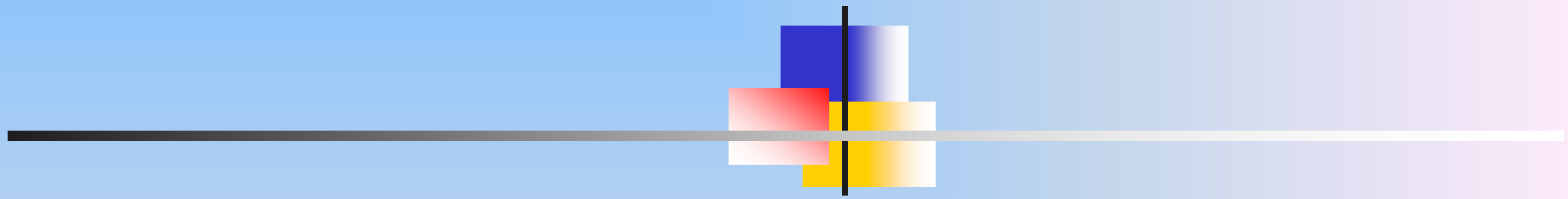
CSE302: Compiler Design



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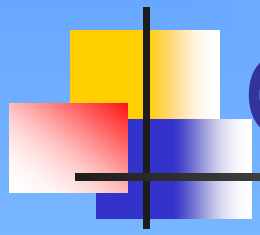
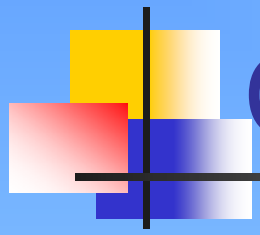
March 27, 2007



Outline

- Recap
  - General/Canonical LR(1) parsing
  - Lookahead LR(1) / LALR(1) parsing
- Yacc
- Syntax-directed translation (Chapter 5)
- Summary and homework



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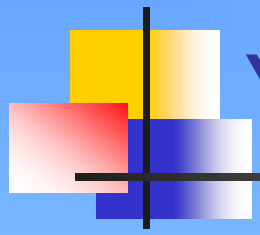
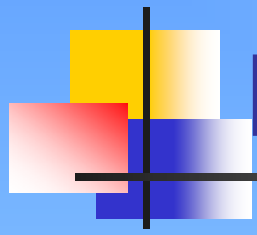


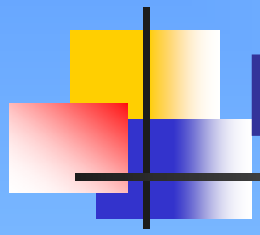
Yacc Introduction

- Yet Another Compiler-Compiler
  - Public domain versions: Bison
- Take a specification file (grammar) and produce an output file for the parser
  - Input: <filename>.y
    - {definitions}
    - %%
    - {productions/rules}
    - %%
    - {auxiliary routines}
  - Output: y.tab.c
    - LALR parser



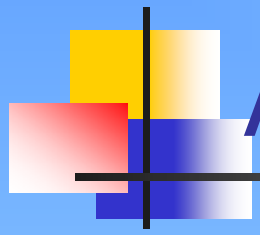
Definition Section

- Information about tokens, data types
- Any code that must go directly into the output file
  - **#include** directives
- May be empty



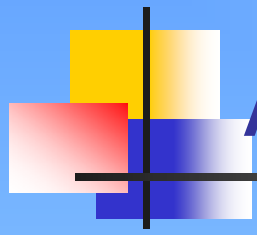
Production Section

- Grammar rules with action codes
  - $\rightarrow$ is replaced by :
  - A semicolon ends each production



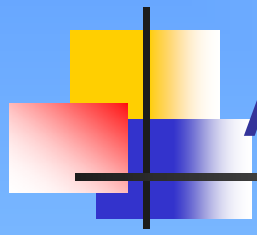
Auxiliary Routine Section

- Procedure and function declarations that are needed to complete the parser
- May be empty



An Example: Grammar

- expr → expr + term | expr - term | term
- term → term * factor | factor
- factor → (expr) | **number**



An Example: Definition Section

- %{
  #include <stdio.h>
  #include <ctype.h>
  %}
  %token NUMBER

- stdio.h: printf(), ungetc()
- ctype.h: isdigit()

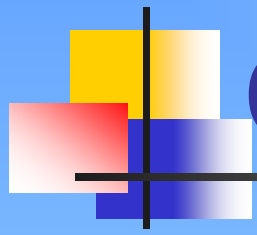
An Example : Production Section

```
%%
line : expr                  {printf("%d\n",$1);} ;
expr : expr '+' term         {$$ = $1 + $3;}
     | expr '-' term         {$$ = $1 - $3;}
     | term                  {$$ = $1;} ;
term : term '*' factor       {$$ = $1 * $3;}
     | factor                {$$ = $1;} ;
factor : '(' expr ')'        {$$ = $2;}
       | NUMBER              {$$ = $1;} ;
```

- $$: attribute value associated with the head
- $*i*: attribute value of the *i*th grammar symbol
- Semantic action is performed when reduced

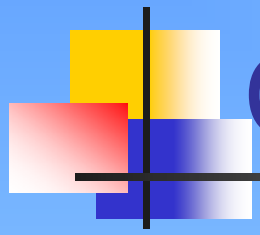
An Example : Auxiliary Routine Section

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

int yylex(void) {
        int c;
        while ( (c=getchar() ) == ‘ ’);
        if (isdigit(c)) {
                ungetc(c,stdin);
                scanf(“%d”,&yylval);
                return(NUMBER);
        }
        if(c==‘\n’) return 0;
        return(c);
}

int yyerror(char *s) {fprintf(stderr, “%s\n”, s); return 0;}
```



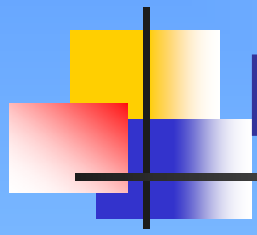
Compile the Example

- yacc calc.y
- gcc -o calc y.tab.c -ly



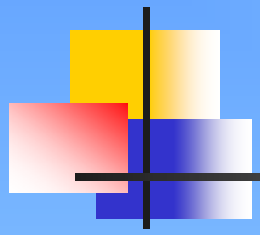
Observe The Parsing Table

- yacc –v calc.y
  - Prepares the file y.output
    - The kernels of the sets of items
    - A description of the parsing tables
    - A report on conflicts generated by ambiguities



Example Extended

- Evaluate a sequence of expressions
- /
- Floating-point values
  - #define YYSTYPE double
  - #ifndef YYSTYPE
  - typedef int YYSTYPE
  - #endif
  - YYSTYPE yylval
  - A parse stack and a value stack



Integrate with Lexer

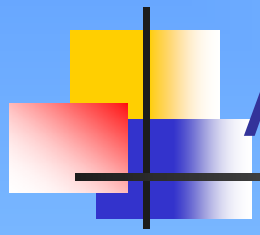
- calc.l

```
%{
%}
number      [0-9]+(\.[0-9]+)?
%%
[ ]         { /* skip blank */ }
{number} {
    sscanf(yytext, "%lf", &yylval);
    return NUMBER;
            }
\n|.        {return yytext[0];}
```

- flex calc.l
- yacc calc.y
- gcc y.tab.c –ly -ll

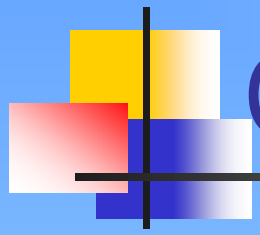
- calc.y

```
%{#include <stdio.h>
#define YYSTYPE double
%}
%token NUMBER
%%
lines : lines expr '\n' {printf("%g\n",$2);} | lines '\n' | ;
expr : expr '+' term    {$$ = $1 + $3;}
   | expr '-' term      {$$ = $1 - $3;}
   | term               {$$ = $1;};
term : term '*' factor {$$ = $1 * $3;}
   | term '/' factor    {$$ = $1 / $3;}
   | factor             {$$ = $1;};
factor : '(' expr ')' {$$ = $2;} | NUMBER {$$ = $1;};
%%
#include "lex.yy.c"
```



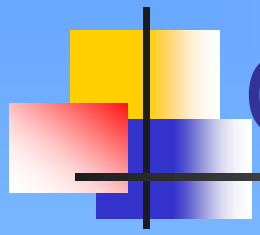
Another Example

- <program> --> <program> <func> | <epsilon>
- <func> --> <type> <ident> () <block>
- <block> --> { <statement_list> } | <statement>
- <statement_list> --> <statement_list> <statement> | <epsilon>
- <statement> --> <expr> ; | ; | <strexpr> ;
- <expr> --> <expr> + <term> | <expr> - <term> | <term>
- <term> --> <term> * <factor> | <term> / <factor> | <factor>
- <factor> --> float | int
- <strexpr> --> <strexpr> + string | string
- <type> --> void | string | float | int



Compile the Example

- flex part1.l
- yacc part1.y
- gcc -o part1 y.tab.c –ly -ll



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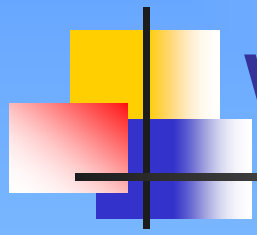
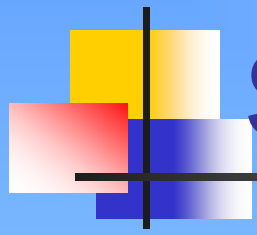


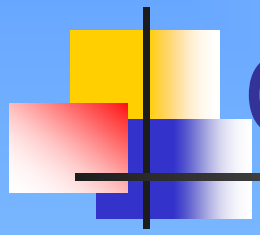
What Can Be Done So Far?

- Lexing to detect lexical errors
  - Lexical analysis
- Parsing to detect syntax errors
  - Syntax analysis
- How about ...?
  - Semantic analysis
    - Type checking
  - Intermediate code generation
    - Applications of SDT



Syntax-Directed Techniques

- For a BNF grammar
  - Associate grammar symbol X (terminals and non-terminals) with a set of attributes A(X): a_1, ..., a_n
    - Type information for type checking/conversion
    - Strings for sequences of code in intermediate language
    - Number, table references, ...
  - Attach a semantic rule to each production
    - Syntax-directed definition
  - Add program fragment(s) to some production(s)
    - Syntax-directed translation
- The BNF grammar becomes an attribute grammar
  - Compute the values of the attributes associated with the symbols in the productions
  - Generate side effects: print results, modify symbol table, ...



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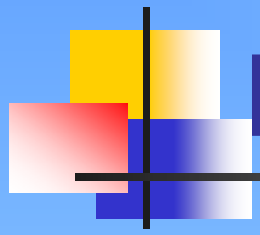

Final Exam Reminder

- THURSDAY, MAY 03, 2007, 08:00-11:00AM