Lecture 14

Semantics Analysis

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Take aways from the last class

- Task and Example of Semantics Analysis

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- Attribute Grammar Framework

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- Attributes

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- Attribute Grammar Framework
- Attributes
- Example of propagation and evaluation of attributes.

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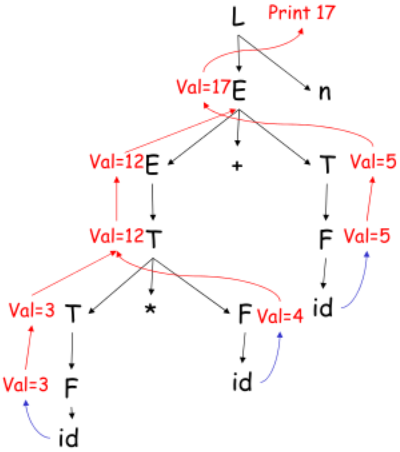
- A parse tree for an S-attributed definition can be annotated by evaluating semantic rules for attributes
- $L \rightarrow En \qquad Print(E.val)$
  $E \rightarrow E + T \qquad E.val = E.val + T.val$
  $E \rightarrow T \qquad E.val = T.val$
  $T \rightarrow T * F \qquad T.val = T.val * F.val$
  $T \rightarrow F \qquad T.val = F.val$
  $F \rightarrow (E) \qquad F.val = E.val$
  $F \rightarrow digit \qquad F.val = digit.lexval$

Parse tree for 3 * 4 + 5 n



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  $D \rightarrow TL \qquad L.in = T.type$

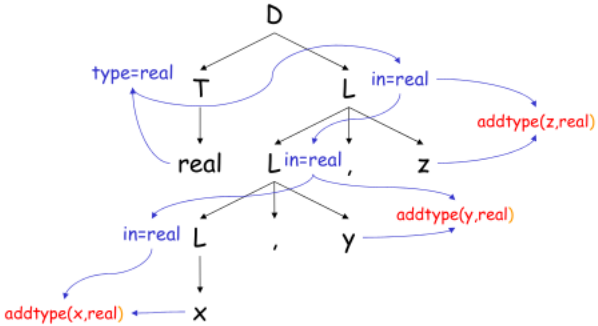
  $T \rightarrow real \qquad T.type = real$

  $T \rightarrow int \qquad T.type = int$

  $L \rightarrow L_1, id \qquad L_1.in = L.in; addtype(id.entry, L.in)$

  $L \rightarrow id \qquad addtype(id.entry, L.in)$

Parse tree for real x, y, z



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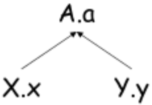
for each node n in the parse tree do
    for each semantic rule b = f(c1, c2, ··· , ck) do
        for i = 1 to k do
            construct an edge from ci to b
```

Example

- Suppose $A.a = f(X.x, Y.y)$ is a semantic rule for $A \rightarrow XY$



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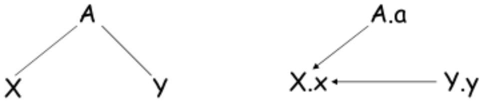

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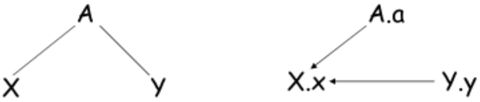
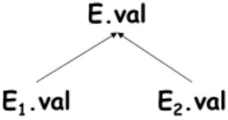


- Whenever following production is used in a parse tree
  $E \rightarrow E_1 + E_2 \quad E.val = E_1.val + E_2.val$



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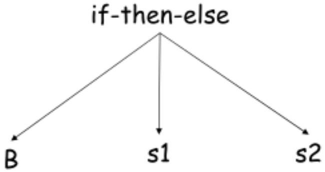
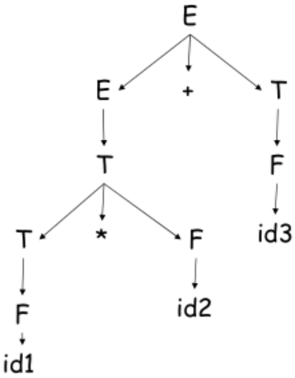


Abstract Syntax Tree

- Chain of single productions may be collapsed, and operators move to the parent nodes



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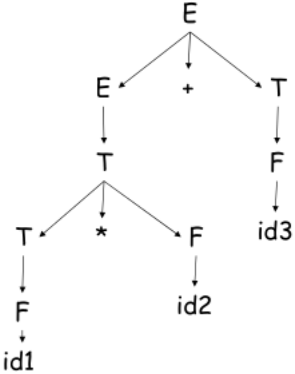

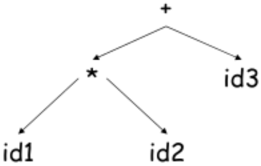

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- **identifier:** one field with label id and another ptr to symbol table
  mkleaf(id,entry)
- **number:** one field with label num and another to keep the value of the number
  mkleaf(num,val)

Example

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  $P_1 = mkleaf(id, entry.a)$
  $P_2 = mkleaf(num, 4)$
  $P_3 = mknode(-, P_1, P_2)$
  $P_4 = mkleaf(id, entry.c)$
  $P_5 = mknode(+, P_3, P_4)$

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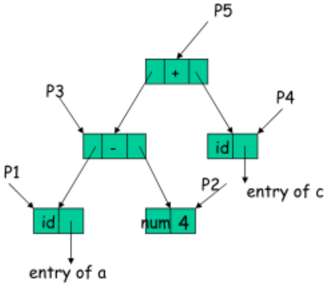

A syntax directed definition for constructing syntax tree

$E \rightarrow E_1 + T$	$E.ptr = mknode(+, E_1.ptr, T.ptr)$
$E \rightarrow T$	$E.ptr = T.ptr$
$T \rightarrow T_1 * F$	$T.ptr := mknode(*, T_1.ptr, F.ptr)$
$T \rightarrow F$	$T.ptr := F.ptr$
$F \rightarrow (E)$	$F.ptr := E.ptr$
$F \rightarrow id$	$F.ptr := mkleaf(id, entry.id)$
$F \rightarrow num$	$F.ptr := mkleaf(num, val)$

DAG for Expressions

Expression a + a * (b – c) + (b - c) * d

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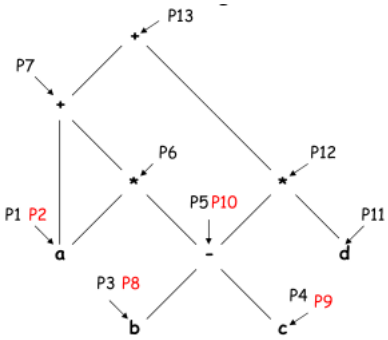

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- After the reduction, top is decremented by 2 and state covering A is put in val(top)

Example: Calculator

$L \to En$	$print(val(top))$
$E \to E + T$	$val(ntop) = val(top - 2) + val(top)$
$E \to T$	
$T \to T * F$	$val(ntop) = val(top - 2) * val(top)$
$T \to F$	
$F \to (E)$	$val(ntop) = val(top - 1)$
$F \to digit$	

Calculator

Input	State	Val	Production
3*5+4n			
*5+4n	digit	3	
*5+4n	F	3	F→digit
*5+4n	T	3	T→ F
5+4n	T*	3*	
+4n	T*digit	3*5	
+4n	T*F	3*5	F → digit
+4n	T	15	T→ T*F
+4n	E	15	E→ T
4n	E+	15-	
n	E+digit	15-4	
n	E+F	15-4	F→ digit
n	E+T	15-4	T→ F
n	E	19	E→ E+T

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  M.i = f2(L.s)
  A.s = f3(M.s)

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- $A \rightarrow QR$ R.i = f4(A.i)
  Qi = f5(R.s)
  A.s = f6(Q.s)

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  $E \rightarrow TR$

  $R \rightarrow addop\ T \quad print(addop)R|\epsilon$

  $T \rightarrow num \quad print(num)$

Parse tree for 9-5+2