

COMPILER CONSTRUCTION

Yacc
Yet Another Compiler-Compiler

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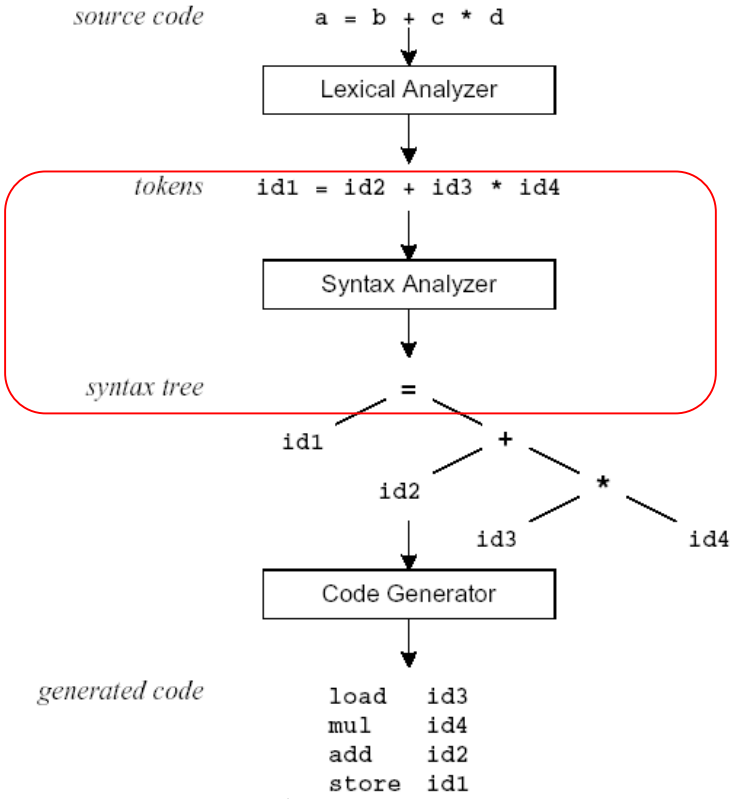
Courtesy of CSE4100, Lex and Yacc, CSE, University of Connecticut. Prof. Steven A. Demurjian; Lex Yacc tutorial, PLLAB, CS, NTHU. Dr. Kun-Yuan Hsieh.



Where are we?

- Lex and Yacc are able to do the following
- Now, our target is Yacc





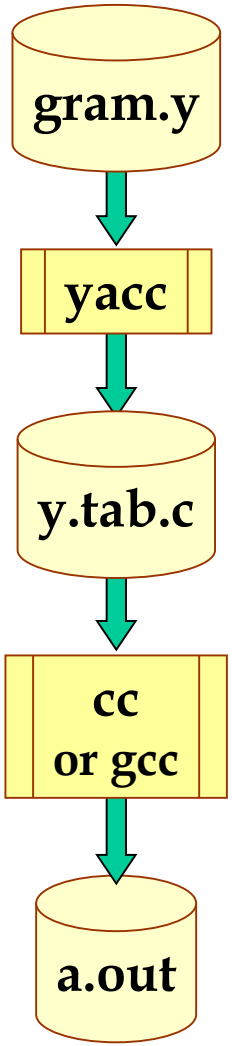
Introduction

- What is **YACC** ?
  - **Tool which will produce a parser for a given grammar**

- YACC (Yet Another Compiler Compiler) is a program designed
  - to compile a LALR(1) grammar and
  - to produce the source code of the syntactic analyzer of the language produced by this grammar



How Yacc Works?



File containing desired grammar in yacc format

yacc program (executable)

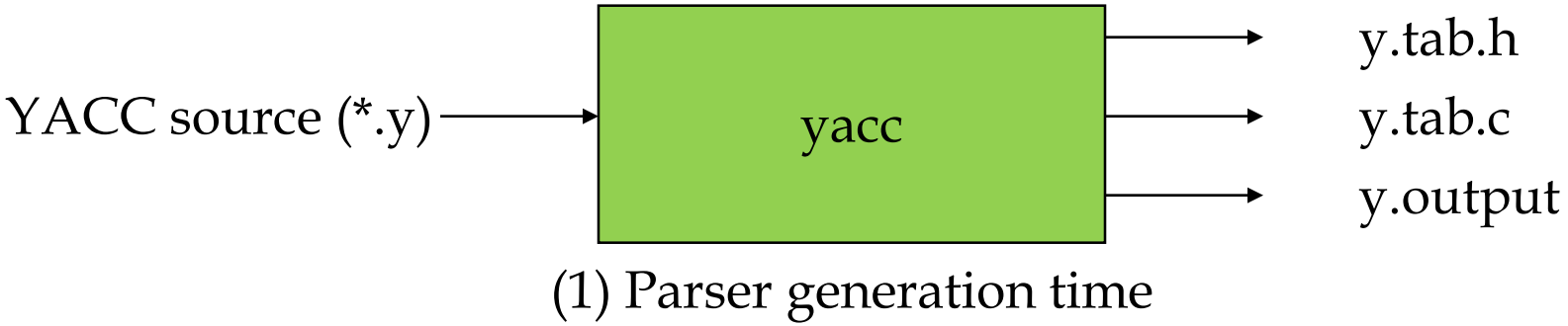
C source program created by yacc

C compiler (executable)

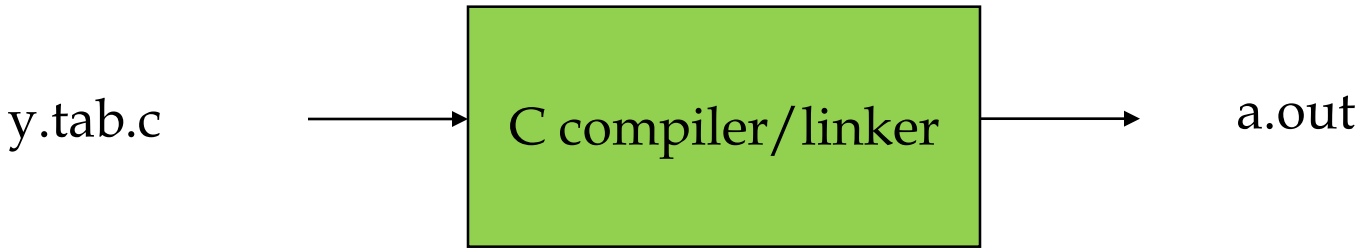
Executable program that will parse grammar given in gram.y



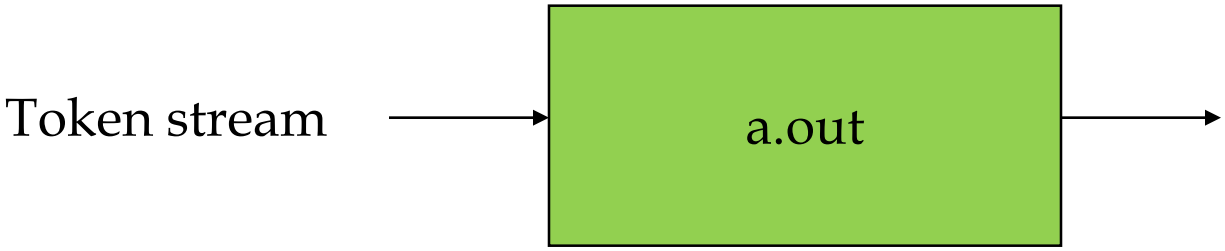
How Yacc Works? (Cont'd)



(1) Parser generation time



(2) Compile time



Abstract Syntax Tree (We dump messages in the assignments)

(3) Run time



Yacc and Lex

LEX
yylex()

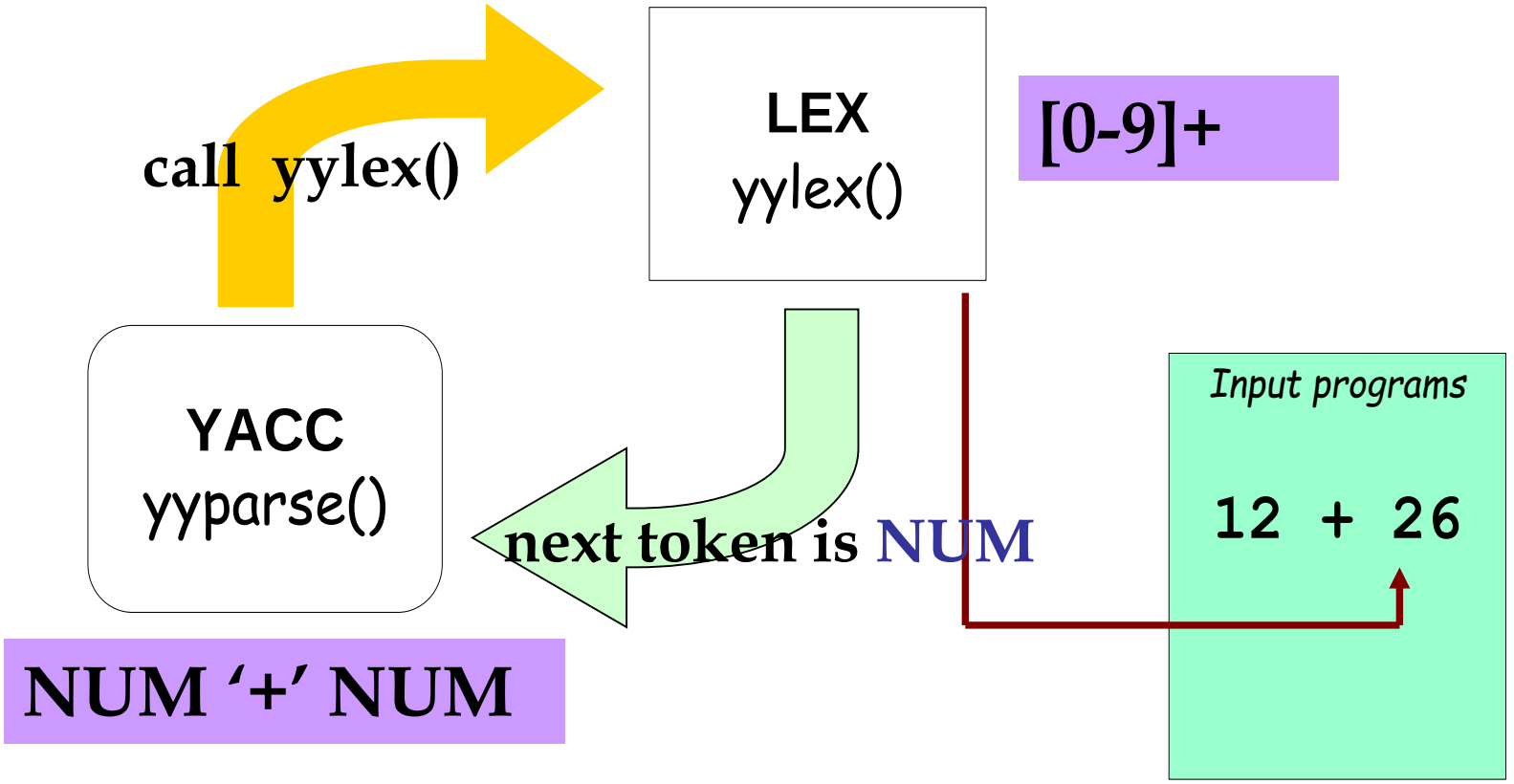
YACC
yyparse()

What's going on?

Input programs

```
12 + 26
```

Yacc and Lex (Control Flow)





An Yacc File Example

- Similar to Lex, Yacc program could be divided into three parts

```
%{
#include <stdio.h>
%}

%token NAME NUMBER
%%

statement: NAME '=' expression
        | expression            { printf("= %d\n", $1); }
        ;

expression: expression '+' NUMBER { $$ = $1 + $3; }
        |   expression '-' NUMBER { $$ = $1 - $3; }
        |   NUMBER                { $$ = $1; }
        ;
%%
int yyerror(char *s)
{
   fprintf(stderr, "%s\n", s);
   return 0;
}

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

C code

Grammar rules and actions

C routines



Yacc File Format

%{

C declarations

%}

yacc declarations

%%

Grammar rules

%%

Additional C code

- **Comments enclosed in /* ... */ may appear in any of the sections.**



Declarations

```
%{
#include <stdio.h>
#include <stdlib.h>
%}
%token ID NUM
%start expr
```

It is a terminal

由 expr 開始parse



Start Symbol

- The first non-terminal specified in the ***grammar specification section***

- To overwrite it with %start declaraction

```
%start  non-terminal
```



Grammar Rules Section

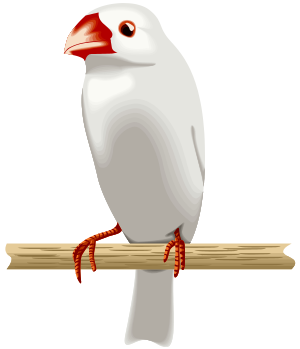
- This section defines grammar
- Example
  - expr : expr '+' term | term;
  - term : term '*' factor | factor;
  - factor : '(' expr ')' | ID | NUM;



Grammar Rules Section (Cont'd)

- Typically, the yacc's rules in the *.y* file look like below
- Example

```
expr    : expr '+' term
        | term
        ;
term    : term '*' factor
        | factor
        ;
factor  : '(' expr ')'
        | ID
        | NUM
        ;
```





The Position of Grammar Rules (1/4)

```
expr : expr '+' term     { $$ = $1 + $3; }
     | term              { $$ = $1; }
     ;
term : term '*' factor   { $$ = $1 * $3; }
     | factor            { $$ = $1; }
     ;
factor : '(' expr ')'    { $$ = $2; }
       | ID
       | NUM
       ;
```

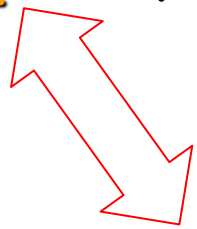
The Position of Grammar Rules (2/4)

```
expr : expr '+' term     { $$ = $1 + $3; }
     | term              { $$ = $1; }
     ;
term : term '*' factor   { $$ = $1 * $3; }
     | factor            { $$ = $1; }
     ;
factor : '(' expr ')'    { $$ = $2; }
       | ID
       | NUM
       ;
```



The Position of Grammar Rules (3/4)

```
expr   : expr '+' term      { $$ = $1 + $3; }
       | term               { $$ = $1; }
       ;
term   : term '*' factor    { $$ = $1 * $3; }
       | factor             { $$ = $1; }
       ;
factor : '(' expr ')'       { $$ = $2; }
       | ID
       | NUM
       ;
```



$2



The Position of Grammar Rules (4/4)

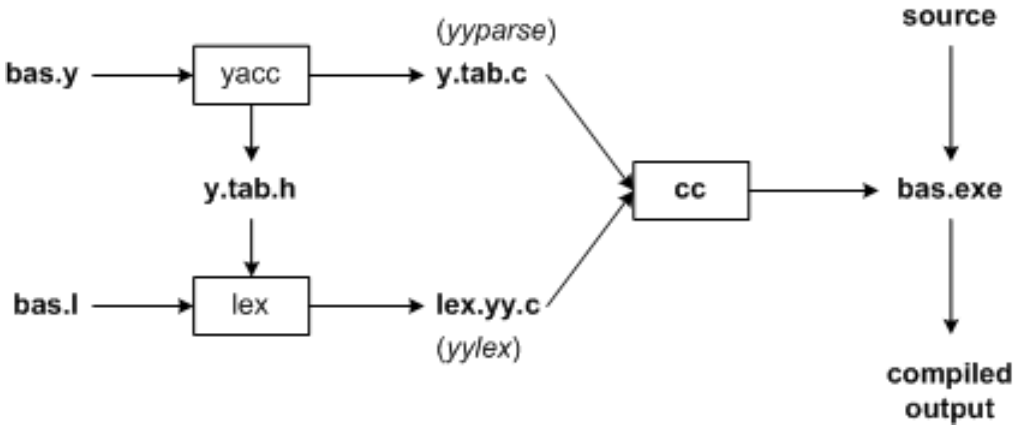
```
expr   : expr '+' term      { $$ = $1 + $3; }
       | term               { $$ = $1; }
       ;
term   : term '*' factor    { $$ = $1 * $3; }
       | factor             { $$ = $1; }
       ;
factor : '(' expr ')'       { $$ = $2; }
       | ID
       | NUM
       ;
```

← Default: $$ = $1;

$3



More about the Lex & Yacc Files

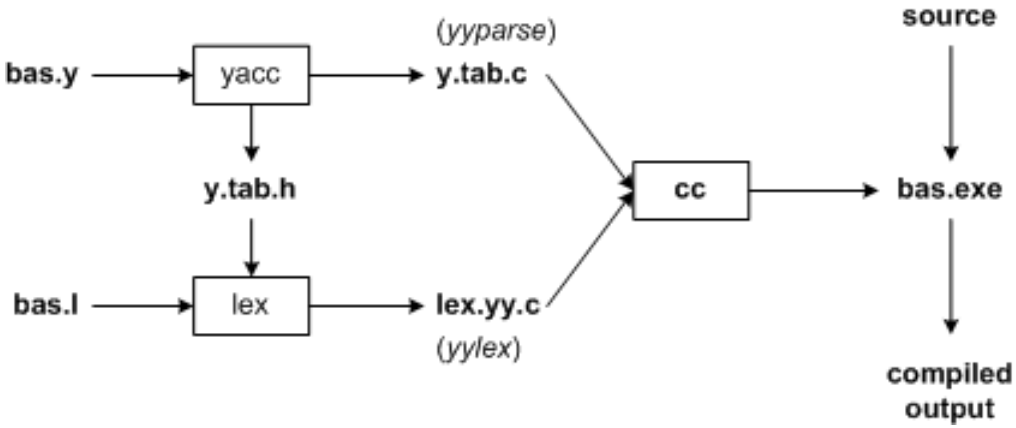


- The figure illustrates the file naming conventions used by lex and yacc
- We need to specify all pattern matching rules for Lex (bas.l) and grammar rules for Yacc (bas.y)
- Commands to create the compiler, bas.exe, are listed below:

```
yacc -d bas.y                  # create y.tab.h, y.tab.c
lex bas.l                      # create lex.yy.c
cc lex.yy.c y.tab.c -o bas.exe # compile/link
```

Courtesy of http://epaperpress.com/lexandyacc/intro.html

More about the Lex & Yacc Files (Cont'd)



- Yacc reads the grammar descriptions in bas.y and generates a syntax analyzer (parser)
  - that includes function yyparse, in file y.tab.c
  - Included in file bas.y are token declarations
  - The -d option asks yacc to generate definitions for tokens and place them in file y.tab.h
- Lex reads the pattern descriptions in bas.l, includes file y.tab.h, and
  - generates a lexical analyzer, function yylex, in file lex.yy.c
- Finally, the lexer and parser are compiled and linked together to create executable bas.exe
  - From main we call yyparse to run the compiler
  - Function yyparse automatically calls yylex to obtain each token

Courtesy of http://epaperpress.com/lexandyacc/intro.html



Data Sharing between Lex and Yacc

scanner.l

```
%{
#include <stdio.h>
#include "y.tab.h"
%}
id      [_a-zA-Z][_a-zA-Z0-9]*
%%
int     { return INT; }
char    { return CHAR; }
float   { return FLOAT; }
{id}    { return ID;}
```

parser.y

```
%{
#include <stdio.h>
#include <stdlib.h>
%}
%token  CHAR, FLOAT, ID, INT
%%
```

yacc -d xxx.y

Produced

y.tab.h:

```
# define CHAR 258
# define FLOAT 259
# define ID 260
# define INT 261
```



Internals of Yacc

- Rules may be recursive ← No problem
- Rules may be ambiguous ← You have learnt how to avoid ambiguous grammar.
- Uses bottom-up parsing
  - Also known as Shift/Reduce parsing
  - Get a token
  - Push onto stack
  - Can it reduced (How do we know?) ← Use **printf** wisely
    - If yes: Reduce using a rule
    - If no: Get another token
- Yacc cannot look ahead more than one token



Internals of Yacc (Cont'd)

- **shift/reduce conflict**
  - occurs when a grammar is written in such a way that a decision between shifting and reducing can not be made
  - E.g., IF-ELSE ambigious
- To resolve this conflict, yacc will choose to shift
- In order to take control of the parsing procedure
  - You could rewrite the grammar to avoid the conflict



Put It All Together

Parser

```
expr : expr '+' term     { $$ = $1 + $3; }
     | term              { $$ = $1; }
     ;
term : term '*' factor   { $$ = $1 * $3; }
     | factor            { $$ = $1; }
     ;
factor : '(' expr ')'    { $$ = $2; }
       | ID
       | NUM
       ;
```

← Default: $$ = $1;

An expression:

a = 4 + 6

// a=10

Scanner

```
%{
#include "y.tab.h"
#include "parser.h"
#include <math.h>
%}
%%
([0-9]+|([0-9]*\.[0-9]+)([eE][-+]?[0-9]+)?) {
    yylval.dval = atof(yytext);
   return NUM;
   }

[ \t]     ;                    /* ignore white space */
```



Yacc Declarations

`**%start**'

Specify the grammar's start symbol

`**%union**'

Declare the collection of data types that semantic values may have

`**%token**'

Declare a terminal symbol (token type name) with no precedence or associativity specified

`**%type**'

Declare the type of semantic values for a nonterminal symbol

Using the declared names from the %union



Yacc Declarations (Cont'd)

`**%right**'

Declare a terminal symbol (token type name) that is right-associative

`**%left**'

Declare a terminal symbol (token type name) that is left-associative

`**%nonassoc**'

Declare a terminal symbol (token type name) that is nonassociative

I.e., using it in a way that would be associative is a syntax error, e.g., x *op*. y *op*. z is syntax error



References

- Please refer to the online manual for Yacc on The Lex & Yacc Page

- lex & yacc, 2nd Edition
  - by John R.Levine, Tony Mason & Doug Brown
  - O'Reilly
  - ISBN: 1-56592-000-7



QUESTIONS?