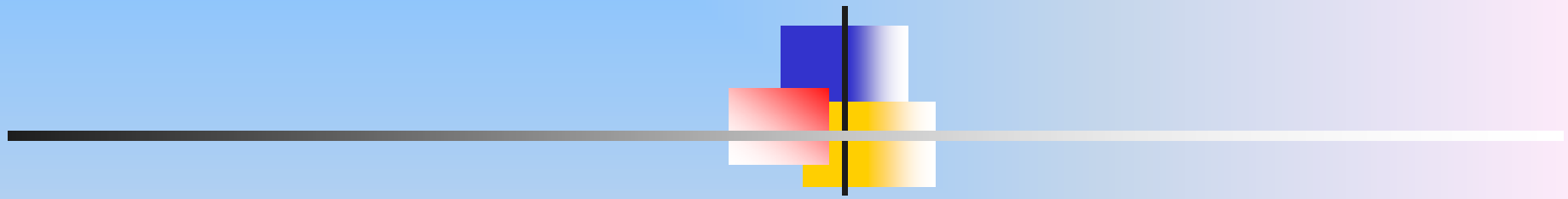
CSE302: Compiler Design



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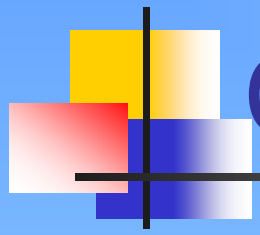
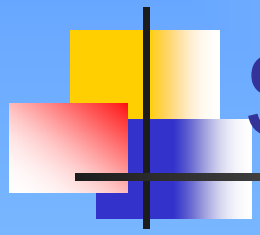
April 3, 2007



Outline

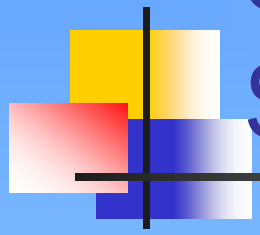
- Recap
- Syntax-directed translation (Chapter 5)
- Summary and homework



SDD's

- For synthesized attributes
  - Perform bottom-up tree traversal for attribute evaluation
  - An SDD is S-attributed if every attribute is synthesized
- For SDD's with both inherited and synthesized attributes
  - Dependency graphs
  - An SDD is L-attributed if in all of its dependency graphs the edges only go from left to right but not from right to left

Syntax-directed Translation Schemes



- Note that SDD is used for specifications
  - SDD $\Rightarrow$ SDT
- SDT's are implemented during parsing without building a parse tree
  - S-attributed SDD based on LR-parsable grammar
  - L-attributed SDD based on LL-parsable grammar

S-attributed SDD's Based on LR-parsable Grammars

- SDD $\Rightarrow$ SDT
  - Construct an SDT where actions are placed at the end of the productions corresponding to semantic rules
    - Postfix SDT's
  - SDD Production — Semantic rules

    $T \rightarrow T_1 * F$ — $T.val = T_1.val * F.val$

    $T \rightarrow F$ — $T.val = F.val$

    $F \rightarrow$ **digit** — $F.val =$ **digit**.lexval
  - SDT

    $T \rightarrow T_1 * F$ — { $T.val = T_1.val * F.val$; }

    $T \rightarrow F$ — { $T.val = F.val$; }

    $F \rightarrow$ **digit** — { $F.val =$ **digit**.lexval; }
- An action is executed along with the reduction of the body to the head of the associated production

Parser-Stack Implementation of Postfix SDT's

- The attribute(s) of each grammar symbol can be put on the stack along with the symbol
  - $T \rightarrow T_1 * F$

T	*	F	...
T.val		F.val	...

  - When reduction
    - stack[top-2].val = stack[top].val * stack[top-2].val;
    - top = top – 2;

T	...
T.val	...

Another SDD to SDT Example

- SDD of **while** to generate 3-address code
  - $S \rightarrow$ while (C) S
    - while(i<a) i=i*2;
      j=j*i;
  - label L5: if i<a goto L6
    goto L7
    label L6: i=i*2
    goto L5
    label L7: j=j*i

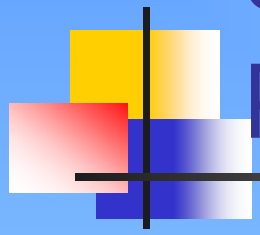
- $S \rightarrow$ while (C) S L1=new(); L2=new();
  S1.next=L1;
  C.true=L2; C.false=S.next;

S.code= **label** || L1 || C.code || **label** || L2 || S1.code

Another SDD to SDT Example

- For synthesized attribute computations
  - End of the production body
- For computing inherited attributes of a nonterminal
  - Immediately before the nonterminal occurrence

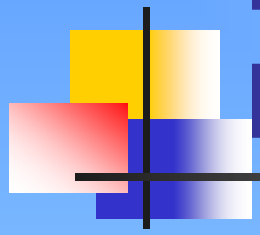
$S \rightarrow$ while ({ L1=new(); L2=new();
C.true=L2; C.false=S.next;
}
C) S1.next=L1;
S1 { S.code= **label** || L1 || C.code || **label** || L2 || S1.code; }



SDT's With Actions Inside Productions

- L-attributed SDD's $\Rightarrow$ SDT's with actions inside productions
- When remove left-recursions in an S-attributed SDD for LL parsing $\Rightarrow$ SDT's with actions inside production

Define A Language and Syntax-Directed Translation (1/23)



- expr → expr + term | expr - term | term
- term → 0 | 1 | ... | 9
- Syntax-directed translation based on semantic actions
- expr → expr + term { print('+') }
  | expr - term { print('-') }
  | term
- term → 0 { print('0') }
  | 1 { print('1') }
  | ...
  | 9 { print('9') }

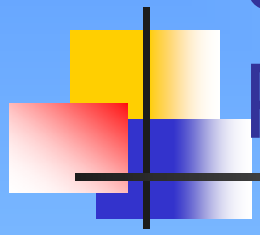
SDT's With Actions Inside Productions

$A \rightarrow A\ \alpha \mid \beta$

$A \rightarrow \beta\ R$
$R \rightarrow \alpha\ R \mid \varepsilon$

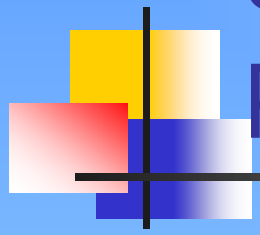
- Left recursion removal for top-down parsing
- expr → term rest
- rest → + term { print('+') } rest
  | - term { print('-') } rest
  | ε
- term → 0 { print('0') }
  | 1 { print('1') }
  | ...
  | 9 { print('9') }

SDT's With Actions Inside Productions

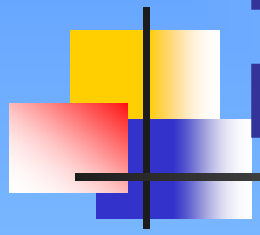


- Any SDT can be implemented as follows
  - Ignore the actions, parse the input and produce a parse tree
  - Add actions into the parser tree corresponding to the SDT
  - Perform a preorder traversal of the tree

SDT's With Actions Inside Productions

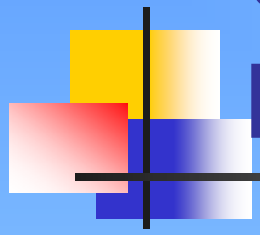


- Use a recursive-descent parser with one function for each nonterminal
- Generate code on the fly using a recursive-descent parser
- Implement an SDT in conjunction with an LL-parser
- Implement an SDT in conjunction with an LR-parser (in April 19th's lecture)



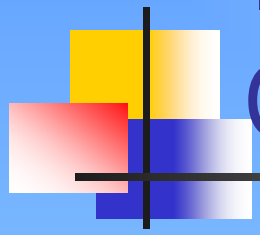
Recursive-descent Parser: One Function For Each Nonterminal

- Function arguments: inherited attributes
- Function return: synthesized attributes
- The **while** example



Generate Code on the Fly Using a Recursive-descent Parser

- Incrementally generate pieces of the code into an array or output file
  - Avoid copying or moving long strings
- The **while** example

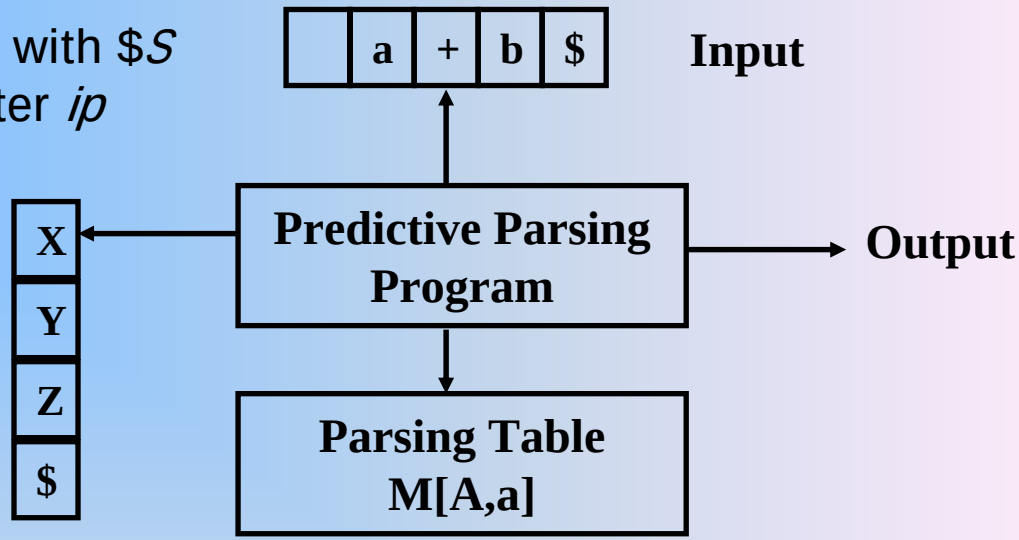


Implement An SDT in Conjunction with An LL-parse

- If L-attributed SDD is based on an LL-grammar
  - Extend the parser stack to hold actions and items for attribute evaluations

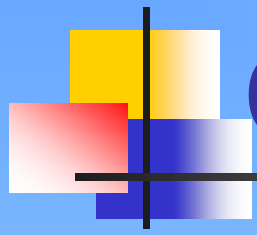
Non-recursive Predictive Parsing (2/27)

- A stack storing symbols, initialized with $\$S$
- An input buffer with an input pointer *ip*
- A parsing table M for grammar G

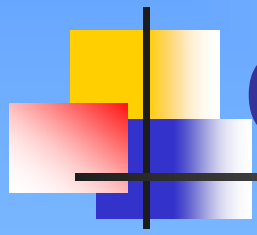


Point *ip* to the 1st input symbol
Set *A* to the top stack symbol
while(*A*≠$) {
    if (*A* is *a*) pop stack; advance *ip*
    else if (*A* is a terminal) error();
    else if (M[*A*,*a*] is an error entry) error();
    else if (M[*A*,*a*] = $A \rightarrow X_1X_2...X_k$) {
        output the production or other actions;
        pop the stack;
        push X_k, ... ,X_2 , X_1 onto the stack with X_1 on top;
    }
    Set *A* to the top stack symbol;
}

Implement An SDT in Conjunction with An LL-parse

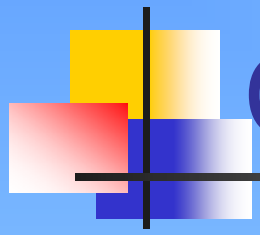


- If L-attributed SDD is based on an LL-grammar
  - Extend the parser stack to hold actions and items for attribute evaluations
    - Action record for inherited attribute computation
      - What should be in the record?
      - Placed above or below the nonterminal?
      - The SDD for **while** to generate code on the Fly



Implement An SDT in Conjunction with An LL-parse

- If L-attributed SDD is based on an LL-grammar
  - Extend the parser stack to hold actions and items for attribute evaluations
    - Action record for inherited attribute computation
    - Synthesize record for synthesized attribute computation
      - Placed above or below the nonterminal?



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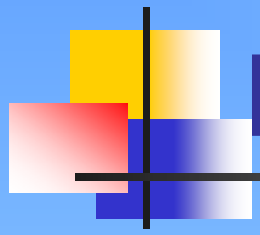
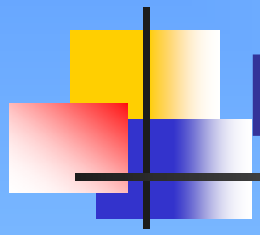


Final Exam Reminder

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



Homework (Due on 04/02)

- 10.1. (a) Exercise 5.2.4 (page 317);
  (b) Exercise 5.2.5 (Page 317).