Chomsky Normal Form(CNF)

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Simplification of CFG

1. Removal of Useless Symbols
2. Elimination of ε Production
3. Removing Unit Productions

Example-1 : Remove useless symbols from the CFG

T → aaB | abA | aaT

A → aA

B → ab | b

C → ad

Answer:

T → aaB | abA | aaT

A → aA

B → ab | b

Example-2: Remove of Null productions from the given CFG

S → XYX

X → 0X | ε

Y → 1Y | ε

Answer:

S → XY | YX | XX | X | Y

X → 0X | 0

Y → 1Y | 1

Example-3: Removal UNIT productions from the given CFG

$S \rightarrow 0A \mid 1B \mid C$

$A \rightarrow 0S \mid 00$

$B \rightarrow 1 \mid A$

$C \rightarrow 01$

Answer:

$S \rightarrow 0A \mid 1B \mid 01$

$A \rightarrow 0S \mid 00$

$B \rightarrow 1 \mid 0S \mid 00$

$C \rightarrow 01$

Chomsky's Normal Form (CNF)

CNF stands for Chomsky normal form. A CFG(context free grammar) is in CNF(Chomsky normal form) if all production rules satisfy one of the following conditions:

1. Start symbol generating ε. For example, $A \rightarrow \varepsilon$. Create new starting symbol.
2. A non-terminal generating two non-terminals. For example, $S \rightarrow AB$.
3. A non-terminal generating a terminal. For example, $S \rightarrow a$.

Example

$G1 = \{S \rightarrow AB, S \rightarrow c, A \rightarrow a, B \rightarrow b\}$

$G2 = \{S \rightarrow aA, A \rightarrow a, B \rightarrow c\}$

The production rules of Grammar G1 satisfy the rules specified for CNF, so the grammar G1 is in CNF.

However, the production rule of Grammar G2 does not satisfy the rules specified for CNF as $S \rightarrow aZ$ contains terminal followed by non-terminal.

So the grammar G2 is not in CNF.

Example-4

Convert the given CFG to CNF. Consider the given grammar G1:

$S \rightarrow a \mid aA \mid B$

$A \rightarrow aBB \mid \varepsilon$

$B \rightarrow Aa \mid b$

Example-5

Convert the given CFG to CNF. Consider the given grammar G1:

S → ASA|aB

A → B/S

B → b/ λ

Example-1 : Solution

$$
\begin{aligned}
S_0 &\longrightarrow AA_1|UB|a|SA|AS \\
S &\longrightarrow AA_1|UB|a|SA|AS \\
A &\longrightarrow b|AA_1|UB|a|SA|AS \\
A_1 &\longrightarrow SA \\
U &\longrightarrow a \\
B &\longrightarrow b
\end{aligned}
$$

Example-6

Convert the given CFG to CNF. Consider the given grammar G1:

S → 1A | 0B

A → 1AA |0S | 0

B → 0BB | 1S | 1

Example-7

Convert the given CFG to CNF. Consider the given grammar G1:

$S \rightarrow aAD$

$A \rightarrow aB \mid bAB$

$B \rightarrow b$

$D \rightarrow d$