

## Unrestricted Grammar

In unrestricted or phrase-structure grammar is a 4-tuple  $G = (V, T, P, S)$  where  $V$  and  $T$  are disjoint sets of variables and terminals, respectively;

$\varnothing \rightarrow \text{start symbol}$

$P \rightarrow$  set of productions of the form

where  $\alpha, \beta \in (v \cup \tau)^*$  and  $\alpha \xrightarrow{\beta}$  contains

$$1). \quad L = \{a^i b^i c^i \mid i \geq 1\}$$

$\alpha \rightarrow \beta$  contains at least one variable.

$$\xrightarrow{S_1 \rightarrow \underline{ABC} S_1 / \underline{ABC}} \rightarrow (ABC)^n$$

$$BA \rightarrow AB$$

$$iA \rightarrow AC$$

$$CB \rightarrow BC$$

→ realig o

$$|\alpha| \leq |\beta|$$

$$\begin{array}{l} cC \rightarrow cc \\ bC \rightarrow bc \end{array} \quad \left. \begin{array}{c} \\ \end{array} \right\} \quad \rightarrow \text{for } 'c'$$

$\mu A \rightarrow a$

$$\begin{array}{l} bB \rightarrow bb \\ aB \rightarrow ab \end{array} \quad \left. \begin{array}{c} \{ \\ \} \end{array} \right\} \rightarrow \text{for } 'b$$

$aA \rightarrow \underline{aa}$  ?  $\rightarrow$  for  $\dot{a}$

A hand-drawn diagram showing a central horizontal line with three curved lines branching out from it to the left, right, and right. The leftmost branch is labeled 'A' at its top. The middle branch is labeled 'B' at its top. The rightmost branch is labeled 'C' at its top. The lines are drawn with a blue pen on a white background.

$$FA \rightarrow a$$

S → FS<sub>1</sub>

ABA Bn

D A B B

$$2) L = \{s_s \mid s \in \{a, b\}^*\}$$

$$S \rightarrow FH$$

$$\left. \begin{array}{l} F \rightarrow FaA \\ F \rightarrow FbB \end{array} \right\} \Rightarrow \text{for producing } a's \text{ & } b's$$

$$\left. \begin{array}{l} Aa \rightarrow aA \\ Ab \rightarrow bA \\ Ba \rightarrow aB \\ Bb \rightarrow bB \end{array} \right\} \Rightarrow \text{allow the variables to migrate past the terminals in the first half.}$$

$$\left. \begin{array}{l} AH \rightarrow Ha \\ BM \rightarrow Mb \\ F \rightarrow E \\ M \rightarrow E \end{array} \right\} \Rightarrow \begin{array}{l} \text{Migrating variable hits } M, \\ \text{at which point it deposits the corresponding terminal on the other side and disappears.} \\ \text{to complete derivation.} \end{array}$$

$$3) L = \{a^n b^n a^n b^n \mid n \geq 0\}$$

$$S \rightarrow F\varphi_1 \mid \epsilon$$

$$\varphi_1 \rightarrow ABCD S_1 \mid ABCD$$

$$\begin{array}{l} BA \rightarrow AB \\ CA \rightarrow AC \\ DA \rightarrow AD \\ CB \rightarrow BC \\ DB \rightarrow BD \\ DC \rightarrow CD \end{array}$$

$$\begin{array}{ll} FA \rightarrow A_1 & A_1 \rightarrow a \\ A_1 A \rightarrow A_1 A_1 & B_1 \rightarrow b \\ A_1 B \rightarrow A_1 B_1 & C_1 \rightarrow a \\ B_1 B \rightarrow B_1 B_1 & D_1 \rightarrow b \\ B_1 C \rightarrow B_1 C_1 & \\ C_1 C \rightarrow C_1 C_1 & \\ C_1 D \rightarrow C_1 D_1 & \\ D_1 D \rightarrow D_1 D_1 & \end{array}$$

4).  $L = \{a^n x b^n \mid n \geq 0, x \in \{a, b\}^*, |x|=n\}$

$S \rightarrow FS_1 | \epsilon$

$S_1 \rightarrow ABCS_1 | ABC$

$BA \rightarrow AB$  }  
 $CA \rightarrow AC$  }  
 $CB \rightarrow BC$  }

$FA \rightarrow A_1$

$A_1 A \rightarrow A_1 A_1$

$A_1 B \rightarrow A_1 B_1$

$B_1 B \rightarrow B_1 B_1$

$B_1 C \rightarrow B_1 C_1$

$C_1 C \rightarrow C_1 C_1$

$A_1 \rightarrow a$

$B_1 \rightarrow a/b$

$C_1 \rightarrow b$

5).  $\{sss \mid s \in \{a, b\}^*\}$

$S \rightarrow LMN$

$L \rightarrow LaA | LbB | \epsilon$

$M \rightarrow \epsilon$

$N \rightarrow \epsilon$

$Aa \rightarrow aA$

$Ab \rightarrow bA$

$Ba \rightarrow aB$

$Bb \rightarrow bB$

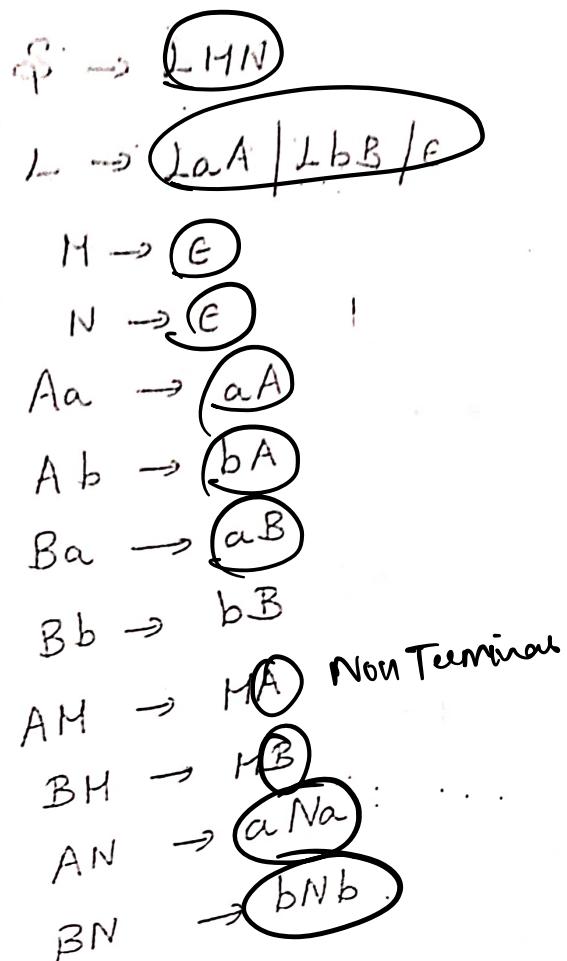
$AH \rightarrow HaA$

$BM \rightarrow MbB$

$AN \rightarrow Na$

$BN \rightarrow Nb$

6).  $\{ S \in S \mid S \in \{a, b\}^* \}$



Context Sensitive Grammar language..

①.  $S \rightarrow a \mid A_1 A_2$   
 $A_1 \rightarrow A_1 A \mid a$   
 $A_2 \rightarrow a$   
 $A_1 \rightarrow aaA$   
 $A_1 A_2 \rightarrow aaA_2$

②  $S \rightarrow a / A_L A_2 a A_R$

$A_L \rightarrow A_L I / E$

$Ia \rightarrow a I / IA_2$

$IA_2 \rightarrow a A_2 \sqrt{I}$

$IA_R \rightarrow a A_2 a A_R$

$Ja \rightarrow a J$

$J A_2 \rightarrow A_2 J$

$J A_R \rightarrow a A_R$

$Ea \rightarrow a E$

$EA_2 \rightarrow a E$

$EA_R \rightarrow aa$

$a_0$

③  $L = \{a^n b^n c^n \mid n \geq 1\}$

$S \rightarrow a SBC$

$S \rightarrow a BC$

$CB \rightarrow BC$

$aB \rightarrow ab$

$bB \rightarrow bb$

$bC \rightarrow bc$

$cC \rightarrow cc$

③



②  $S \rightarrow a \mid A_L A_2 a A_R$

$A_L \rightarrow A_L I \mid E$

$Ia \rightarrow a \underline{I} \mid \underline{IA_2}$

$IA_2 \rightarrow a A_2 \sqrt{I}$

$\leftarrow a$

$IA_R \rightarrow a A_2 a A_R$

$J_a \rightarrow a \underline{J}$

$J A_2 \rightarrow A_2 \underline{J}$

$J A_R \rightarrow a A_R$

$E_a \rightarrow a E$

$E A_2 \rightarrow a E$

$E A_R \rightarrow a a$

③  $L = \{a^n b^n c^n \mid n \geq 1\}$

$S \rightarrow a SBC$

$S \rightarrow a BC$

$CB \rightarrow BC$

$aB \rightarrow ab$

$bB \rightarrow bb$

$bC \rightarrow bc$

$cC \rightarrow cc$

B

A B C  
| | |  
+ + +

④

$L \Rightarrow \text{no. of } a's = \text{no. of } b's = \text{no. of } c's$

$\$ \rightarrow ABC$

$\$ \rightarrow ABC\$$

$AB \rightarrow BA$

$AC \rightarrow CA$

$BC \rightarrow CB$

$BA \rightarrow AB$

$CA \rightarrow AC$

$CB \rightarrow BC$

$A \rightarrow a$

$B \rightarrow b$

$C \rightarrow c$

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

LBA:

$\delta(q_0, I) = (q_1, L, R)$

$\delta(q_1, I) = (q_1, I, Y)$

$\delta(q_1, \#) = (q_1, \#, R)$

$\delta(q_1, a) = (q_2, \#, R)$

$\delta(q_2, a) = (q_2, a, R)$

$\delta(q_2, \#) = (q_2, \#, R)$

$\delta(q_2, b) = (q_3, \#, R)$

$\delta(q_3, b) = (q_3, b, R)$

$$\delta(q_3, \#) = (q_5, \#, R)$$

$$\delta(q_3, c) = (q_4, \#, L)$$

$$\delta(q_4, c) = (q_4, c, L)$$

$$\delta(q_4, b) = (q_4, b, L)$$

$$\delta(q_4, a) = (q_4, a, L)$$

$$\delta(q_4, \#) = (q_4, \#, L)$$

$$\delta(q_4, L) = (q_1, L, R).$$

2a  $\rightarrow$  a1