

CS & IT ENGINEERING

Compiler Design

Syntax Directed Translations



Lecture No. 3



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SDT Practice Questions



TOPICS TO BE
COVERED

The icon depicts a computer monitor with a white screen and a blue frame. The text "TOPICS TO BE COVERED" is displayed in a dark teal font on the screen. Below the monitor is a stylized representation of a keyboard or a stack of books, featuring orange and brown colors.

L-attributed SDT

Evaluation (translation)

→ All translations evaluated from "Left to Right"

(Topological order)

(In order)

(DFS, Left to Right)

S-Attributed SDT

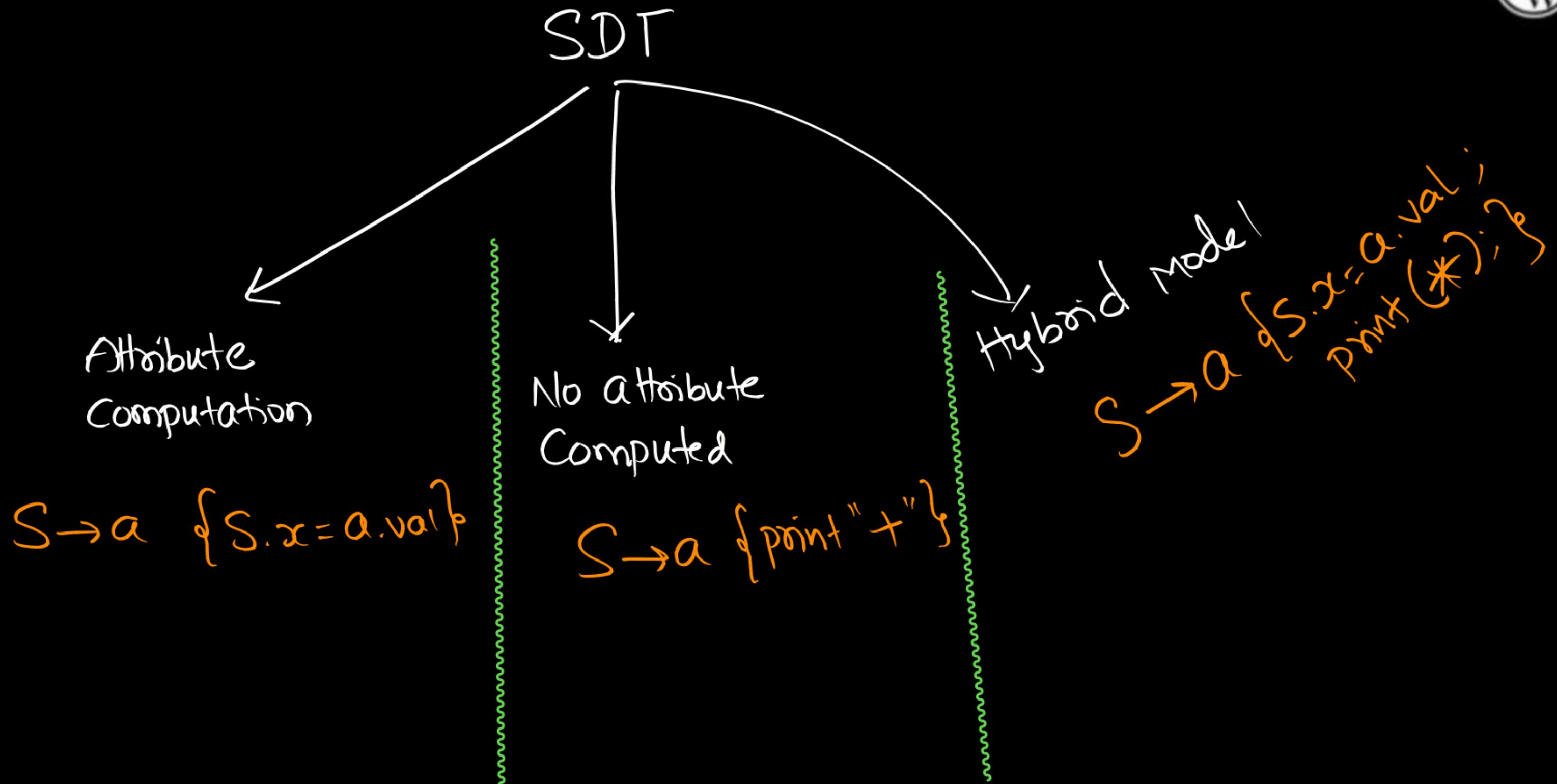
Evaluation (translation)

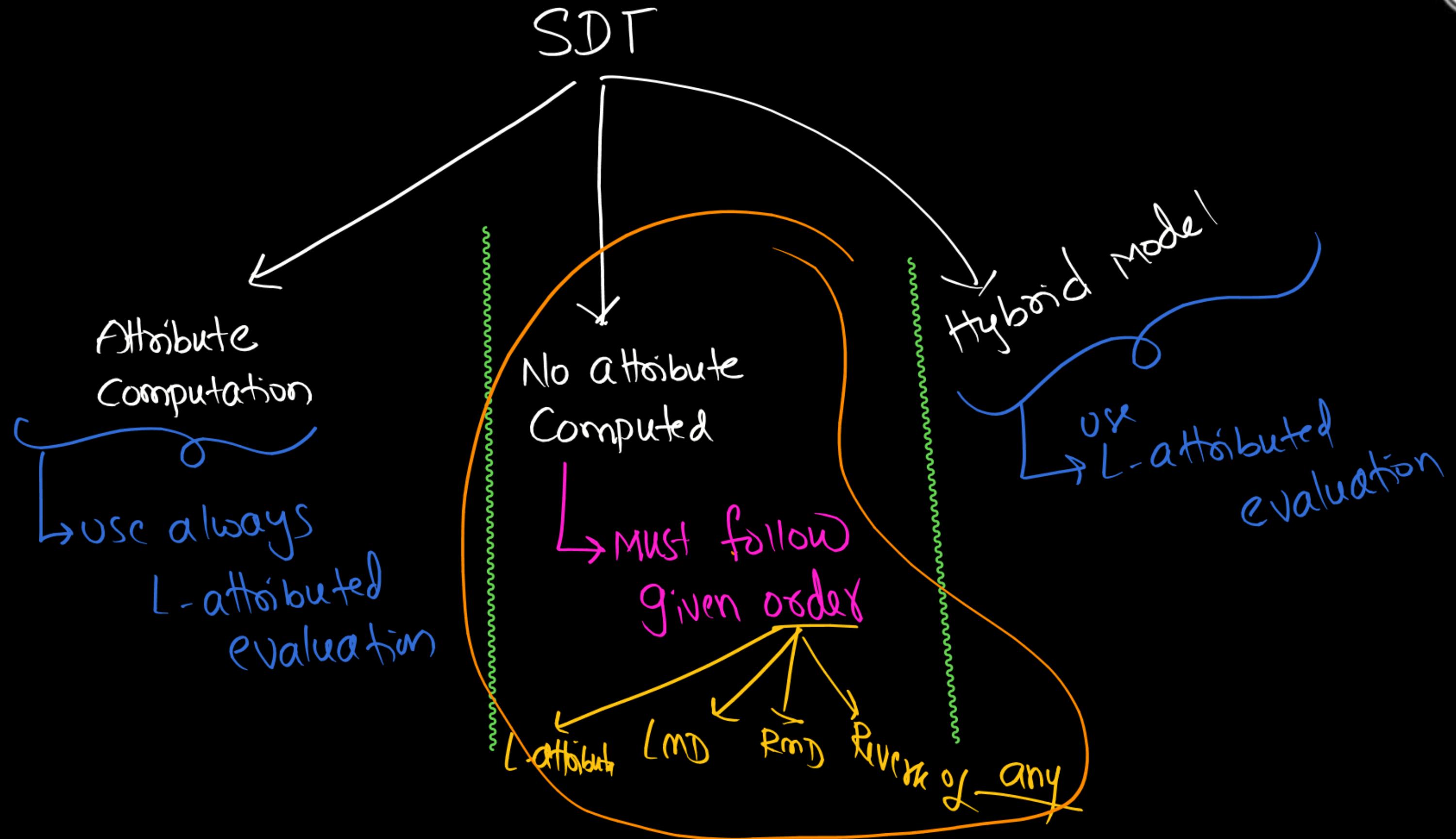
→ Evaluation of non-terminals, depends on Reverse of RMD

(Bottom up parsing)

(LR parsing)

(SR parsing)





①

$$S \rightarrow A \# B \quad \{ S.x = A.x + B.x \}$$

$$A \rightarrow a \quad \{ A.x = a.\text{val} \}$$

$$B \rightarrow b \quad \{ B.x = b.\text{val} \}$$

Input : 10 # 3

Find the attribute value computed
at the root for given input.

①

$$S \rightarrow A \# B \quad \{ S.x = A.x + B.x \}$$

$$A \rightarrow a \quad \{ A.x = a.val \}$$

$$B \rightarrow b \quad \{ B.x = b.val \}$$

⇒ It is S -attributed
(so \setminus -attributed)

Input : 10 # 3

Find the attribute value computed
at the root for given input.

①

$$S \rightarrow A \# B \quad \{ S.x = A.x + B.x \}$$

$$A \rightarrow a \quad \{ A.x = a.val \}$$

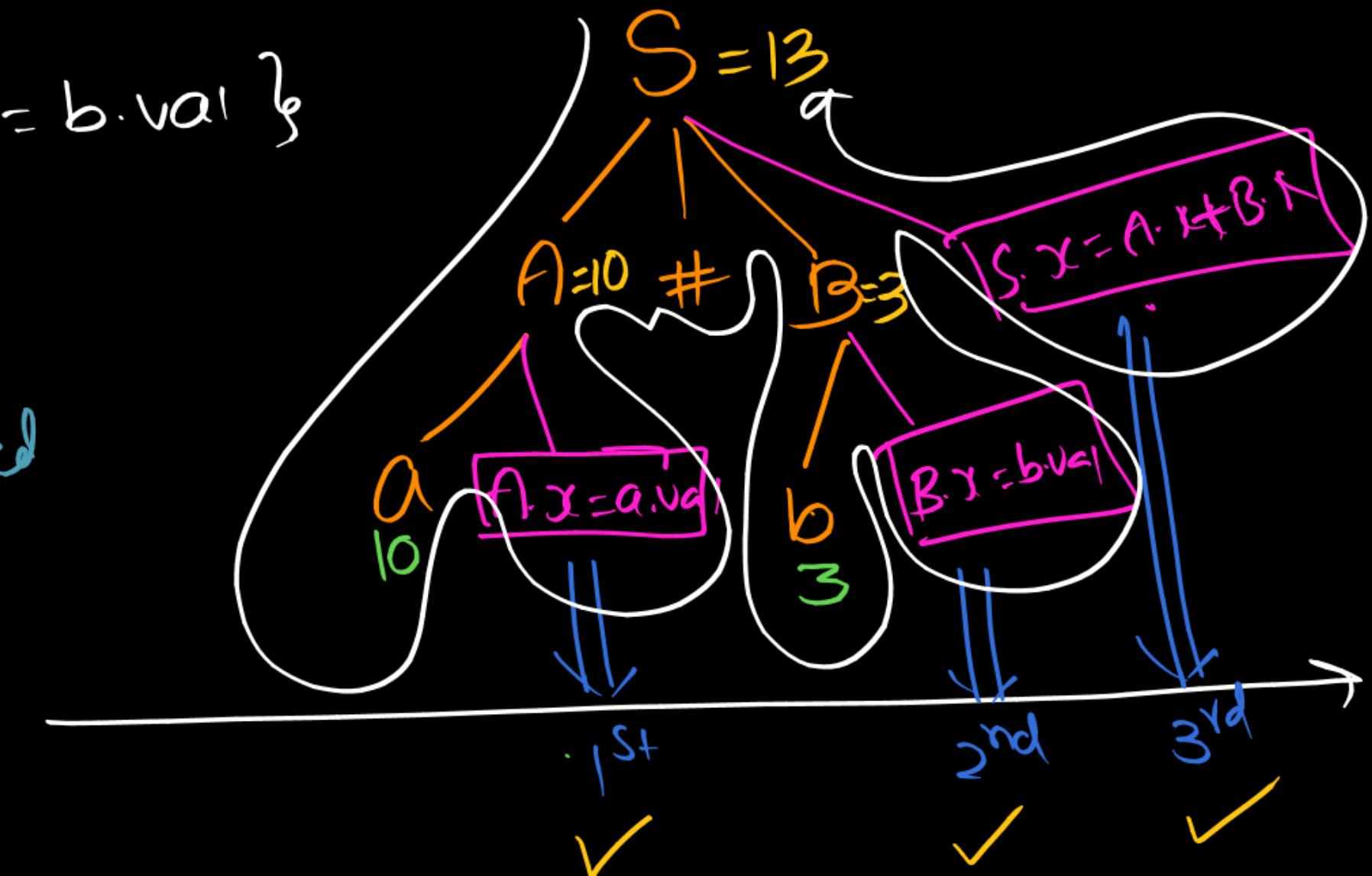
$$B \rightarrow b \quad \{ B.x = b.val \}$$

Input : 10 # 3

Method-I : Using L-attributed evaluation.

= 13 //

(Decorated PT)
Annotated Parse Tree



$$\textcircled{1} \quad S \rightarrow A \# B \quad \{S.x = A.x + B.x\}$$

$$A \rightarrow a \quad \{A.x = a.\text{val}\}$$

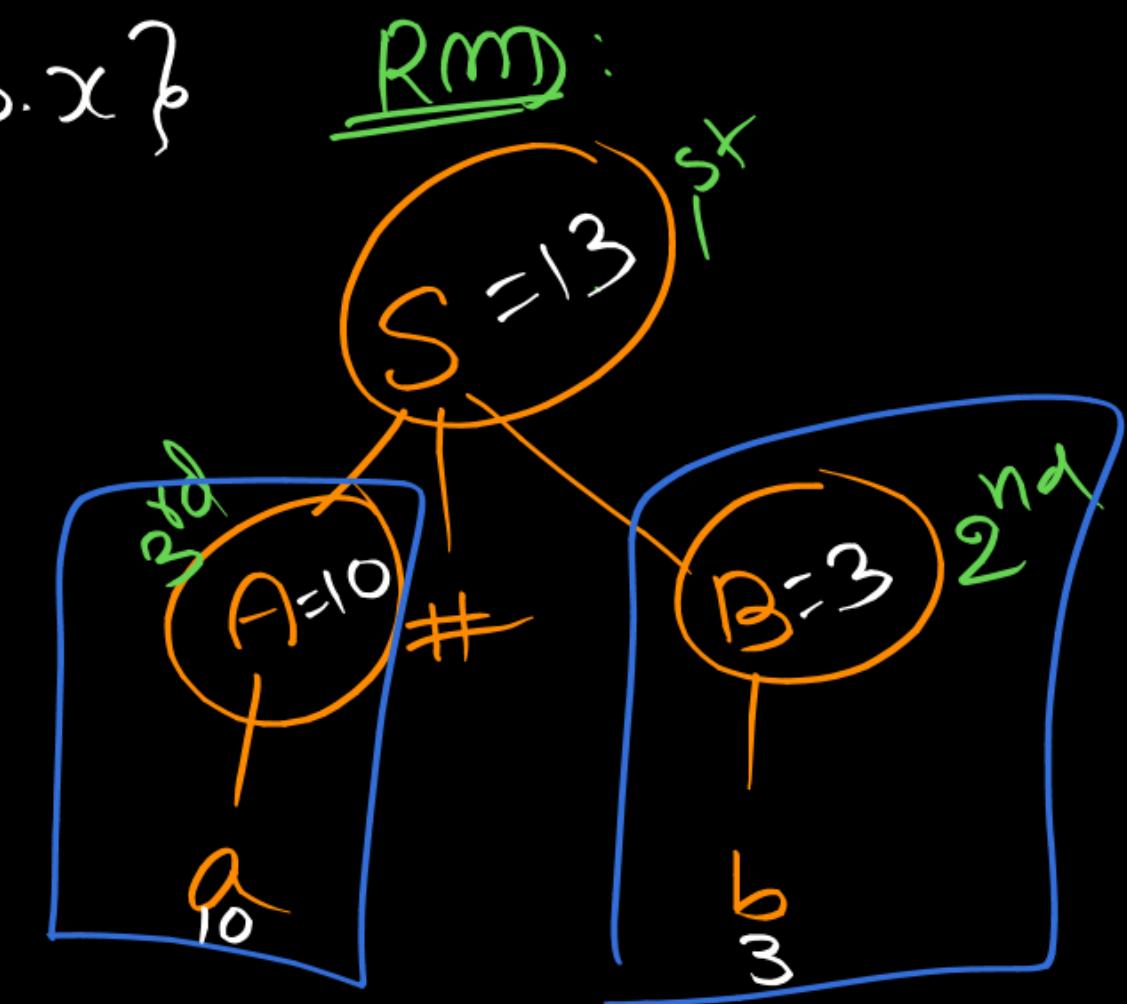
$$B \rightarrow b \quad \{B.x = b.\text{val}\}$$

Input : 10 # 3

Method-2 :

use S-attributed Evaluation
(Reverse of RMD)

= B



RMD numbering : S^1 B^2 A^3

Reverse of RMD : A^3 B^2 S^1

②

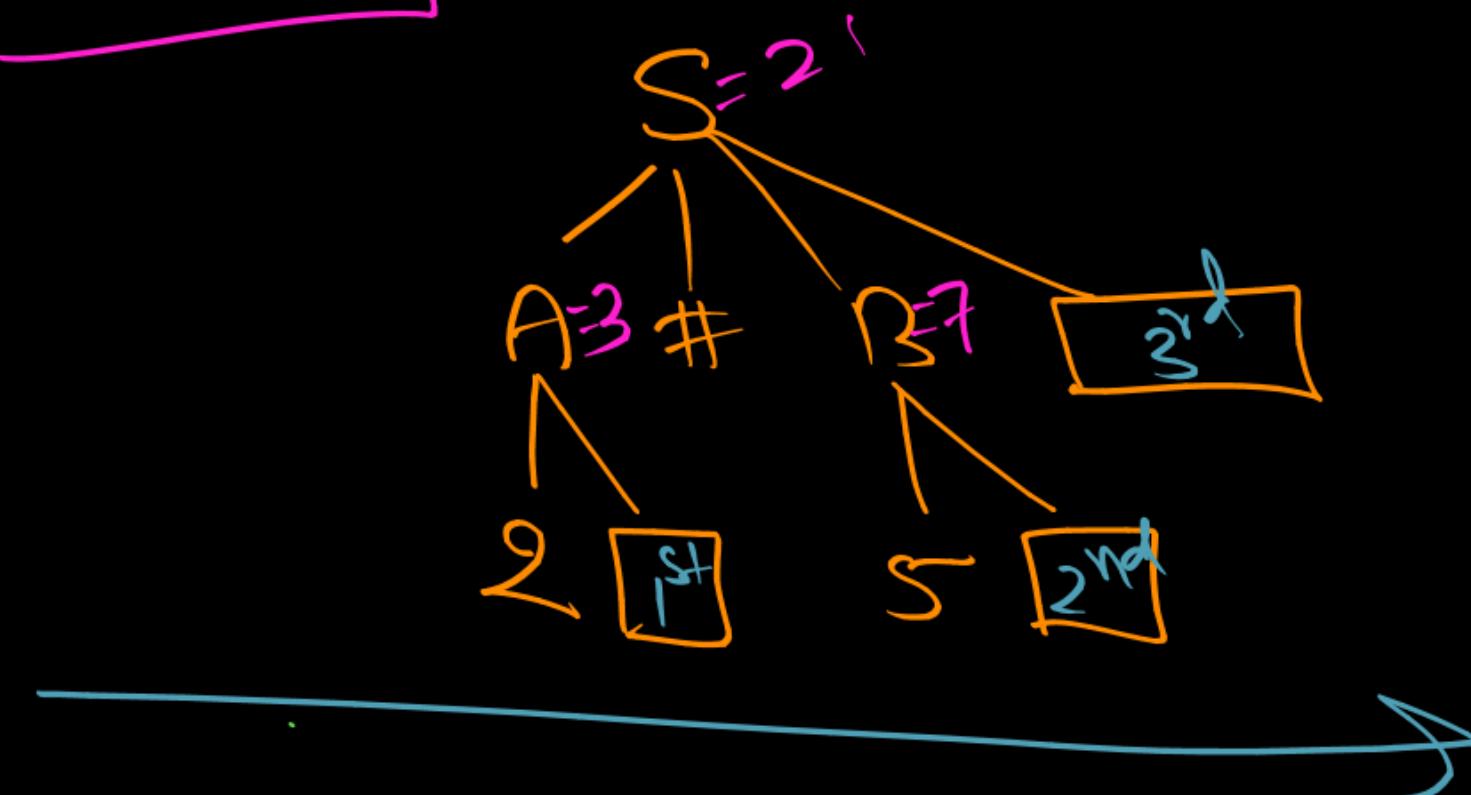
$$S \rightarrow A \# B \quad \{ S.x = A.x * B.x \}$$

$$A \rightarrow a \quad \{ A.x = a.val + 1 \}$$

$$B \rightarrow b \quad \{ B.x = b.val + 2 \}$$

Input : 2 # 5

Find the attribute value computed at the root for given input.



③

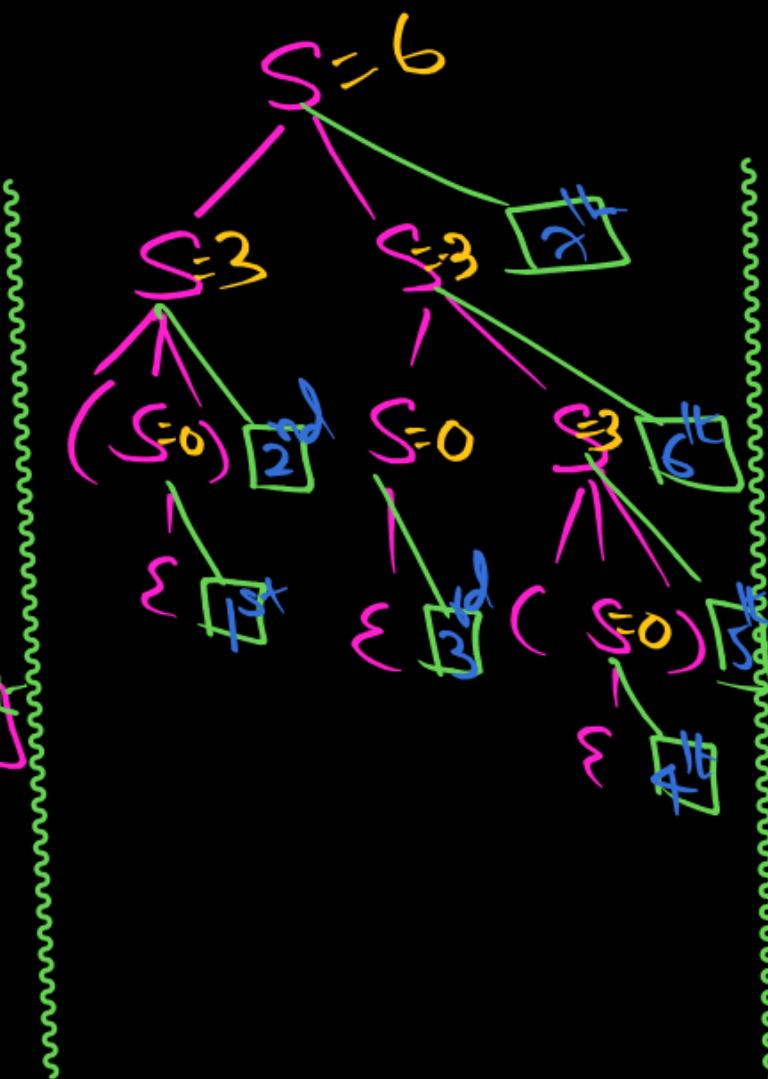
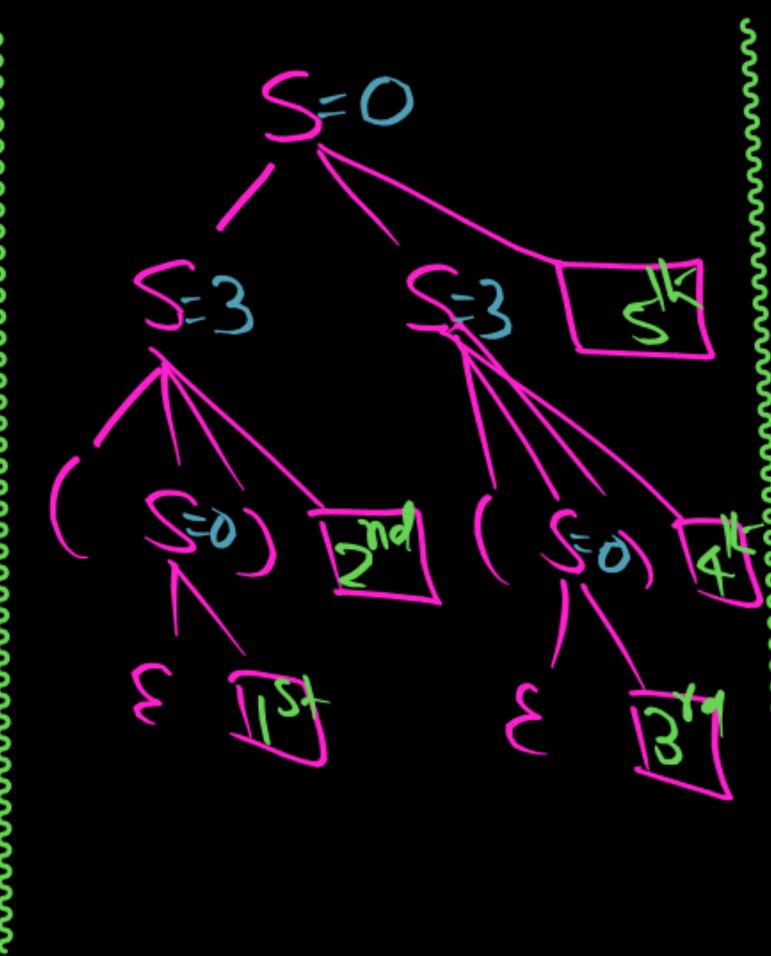
$$S \rightarrow S_1, S_2 \quad \{ S.x = S_1.x - S_2.x \}$$

$$S \rightarrow (S_1) \quad \{ S.x = 3 + S_1 \}$$

$$S \rightarrow \epsilon \quad \{ S.x = 0 \}$$

Input : () ()

multiple answers
 ↳ Ambiguity



many different
answers

(4)

$$S \rightarrow S_1 S_2 \quad \{ S.x = S_1.x + S_2.x \}$$

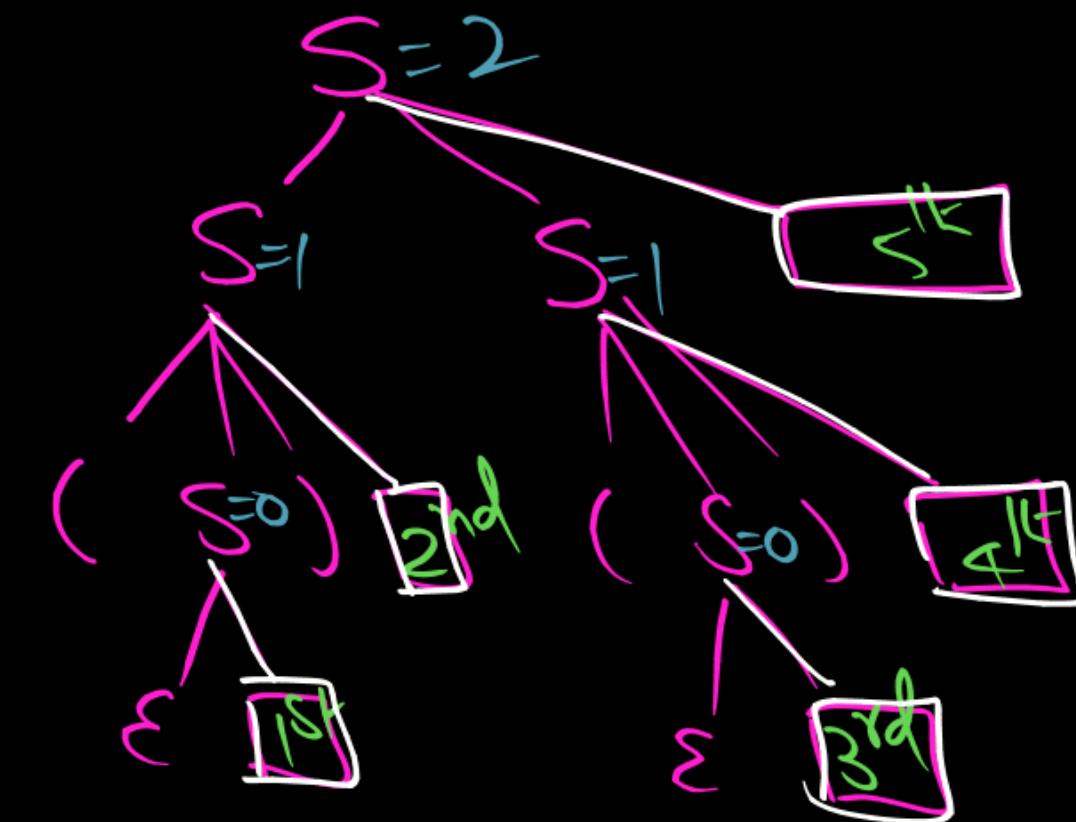
$$S \xrightarrow{SS(S)E} S$$

$$S \rightarrow (S_1) \quad \{ S.x = 1 + S_1.x \}$$

$$S \rightarrow \epsilon \quad \{ S.x = 0 \}$$

Input: ((())())
 Attribute value at root = ?.

Input: ()()

 $= 2_{11}$  $= 4$

(5) $S \rightarrow S_1 S_2 \quad \{ S \cdot x = S_1 \cdot x + S_2 \cdot x \}$

$$S \rightarrow (S_1) \quad \{ S \cdot x = 1 + S_1 \cdot x \}$$

$$S \rightarrow \varepsilon \quad \{ S \cdot x = 0 \}$$

What is functionality of above SDT?

[It counts no. of balanced parentheses at root.]

⑥ $S \rightarrow S_1 S_2 \quad \{ S.x = S_1.x + S_2.x \}$

P
W

$$S \rightarrow (S_1) \quad \{ S.x = 1 + S_1.x \}$$

$$, \quad S \rightarrow \epsilon \quad \{ S.x = 0 \}$$

What is functionality of above SDT?

[It counts no. of terminals in the input
(paranthesis)
(length of input)]

⑦

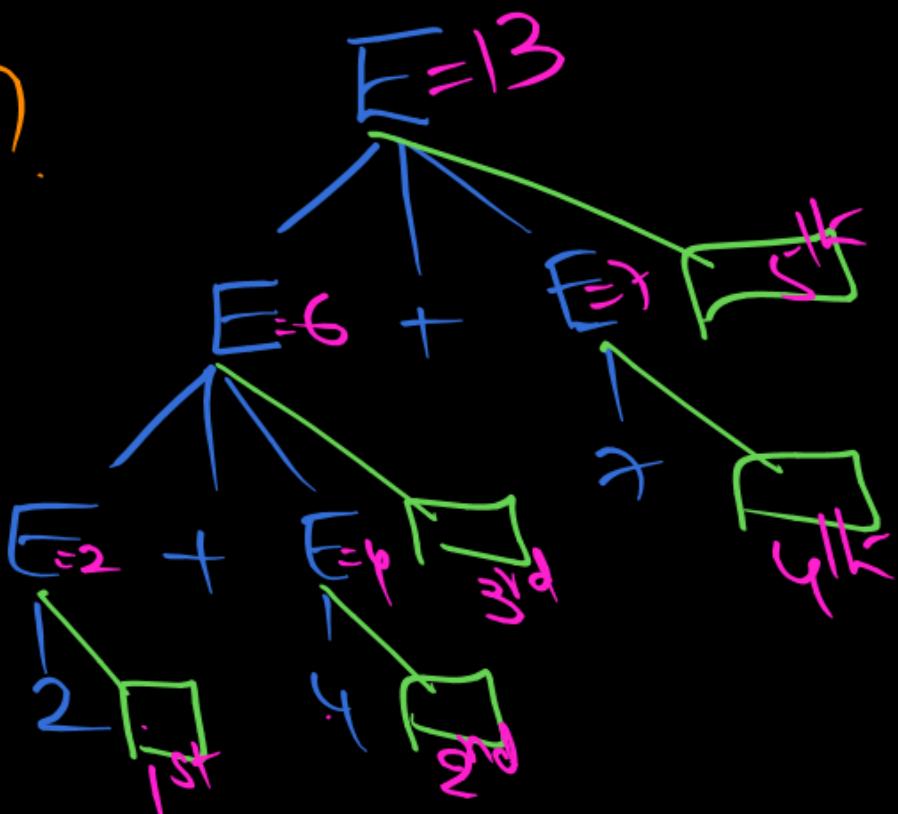
$$E \rightarrow E_1 + E_2 \quad \{ E.x = E_1.x + E_2.x \}$$

$$E \rightarrow \text{id} \quad \{ E.x = \text{id}.val \}$$

Input: $2 + 4 + 7$

What is attribute value computed at root?

$= 13$



⑧

$$E \rightarrow E_1 + E_2 \quad \{ E.x = E_1.x + E_2.x + 1 \}$$

$$E \rightarrow id \quad \{ E.x = 0 \}$$

What is the functionality of SDT ?
It counts no. of operators

$$id + id \Rightarrow 1$$

$$id + id + id \Rightarrow 2$$

$$id + id + id + id \Rightarrow 3$$

⑨

$$E \rightarrow E_1 + E_2 \quad \{ E.x = E_1.x + E_2.x \}$$

$$E \rightarrow id \quad \{ E.x = 1 \}$$

What is the functionality ?

$$\begin{array}{c} \checkmark \quad \checkmark \quad \checkmark \\ id + id + id \\ \underbrace{}_{=3} \end{array}$$

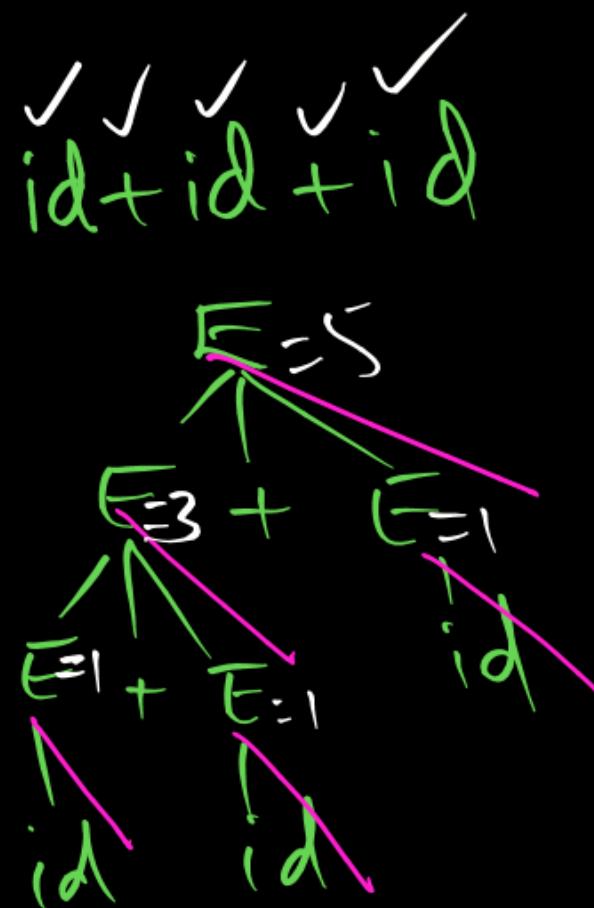
↓
no. of operands

(10)

$$E \rightarrow E_1 + E_2 \quad \{ E.x = E_1.x + E_2.x + 1 \}$$

$$E \rightarrow id \quad \{ E.x = 1 \}$$

What is the functionality?



Length of input
(No. of terminals)

(No. of operands & operators)

(11)

$$E \rightarrow T + F \{ \text{point } + \}$$

$$E \rightarrow id \{ \text{point } id.\text{val} \}$$

$$T \rightarrow T * F \{ \text{point } * \}$$

$$T \rightarrow id \{ \text{point } id.\text{val} \}$$

$$F \rightarrow id \{ \text{point } id.\text{val} \}$$

Input: $a * b + c$

Q1) What is output?

Q2) What is output using L-attributed?

Q3) " " "

Bottom up Parsing?

Q4) " " "

Top-down Parsing?

(11)

$$E \rightarrow T + F \{ \text{point } + \}$$

$$E \rightarrow id \{ \text{point } id.\text{val} \}$$

$$T \rightarrow T * F \{ \text{point } * \}$$

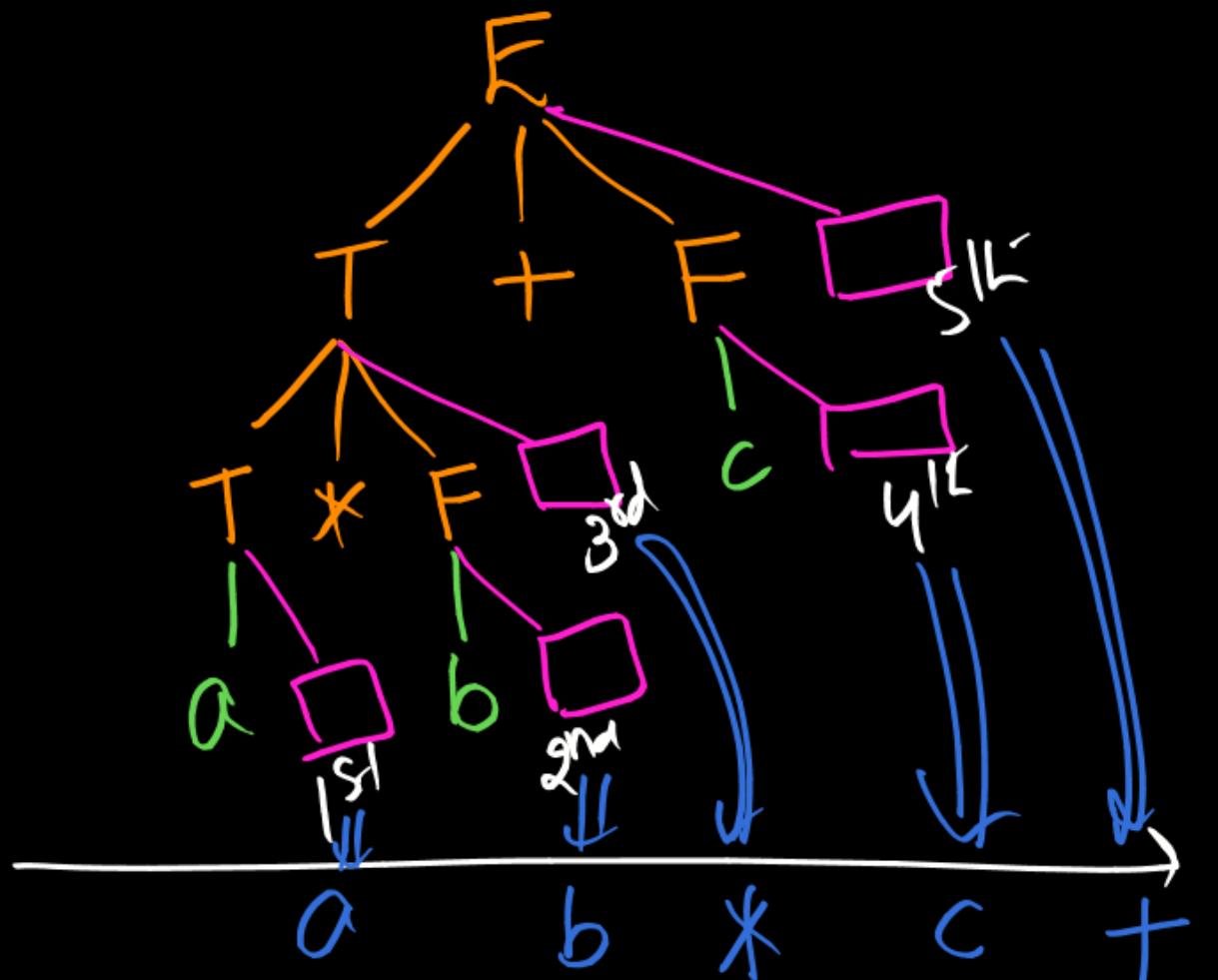
$$T \rightarrow id \{ \text{point } id.\text{val} \}$$

$$F \rightarrow id \{ \text{point } id.\text{val} \}$$

$$\begin{array}{l} E \rightarrow T + F | id \\ T \rightarrow T * F | id \\ F \rightarrow id \end{array}$$

Input: $a * b + c$

same {Q1) What is output?
 [Q2) What is output using l-attributed?



O/p: $ab * c +$

(11)

$$E \rightarrow T + F \{ \text{point } + \}$$

$$E \rightarrow id \{ \text{point } id.\text{val} \}$$

$$T \rightarrow T * F \{ \text{point } * \}$$

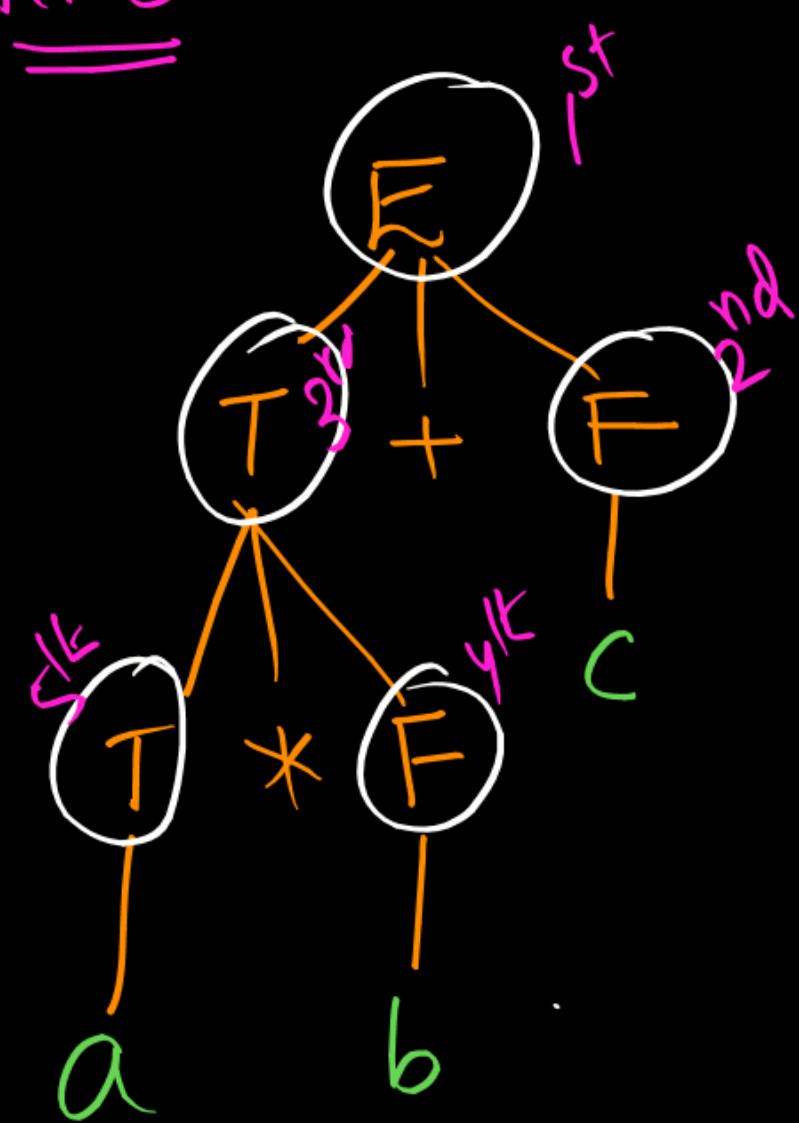
$$T \rightarrow id \{ \text{point } id.\text{val} \}$$

$$F \rightarrow id \{ \text{point } id.\text{val} \}$$

Input: $a * b + c$

(iii) Find o/p using

RMD:



Bottom up Parsing? Review of RMD: $\{ E \mid a * b + c \}$

(11)

$$E \rightarrow T + F \{ \text{point } + \}$$

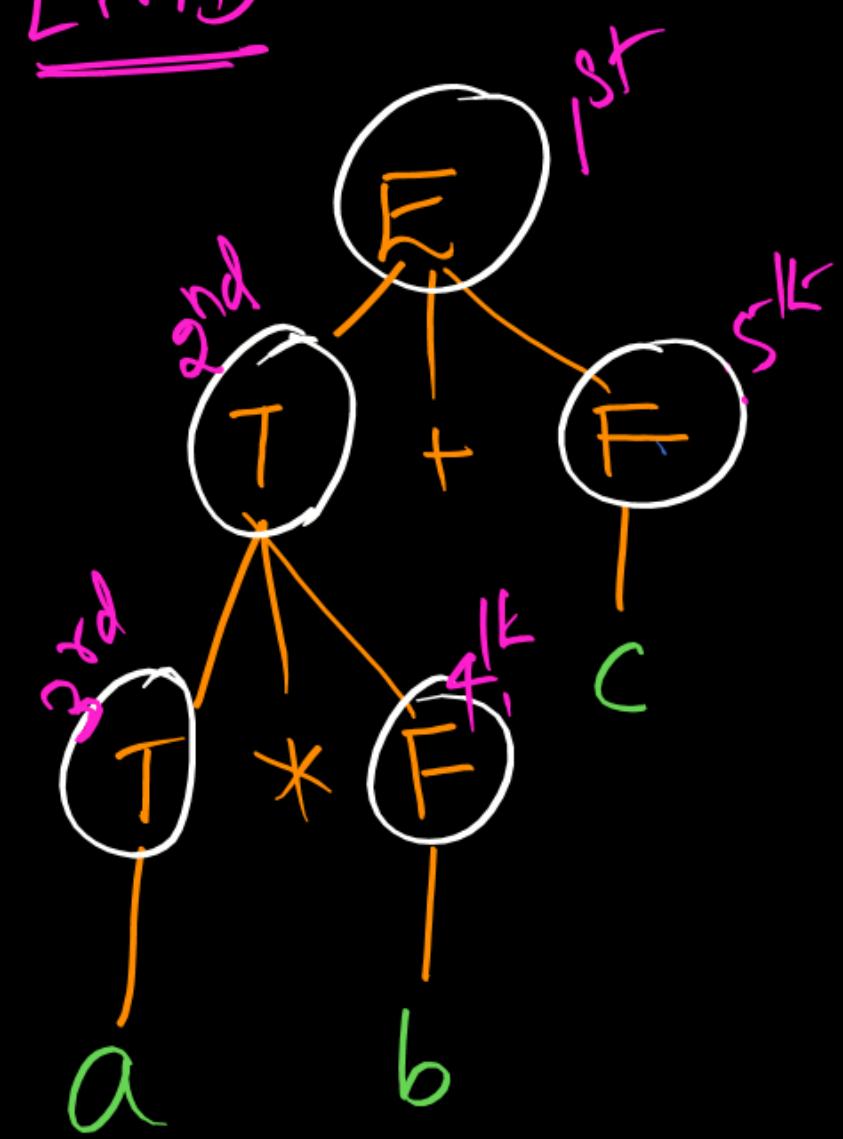
LMD:

$$E \rightarrow id \{ \text{point } id.\text{val} \}$$

$$T \rightarrow T * F \{ \text{point } * \}$$

$$T \rightarrow id \{ \text{point } id.\text{val} \}$$

$$F \rightarrow id \{ \text{point } id.\text{val} \}$$

Input: $a * b + c$ Q4) Find o/p using *TOP-down Parsing?*

LMD: 1. 2nd 3rd 4th.
 + * a b c

(12)

$$E \longrightarrow \{ \text{point} + \} T+F$$

$$E \rightarrow id \quad \{ \text{point} \quad id.\text{val} \}$$

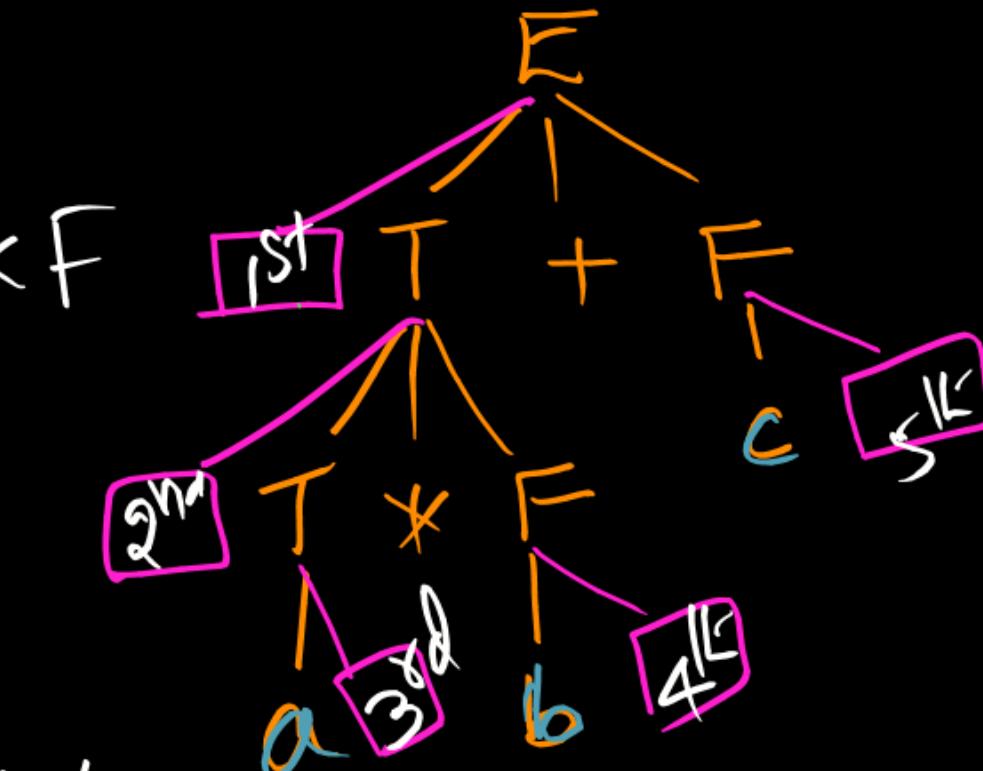
$$T \longrightarrow \{ \text{point} * \} T * F$$

$$T \rightarrow id \quad \{ \text{point} \quad id.\text{val} \}$$

$$F \rightarrow id \quad \{ \text{point} \quad id.\text{val} \}$$

Input: $a * b + c$

^{some} {Q1) What is output?
 [Q2) What is output using l-attributed?



~~Translations order:~~

1st 2nd 3rd 4th s[K] →
 + * a b c

(12)

$$E \longrightarrow \{ \text{point} + \} T+F$$

$$E \rightarrow id \quad \{ \text{point} \quad id.\text{val} \}$$

$$T \longrightarrow \{ \text{point} * \} T*F$$

$$T \rightarrow id \quad \{ \text{point} \quad id.\text{val} \}$$

$$F \rightarrow id \quad \{ \text{point} \quad id.\text{val} \}$$

Input: $a*b+c$

^{same} {Q1) What is output?

{Q2) What is output using L-attributed?

Q3) " " "

" Bottom up Parsing?

Top-down Parsing?

Same as Q1

Q1

Q1

Bottom up Parsing

Top-down Parsing

- I) L-attributed Evaluation depends on Translation order.
(If translation position changes then O/p may change)
- II) TDP & BUP Evaluations depend on Non-terminal order.
(If translation position changes then O/p will be same as previous)

I) In S-attributed SDT,

attributes are evaluated using

Bottom-UP approach.

Reverse of RMD

II) In L-attributed SDT,

Parent/legislating Inherited attributes

and Synthesized attributes

children

evaluated using top-down approach

evaluated using bottom-up approach

① $S \rightarrow S_1 \# T \quad \{S.\text{val} = S_1.\text{val} * T.\text{val}\}$

7.18

$S \rightarrow T \quad \{S.\text{val} = T.\text{val}\}$

$T \rightarrow T_1 \% R \quad \{T.\text{val} = T_1.\text{val} / R.\text{val}\}$

$T \rightarrow R \quad \{T.\text{val} = R.\text{val}\}$

$R \rightarrow \text{id} \quad \{R.\text{val} = \text{id}.\text{val}\}$

X/W

Input : $20 \# 10 \% 5 \# 8 \% 2 \% 2$

Compute the value at Root.

$20 * (10/5) * (8/2)/2$

= 80 //

②

$$N \rightarrow I \# F \quad N.\text{val} = I.\text{val} + F.\text{val}$$

$$I \rightarrow I_1 B \quad I.\text{val} = 2 I_1.\text{val} + B.\text{val}$$

$$I \rightarrow B \quad I.\text{val} = B.\text{val}$$

$$F \rightarrow BF_1 \quad F.\text{val} = \frac{1}{2} (B.\text{val} + F_1.\text{val})$$

$$F \rightarrow B \quad F.\text{val} = \frac{1}{2} B.\text{val}$$

$$B \rightarrow 0 \quad B.\text{val} = 0$$

$$B \rightarrow 1 \quad B.\text{val} = 1$$

H.W.

Input 10 #011

③

$D \rightarrow T \ L$	$X_1.type = X_2.type$
$T \rightarrow int$	$T.type = int$
$T \rightarrow float$	$T.type = float$
$L \rightarrow L_1, id$	$X_3.type = X_4.type ; AddType(id.entry, X_5.type)$
$L \rightarrow id$	$AddType(id.entry, X_6.type)$

P
W

④

 $S \rightarrow TR$ $R \rightarrow +T \{ \text{print} `+' \} R$ $R \rightarrow \epsilon$ $T \rightarrow \text{num} \{ \text{print} (\text{num}.val) \}$

Input : 9+5+2

⑤ $S \rightarrow id := E \{ \underline{\text{gen}}(id.\text{place} = E.\text{place}) \}$

$E \rightarrow E_1 + E_2 \{ t = \text{newtmp}(); E.\text{place} = t; \\ \underline{\text{gen}}(t = E_1.\text{place} + E_2.\text{place}) \}$

$E \rightarrow id \notin E.\text{place} = id.\text{place}$

Input . $X := Y + Z$

⑥ $S \rightarrow aB \quad \{ \text{point 1} \}$
 $S \rightarrow a \quad \{ \text{point 2} \}$
 $A \rightarrow Sb \quad \{ \text{point 3} \}$

Input: aab

(TOKEN checking)
Lexical Errors

① 23ab

② 029_6

③ 0x29fa_h3

④ /*

⑤ 'abc'

⑥ 23\$_ab

23+a_b
= =(STRUCTURE checking)
Syntax Errors

① for(2,3,4);

② if();

③ while();

④ if(2);
else { }

⑤ x=y

⑥ int x, int y;

⑦ void main() { }
x=(y+(a*b)));(TYPE checking)
Semantic Errors① int x;
x=y;② char ch;
int x;
ch=x;③ void main()
{
fun();
}

④ 2=x;

⑥ (x++)++;

⑤ x+y=z;

→ SDTs ✓

→ Next: Intermediate code & code optimization

H.W. K

