, 3_Semantic, …
  - Teaching Assistant
    - **compiler.teachingassistant@gmail.com**
    - **If you don't have the GITLAB account, please let him know the account information after creation.**
  - **What to submit**
    - **All the source codes and the report**