COMPILER CONSTRUCTION

Yacc

Yet Another Compiler-Compiler

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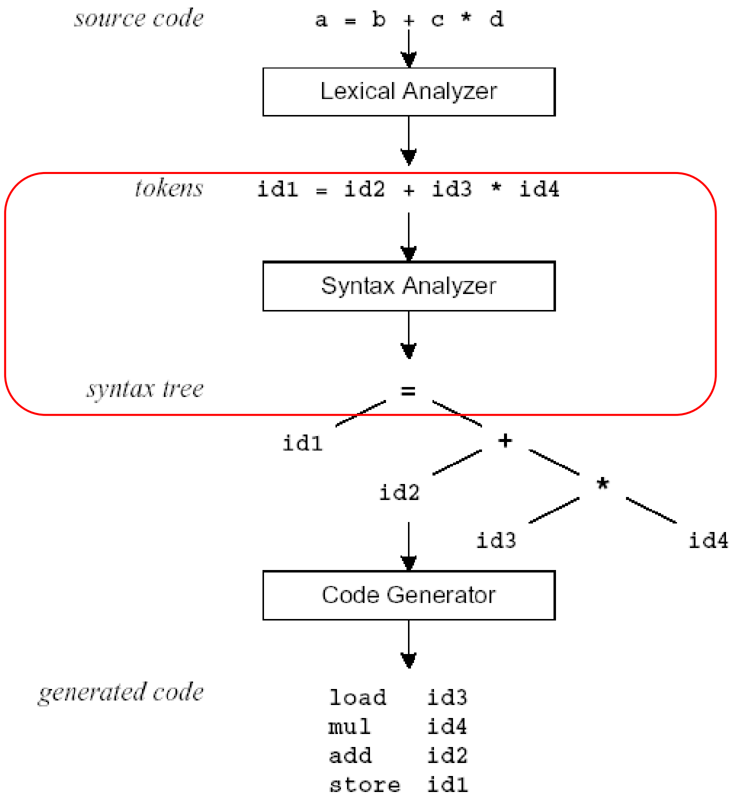
Courtesy of CSE4100, Lex and Yacc, CSE, University of Connecticut. Prof. Steven A. Demurjian; Lex Yacc tutorial, PLLAB, CS, NTHU. Dr. Kun-Yuan Hsieh.

Where are we?

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

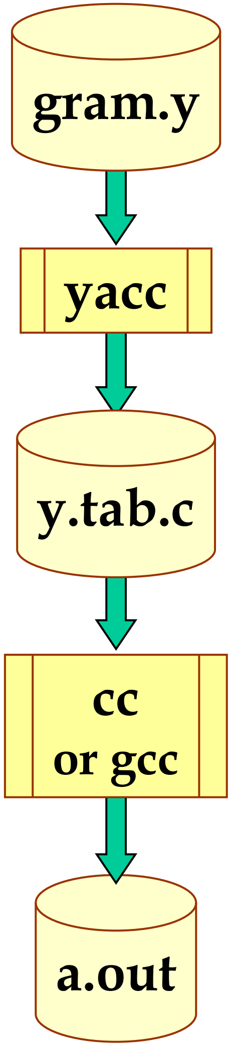


Introduction

- 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

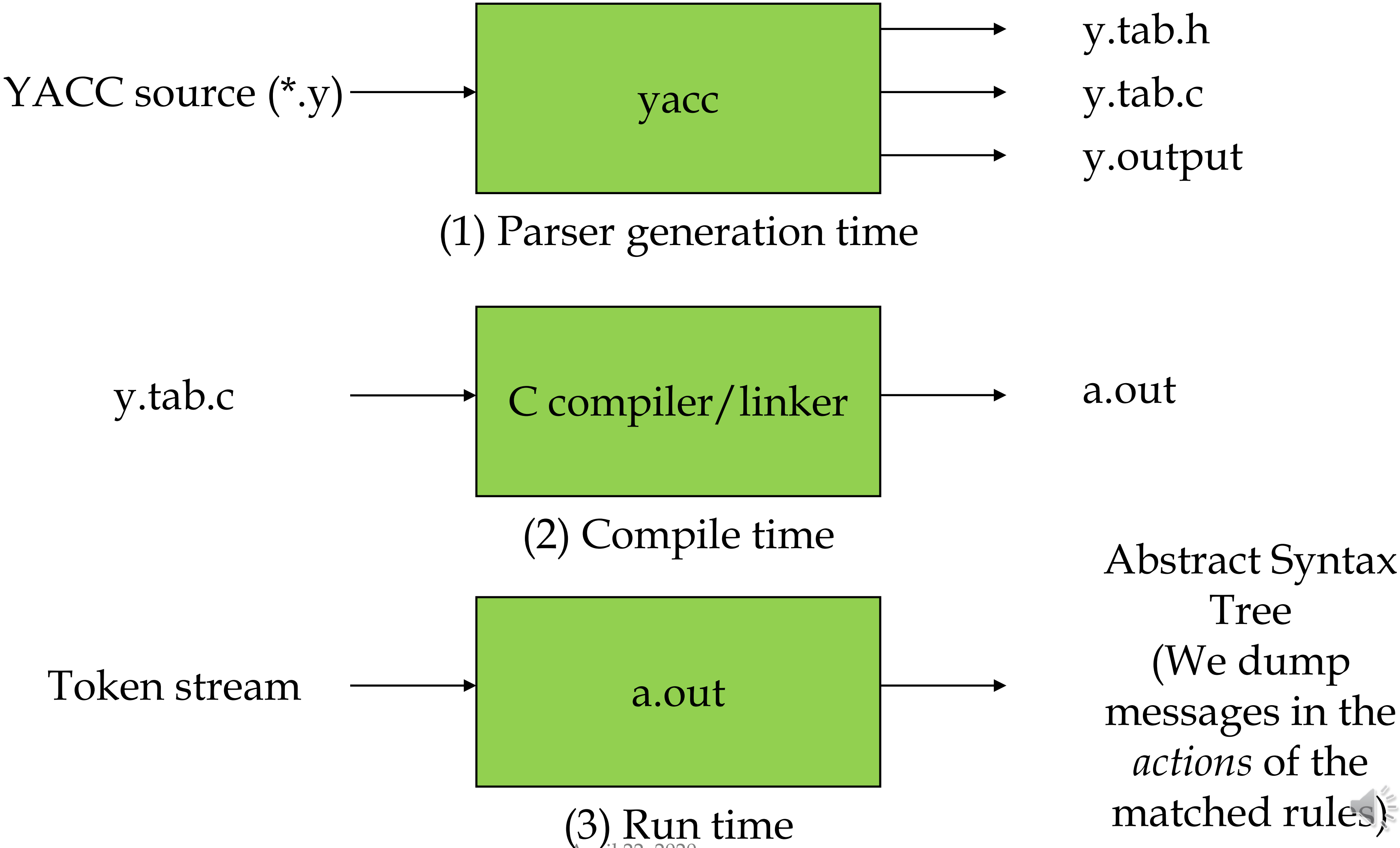
yacc program (executable)

C source program created by yacc

C compiler (executable)

Executable program that will parse grammar given in gram.y

How Yacc Works? (Cont'd)



YACC source (*.y) → yacc → y.tab.h, y.tab.c, y.output

(1) Parser generation time

y.tab.c → C compiler/linker → a.out

(2) Compile time

Token stream → a.out → Abstract Syntax Tree (We dump messages in the *actions* of the matched rules)

(3) Run time

Yacc and Lex

LEX
yylex()

YACC
yyparse()

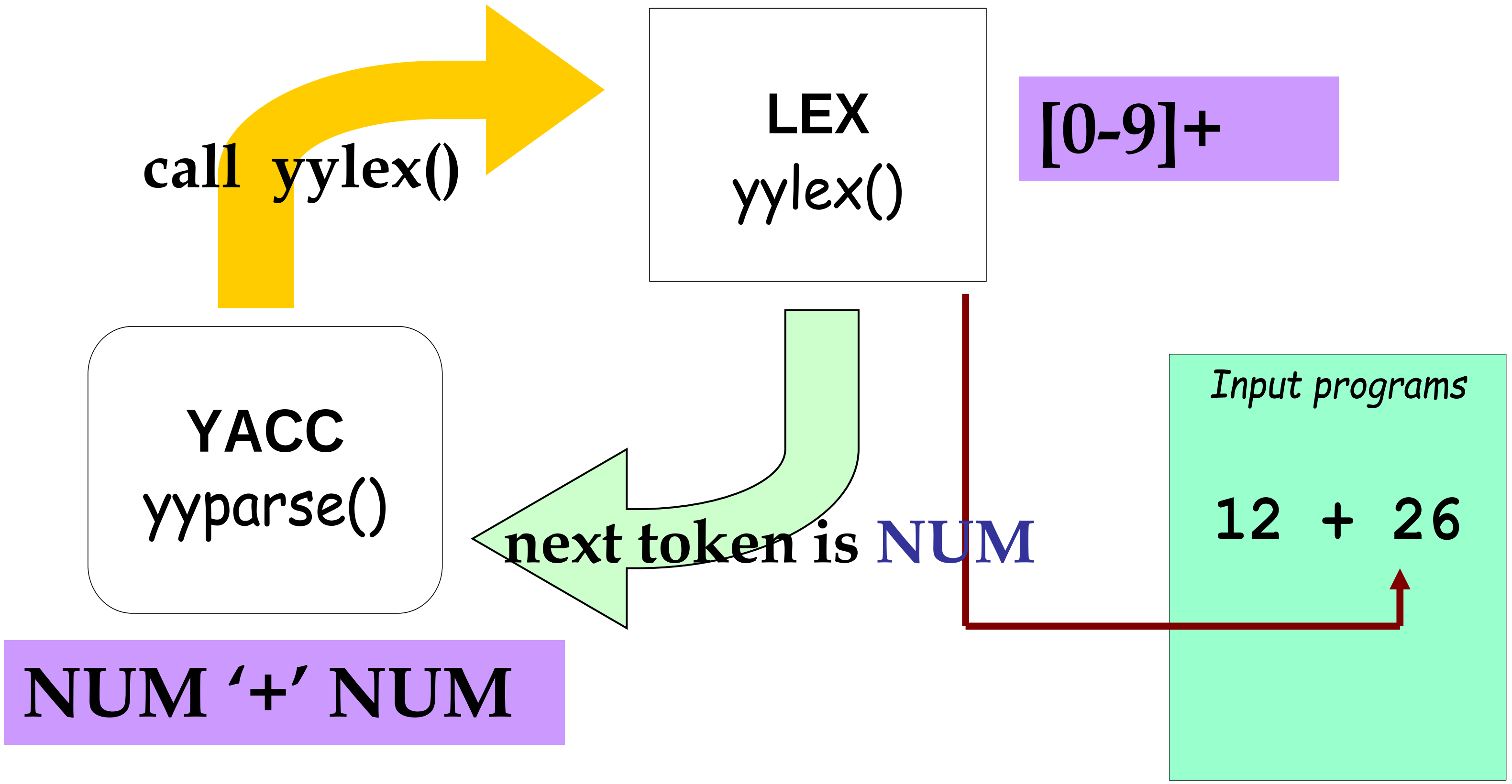
a.out

What's going on?

Input programs

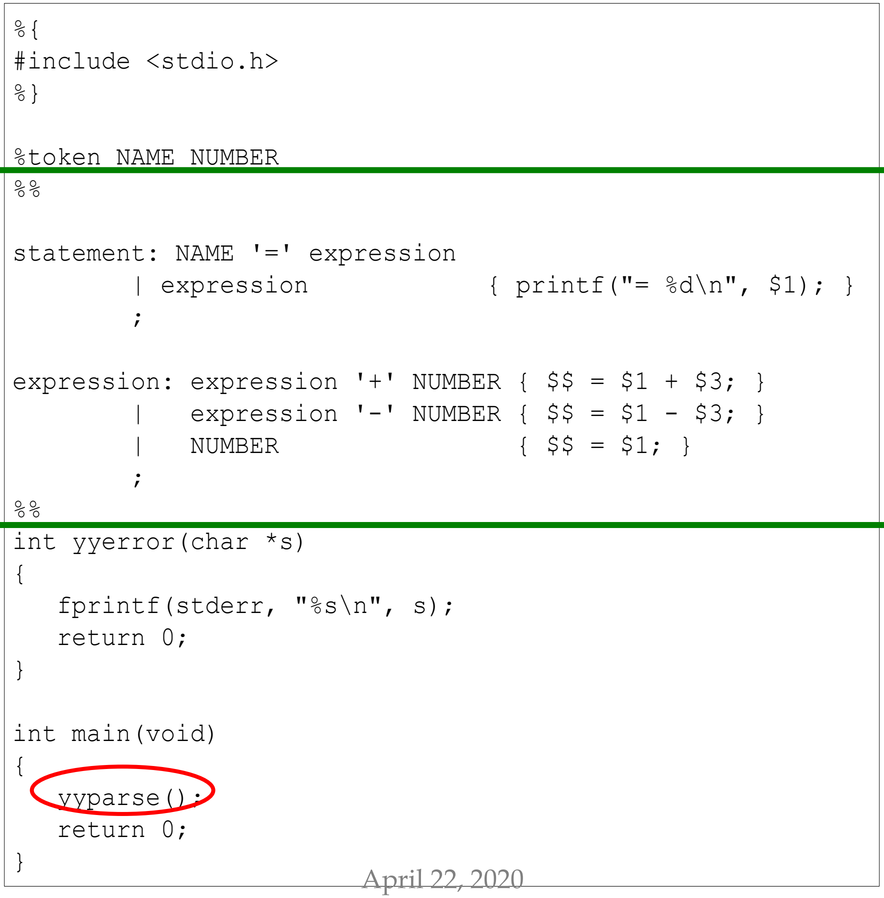
```
12 + 26
```

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
```

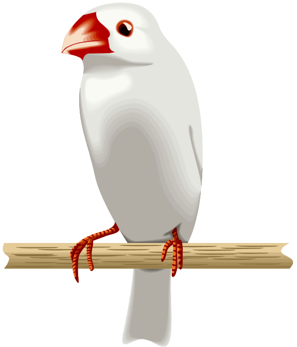
Grammar Rules Section

- 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
       ;
```

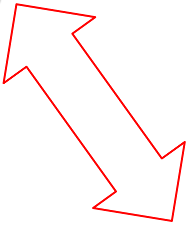
$1

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
       ;
```



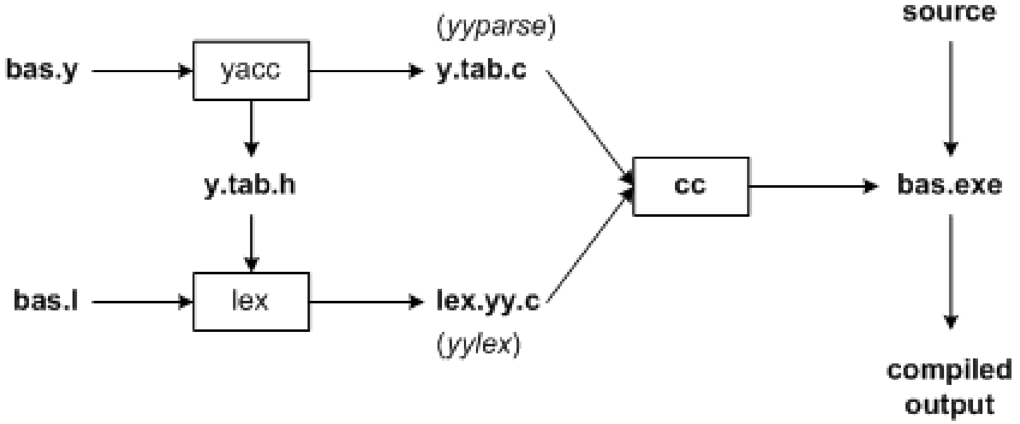
$2

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

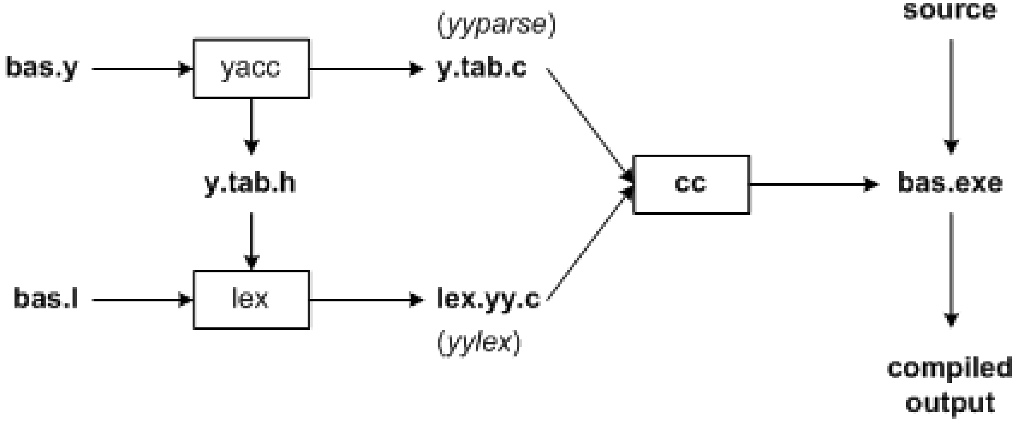


- The figure illustrates the file naming conventions used by lex and yacc
- We need to specify all pattern matching rules for Lex (**bas.l**) and grammar rules for Yacc (**bas.y**)
- Commands to create the compiler, **bas.exe**, are listed below:

```
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

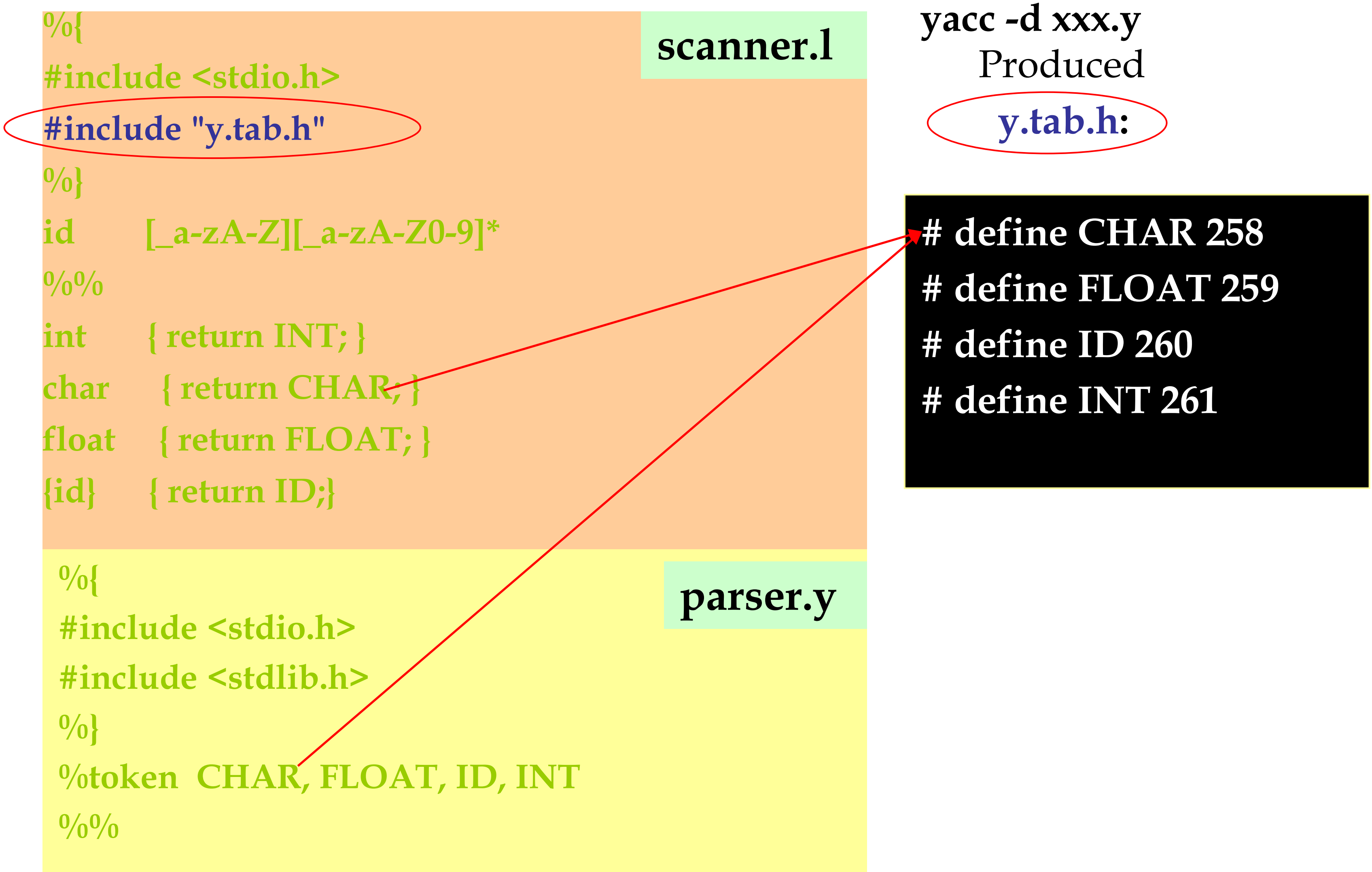
More about the Lex & Yacc Files (Cont'd)



- 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 ambiguous (=> keep a *short* rule.)
- 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

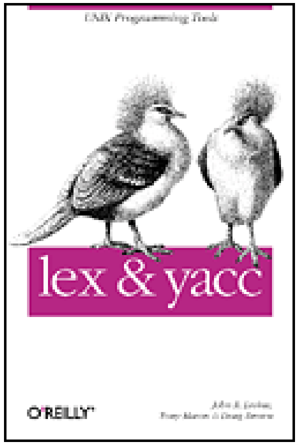
`%nonassoc'

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?