Unrestricted Grammar

An 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;

$S \rightarrow$ start symbol

$P \rightarrow$ set of productions of the form

$\alpha \rightarrow \beta$.

where $\alpha, \beta \in (V \cup T)^*$ and α contains at-least one variable.

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

$S_1 \rightarrow ABCS_1 \mid ABC \rightarrow (ABC)^n$

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

$cC \rightarrow cc$
$bC \rightarrow bc$ } $\rightarrow$ for 'c'

$bB \rightarrow bb$
$aB \rightarrow ab$ } $\rightarrow$ for 'b'

$aA \rightarrow aa$
$FA \rightarrow a$ } $\rightarrow$ for 'a'

$S \rightarrow FS_1$

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

$AA \rightarrow q$

A) BABA

AABB

a)

$L = \{ss \mid s \in \{a,b\}^*\}$

$S \rightarrow FM$

$F \rightarrow FaA$
$F \rightarrow FbB$ } ⇒ for producing a's & b's

$Aa \rightarrow aA$
$Ab \rightarrow bA$
$Ba \rightarrow aB$
$Bb \rightarrow bB$ } ⇒ allow the variables to migrate past the terminals in the first half.

$AM \rightarrow Ma$
$BM \rightarrow Mb$ } ⇒ Migrating variable hits M, at which point it deposits its corresponding terminal on the other side and disappears.

$F \rightarrow \epsilon$
$M \rightarrow \epsilon$ } ⇒ to complete derivation.

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

$S \rightarrow FS_1 \mid \epsilon$

$S_1 \rightarrow ABCD\,S_1 \mid ABCD$

$BA \rightarrow AB$
$CA \rightarrow AC$
$DA \rightarrow AD$
$CB \rightarrow BC$
$DB \rightarrow BD$
$DC \rightarrow CD$

$FA \rightarrow A_1$
$A_1 A \rightarrow A_1 A_1$
$A_1 B \rightarrow A_1 B_1$
$B_1 B \rightarrow B_1 B_1$
$B_1 C \rightarrow B_1 C_1$
$C_1 C \rightarrow C_1 C_1$
$C_1 D \rightarrow C_1 D_1$
$D_1 D \rightarrow D_1 D_1$

$A_1 \rightarrow a$
$B_1 \rightarrow b$
$C_1 \rightarrow a$
$D_1 \rightarrow b$

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

$$S \to FS_1 \mid \epsilon$$
$$S_1 \to ABCS_1 \mid ABC$$
$$BA \to AB$$
$$CA \to AC$$
$$CB \to BC$$
$$FA \to A_1$$
$$A_1A \to A_1A_1$$
$$A_1B \to A_1B_1$$
$$B_1B \to B_1B_1$$
$$B_1C \to B_1C_1$$
$$C_1C \to C_1C_1$$
$$A_1 \to a$$
$$B_1 \to a \mid b$$
$$C_1 \to b$$

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

$$S \to LMN$$
$$L \to LaA \mid LbB \mid \epsilon$$
$$M \to \epsilon$$
$$N \to \epsilon$$
$$Aa \to aA$$
$$Ab \to bA$$
$$Ba \to aB$$
$$Bb \to bB$$
$$AM \to MaA$$
$$BM \to MbB$$
$$AN \to Na$$
$$BN \to Nb.$$

(i). $\{ss^R s \mid s \in \{a,b\}^*\}$

$S \rightarrow LMN$

$L \rightarrow LaA \mid LbB \mid \epsilon$

$M \rightarrow \epsilon$

$N \rightarrow \epsilon$

$Aa \rightarrow aA$

$Ab \rightarrow bA$

$Ba \rightarrow aB$

$Bb \rightarrow bB$

$AM \rightarrow MA$ Non Terminal

$BM \rightarrow MB$

$AN \rightarrow aNa$

$BN \rightarrow bNb$

Context Sensitive Grammar.

Language.

(i). $S \rightarrow a \mid A_1 A_2$

$A_1 \rightarrow A_1 A \mid a$

$A_2 \rightarrow a$

$Aa \rightarrow aA$

$AAA_2 \rightarrow aaA_2$.

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

$A_L \rightarrow A_L I \mid E$

$Ia \rightarrow aI \mid IA_2$

$IA_2 \rightarrow a A_2 \downarrow I$

$IA_R \rightarrow a A_2 a A_R$

$Ja \rightarrow aJ$

$JA_2 \rightarrow A_2 J$

$JA_R \rightarrow a A_R$

$Ea \rightarrow aE$

$EA_2 \rightarrow aE$

$EA_R \rightarrow aa$

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

$S \rightarrow aSBC$

$S \rightarrow aBC$

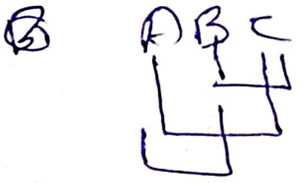
$CB \rightarrow BC$

$aB \rightarrow ab$

$bB \rightarrow bb$

$bC \rightarrow bc$

$cC \rightarrow cc$



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

$A_L \rightarrow A_L I \mid E$

$Ia \rightarrow aI \mid IA_2$

$I A_2 \rightarrow a A_2 \downarrow I$

$I A_R \rightarrow a A_2 a A_R$

$Ja \rightarrow aJ$

$JA_2 \rightarrow A_2 J$

$JA_R \rightarrow a A_R$

$Ea \rightarrow aE$

$EA_2 \rightarrow aE$

$EA_R \rightarrow aa$

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

$S \rightarrow aSBC$

$S \rightarrow aBC$

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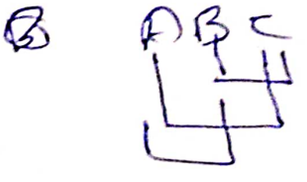

(4) $L \Rightarrow$ no. of a's = no. of b's = no. of c's

$$S \rightarrow ABC$$
$$S \rightarrow ABCS$$
$$AB \rightarrow BA$$
$$AC \rightarrow CA$$
$$BC \rightarrow CB$$
$$BA \rightarrow AB$$
$$CA \rightarrow AC$$
$$CB \rightarrow BC$$
$$A \rightarrow a$$
$$B \rightarrow b$$
$$C \rightarrow c$$

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

LBA:

$\delta(q_0, I) = (q_1, I, R)$
$\delta(q_1, I) = (q_1, I, Y)$
$\delta(q_1, \#) = (q_1, \#, R)$
$\delta(q_1, a) = (q_2, \#, R)$
$\delta(q_2, a) = (q_2, a, R)$
$\delta(q_2, \#) = (q_2, \#, R)$
$\delta(q_2, b) = (q_3, \#, R)$
$\delta(q_3, b) = (q_3, b, R)$

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

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

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

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

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

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

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

Jasal