

$S \rightarrow AB \mid BC$

$A \rightarrow a$

$B \rightarrow b$

$C \rightarrow SB$

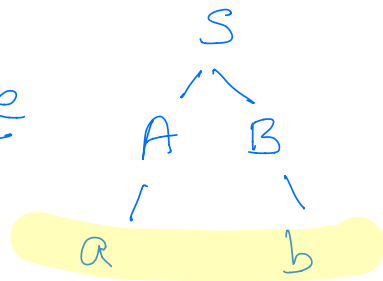
- ambiguity
- normal form
- pumping lemma
- algorithms
- class.

left most derivation

$S \rightarrow AB \rightarrow aB \rightarrow ab$

$S \rightarrow AB \rightarrow Ab \rightarrow ab$ - rightmost.

Parse tree



yield of the tree

Ambiguous

If two different parse trees / left-most derivations / right-most derivations for some word.

L: Inherently ambiguous : if all grammars

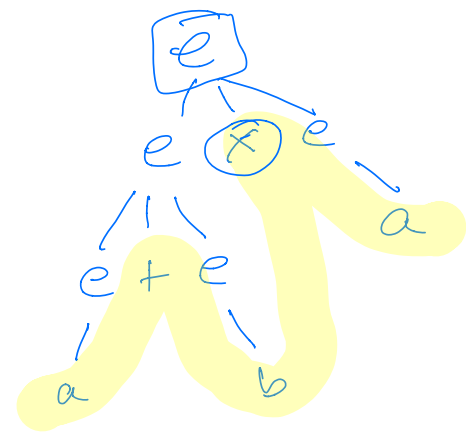
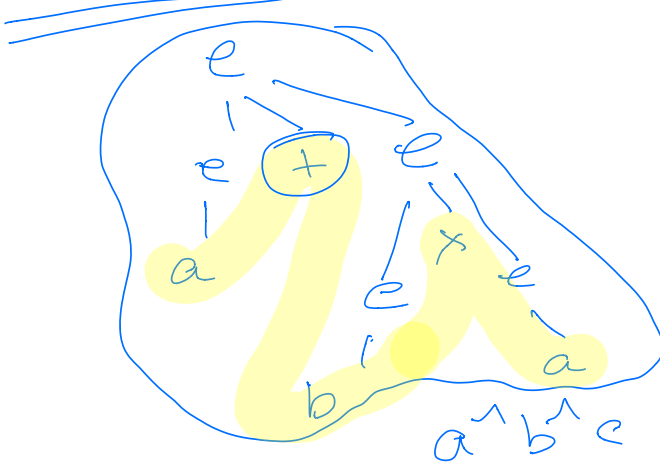
for L are ambiguous.

$\{a, b, +, x\}$

$e ::= a | b | e + e | e x e$

$a + b x a$

$a + b + a$



$e ::= \text{prod} | \text{prod} + e$
 $\text{prod} ::= a | a x \text{prod}$

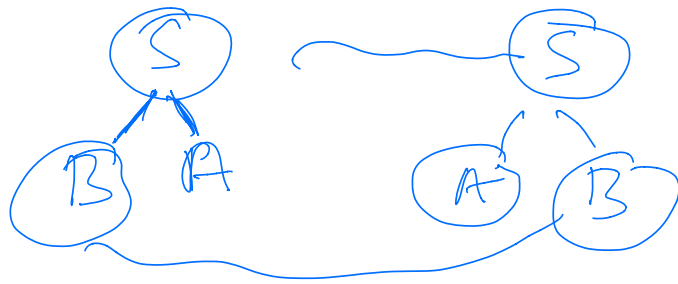
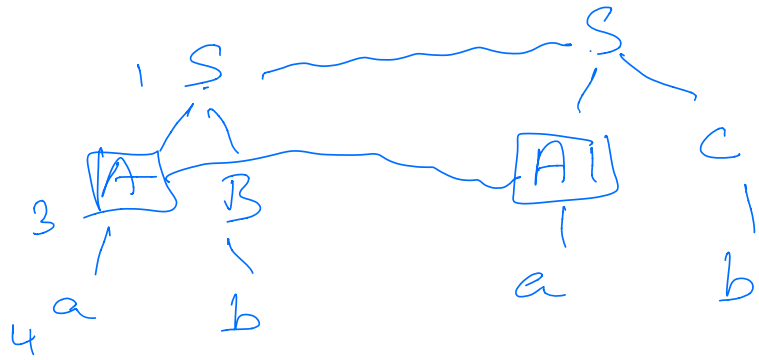


$a \hat{+} b$

$b \hat{+} a$

$a \hat{+} a$





Chomsky Normal Form

Greibach Normal Form

CNF

$$A \rightarrow BC$$

$$A \rightarrow a$$

G in CNF

$$\epsilon \notin L(G)$$

$$L(G) \setminus \{\epsilon\} = L'$$

$$B \rightarrow C$$

$$A \rightarrow BC \mid BCA \mid \dots$$

$$C \rightarrow \textcircled{B} \mid DA$$

$$A \rightarrow \underline{B} \mid BA \mid \underline{BC} \mid BCA \mid C$$

$$C \rightarrow DA$$

$$S \rightarrow B a C$$

ϵ -removal procedure.

$$G \xrightarrow{\quad\quad\quad} G'$$

$$L(G') = \underset{\text{N/D}}{L(G) \setminus \{\epsilon\}}$$

$$S \xrightarrow{a} B a C \mid a b \mid C a \mid B C D a B A$$

$$A_a \rightarrow a$$

$$A_b \rightarrow b$$

$$S \rightarrow B A_a C \mid A_a A_b \mid C A_a \mid B C D A_a B A$$

$$S \rightarrow \cancel{A_a} a \mid B C \mid C B \mid A D B$$

$$B \rightarrow B C \mid C B \mid A D B$$

$$S \rightarrow a a a$$

$$Aa \rightarrow a$$

$$S \rightarrow AaAa$$

$$S \rightarrow a$$

$$B \rightarrow B$$

$$A \rightarrow B \Leftrightarrow$$

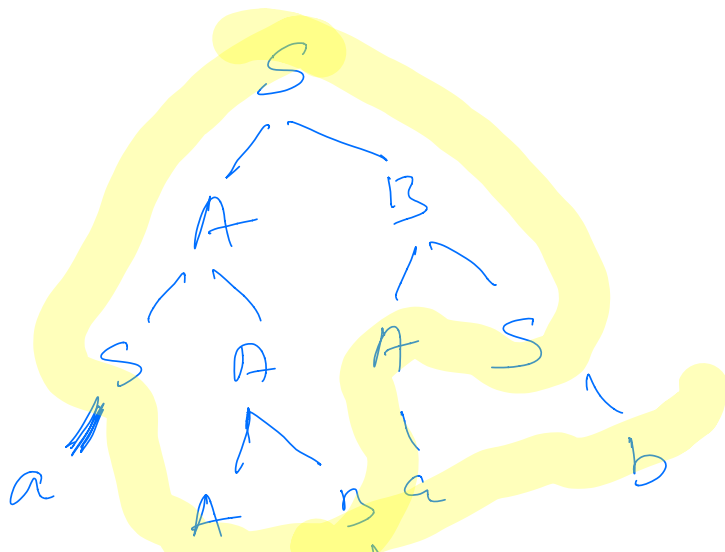
$$B \rightarrow A$$

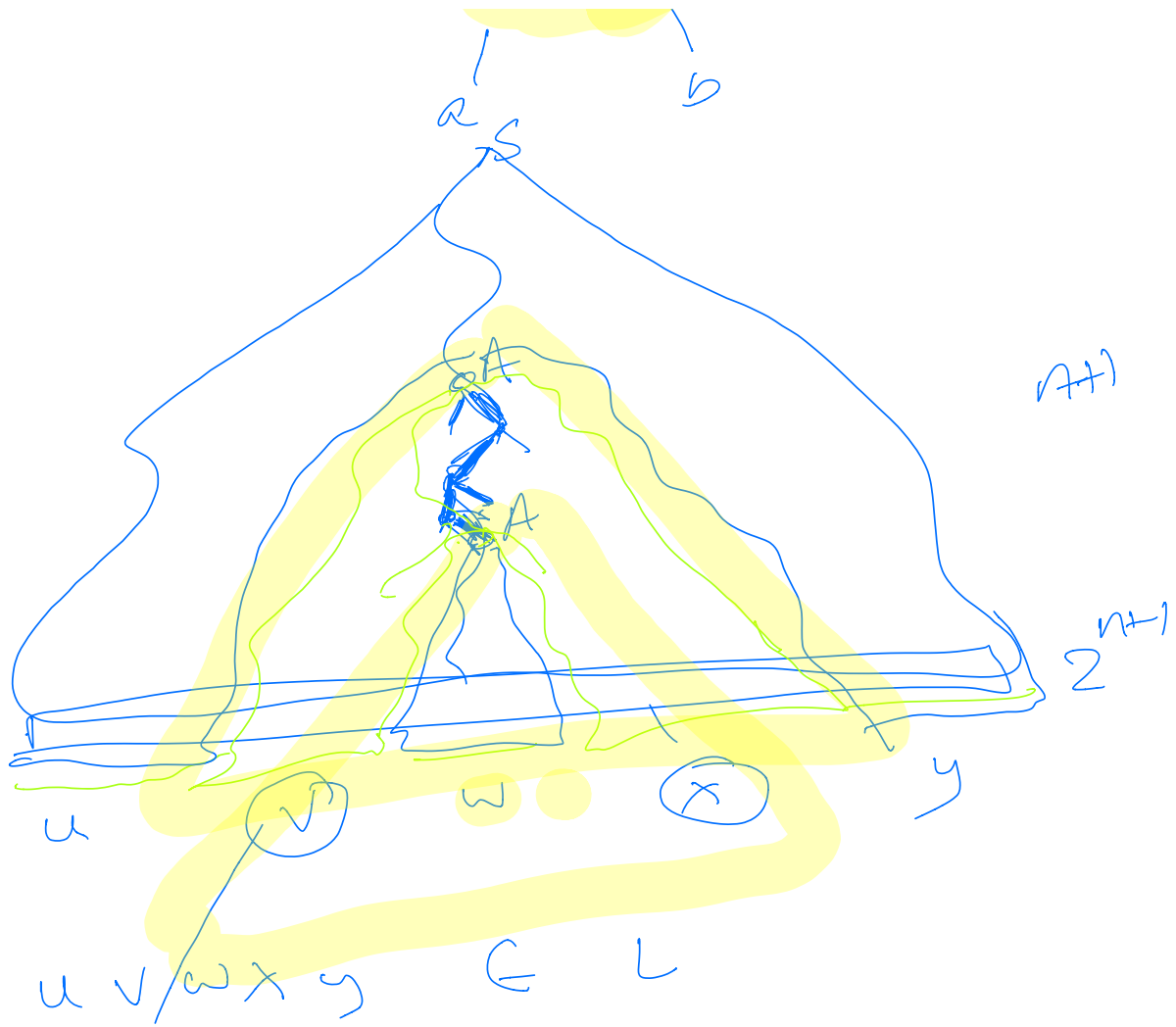
$$A \rightarrow B_1 B_2 B_3 \dots B_{2k}$$

$$B_{2k} \rightarrow B_2 B_3 \dots B_k$$

$$A \rightarrow B_1 B_{2k}$$

CNF \rightarrow binary parse trees.



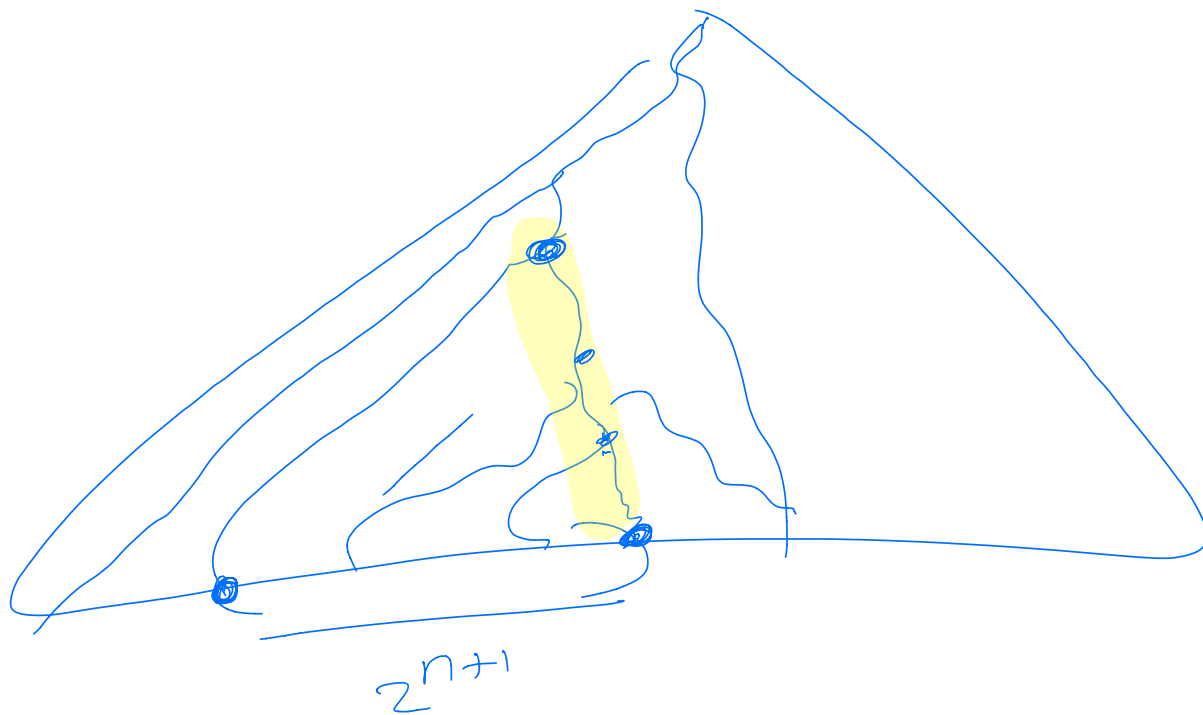


$u v w x y \in L$

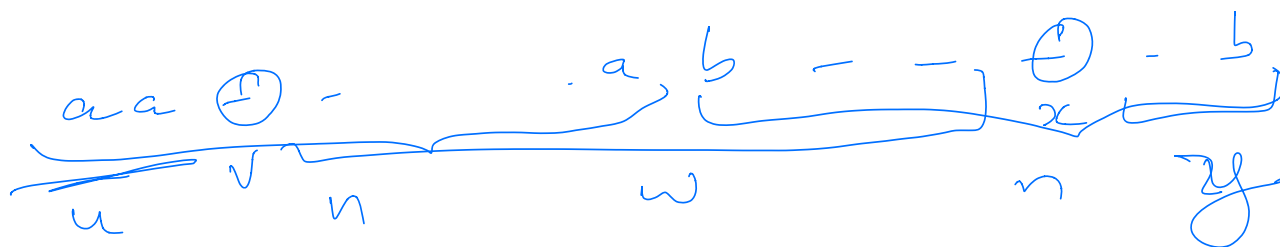
$u w y \in L$

$u v \boxed{v w x x} y$

$u v^i w x^l y$



$$\{a^n b^n \mid n \geq 0\} = L$$



$u v^i w x^i y \in L$

$a^n b^n c^n \mid n \geq 0$