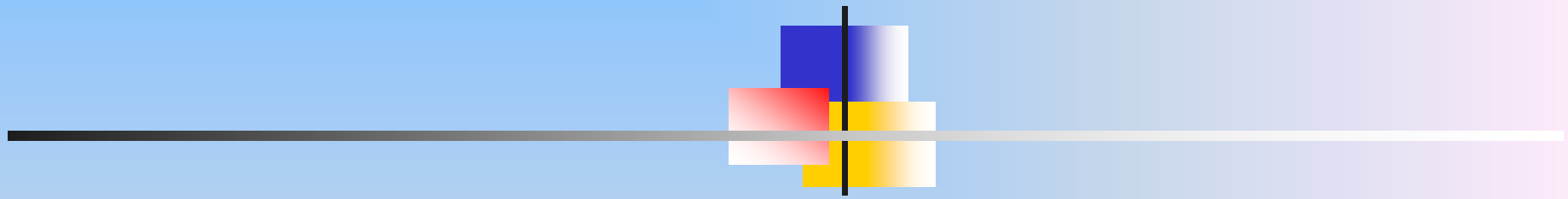
CSE302: Compiler Design



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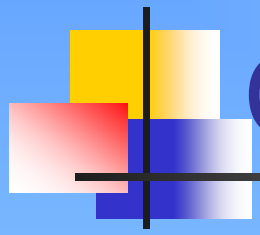
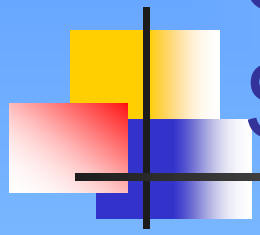
April 5, 2007



Outline

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

Syntax-directed Translation Schemes



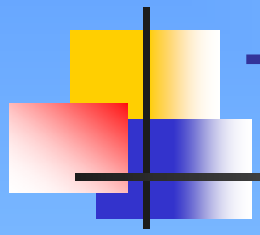
- SDD $\Rightarrow$ SDT
  - SDT's can be implemented during parsing without building a parse tree
    - S-attributed SDD based on LR-parsable grammar
    - L-attributed SDD based on LL-parsable grammar

An L-attributed SDD 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



The Corresponding SDT

- 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; }

Recursive-descent Parser: One Function For Each Nonterminal

S → 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; }

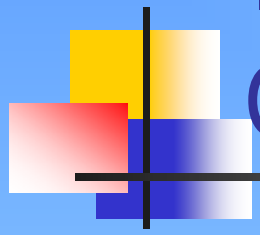
```
String S(label next) {
    String Scode, Ccode;        Label L1, L2;
    if(inputToken == whileToken) {
      advanceInput();           match('(');       L1=new(); L2=new();
      Ccode = C(next, L2);      match(')');       Scode = S(L1);
      return("label"||L1||Ccode||"label"||L2||Scode);
}
```

Generate Code on the Fly Using a Recursive-descent Parser

```
String S(label next) {
    String Scode, Ccode;          Label L1, L2;
    if(inputToken == whileToken) {
      advanceInput();             match('(');        L1=new(); L2=new();
      Ccode = C(next, L2);        match(')');        Scode = S(L1);
      return("label"||L1||Ccode||"label"||L2||Scode);
 }

 String S(label next) {
    String Scode, Ccode;          Label L1, L2;
    if(inputToken == whileToken) {
      advanceInput();             match('(');        L1=new(); L2=new();
      print("label",L1); C(next, L2); match(')');    print("label",L2); S(L1);
      return("label"||L1||Ccode||"label"||L2||Scode);
 }
```

- New SDD

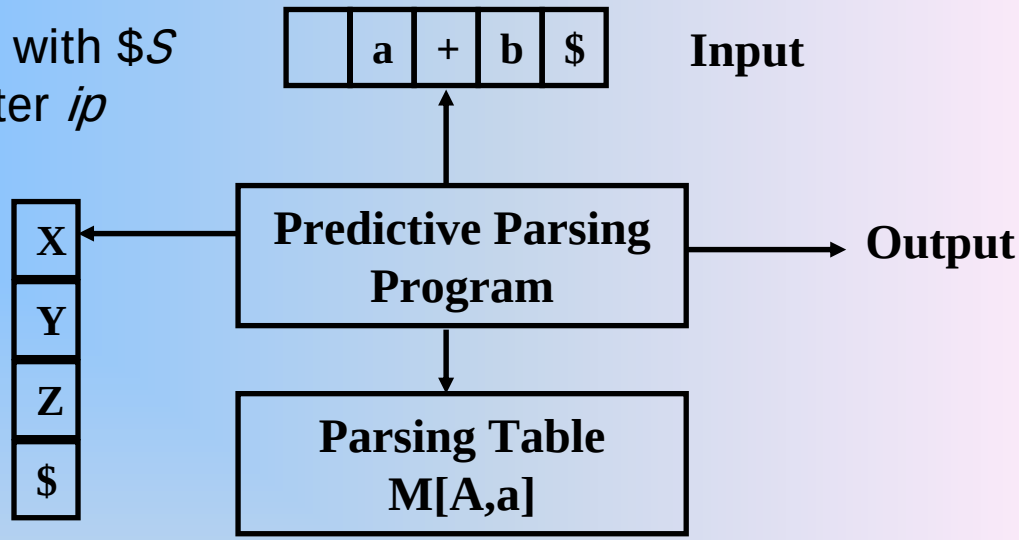


Implement An SDT in Conjunction with An LL-parser

- 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($A \neq \$$) {
    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

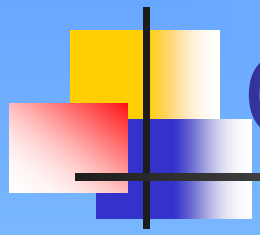
- If L-attributed SDD is based on an LL-grammar
  - Extend the parser stack to hold actions and items for attribute evaluations
    - Action record for inherited attribute computation
      - What should be in the record?
      - Placed above or below the nonterminal?

$S \rightarrow$ while ({ L1=new(); L2=new(); print(“label”,L1);
C.true=L2; C.false=S.next;
}
C) {print(“label”,L2); S1.next=L1;}
S1

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?

$S \rightarrow$ 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; }



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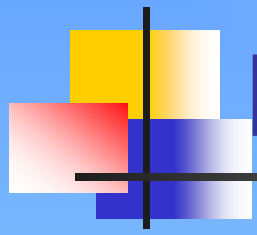
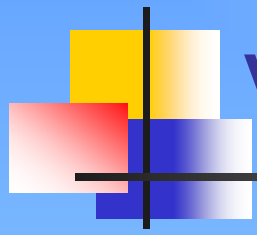


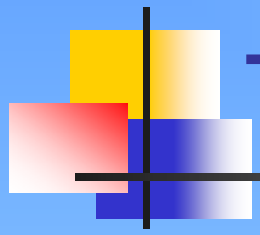
Major Topics in Chapter 6

- Intermediate representations
- Static checking
- Intermediate code generation



Variant of Syntax Trees

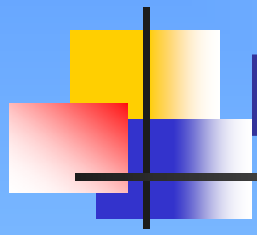
- Directed acyclic graph (DAG) for expression
  - Identify common subexpressions
    - a+a*(b-c)+(b-c)*d
    - Before creating a new node, check whether an identical node already exists
      - Node(op, left, right)
- Stored in an array of records
  - Production — Semantic rules
    - $A \rightarrow T = E$ — A.node = **new** Node('=', T.node, E.node)
    - $E \rightarrow T_1 + T_2$ — E.node = **new** Node('+', T_1.node, T_2.node)
    - $T \rightarrow$ **id** — T.node = **new** Leaf(**id**, **id**.entry)
    - $T \rightarrow$ **num** — T.node = **new** Leaf(**num**, **num**.val)



Three-Address Code

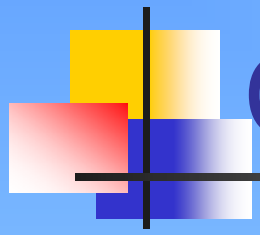
- Three-address code for the DAG example
  - a+a*(b-c)+(b-c)*d
- An address
  - A name
    - A pointer to its symbol-table entry
  - A constant
  - A compiler-generated temporary
- Symbolic labels
  - L1, L2, ...

Three-Address Instruction Forms



- x = y op z
- x = op y
- x = y
- goto L
- x = y[i]
- x[i] = y
- x = &y
- x = *y
- *x = y

- if x goto L and ifFlase x goto L
- if x relop y goto L
- Procedure calls and returns
  - param x_1
  - param x_2
  - ...
  - param x_n
  - call p, n or y = call p, n
  - return w



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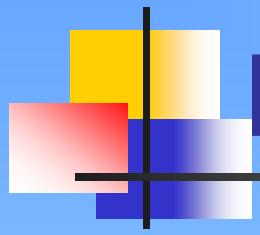
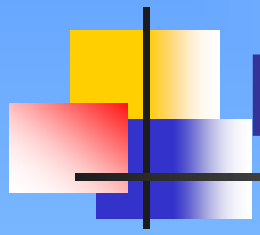


Final Exam Reminder

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



Homework (Due on 04/09)

- HW11.1 and HW11.2 are posted at the Blackboard.