

Chomsky Normal Form (CNF)

Normal form implies the rewriting of the CFG as per specified conditions.

(CNF) \rightarrow A CFG that contains all the productions of the form $A \rightarrow BC$, (or) $A \rightarrow a$ and it is simplified already is said to be in Chomsky Normal form.

$$\begin{array}{ccccc} A \rightarrow BC & , & \text{or} & A \rightarrow a \\ \downarrow & \downarrow & & \downarrow & \downarrow \\ 1V & 2V & & 1V & 1T \\ & & & & S \rightarrow \epsilon \end{array}$$

Step 1 - simplify the grammar.

- ① Remove ϵ productions.
- ② Remove unit productions.
- ③ Remove useless symbols. (Non generating & Non reachable)

Step 2 - Add the productions which are already in CNF into solution list.

Step 3 - For every non-CNF production rules

- ① replace the terminal by new Chomsky variable to limit the number of var. at right side to 2.

Avoid having S at RHS.

$$\begin{aligned} \textcircled{*} \quad & S \rightarrow abAB \\ & A \rightarrow bAB / \epsilon \\ & B \rightarrow BAa / A / \epsilon \end{aligned}$$

convert given
CFG into CNF.

Step 1 (a) Remove ϵ productions.

$$\begin{array}{l|l} A \rightarrow \epsilon & S \rightarrow abAB / abB / abA / ab / \epsilon \\ B \rightarrow \epsilon & A \rightarrow bAB / bB / bA / b \\ & B \rightarrow BAa / A / Ba / Aa / a \end{array}$$

(b) Remove unit productions

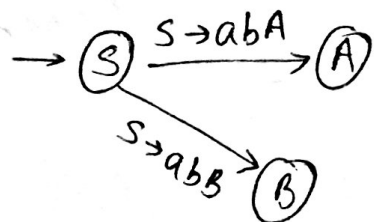
$$\begin{array}{l|l} B \rightarrow A & S \rightarrow abAB / abB / abA / ab \\ & A \rightarrow bAB / bB / bA / b \\ & B \rightarrow BAa / Aa / a / Ba / bAB / bB / bA / b \end{array}$$

(c) Remove non-generating symbols.

assume generating = (a, b)
symbols

$$\begin{array}{l} S \rightarrow ab \\ \downarrow \\ A \rightarrow b \\ \downarrow \\ B \rightarrow b \end{array}$$

(d) No non-gen. symbol. (a, b, S, A, B) all are generating.
Remove non-reachable symbols.
draw dependency graph.



all the symbols are
reachable.
so no change in the
grammar.

Step II - Add chomsky variable.

$$Ca \rightarrow a, \quad cb \rightarrow b$$

All the rules must be in the form,
 $A \rightarrow BC, A \rightarrow a$

cnf form rules.

$$C_a \rightarrow a$$

$$C_b \rightarrow b$$

$$\textcircled{1} S \rightarrow abAB \longrightarrow S \rightarrow C_1 C_2$$

$$C_1 \rightarrow C_a C_b$$

$$C_2 \rightarrow AB$$

$$\textcircled{2} S \rightarrow abA \longrightarrow S \rightarrow C_1 A$$

$$\textcircled{3} S \rightarrow abb \longrightarrow S \rightarrow C_1 B$$

$$\textcircled{4} S \rightarrow ab \longrightarrow S \rightarrow C_a C_b$$

$$\textcircled{5} A \rightarrow bAB \longrightarrow A \rightarrow C_3 B$$

$$C_3 \rightarrow C_b A$$

$$\textcircled{6} A \rightarrow bB \longrightarrow A \rightarrow C_b B$$

$$\textcircled{7} A \rightarrow bA \longrightarrow A \rightarrow C_b A$$

$$\textcircled{8} A \rightarrow b \longrightarrow A \rightarrow b$$

$$\textcircled{9} B \rightarrow BAa \longrightarrow B \rightarrow B C_4$$

$$C_4 \rightarrow A C_a$$

$$\textcircled{10} B \rightarrow Aa \longrightarrow B \rightarrow A C_a$$

$$\textcircled{11} B \rightarrow a \longrightarrow B \rightarrow a$$

$$\textcircled{12} B \rightarrow Ba \longrightarrow B \rightarrow B C_a$$

$$\textcircled{13} B \rightarrow bAB \longrightarrow B \rightarrow C_b C_2$$

$$\textcircled{14} B \rightarrow bB \longrightarrow B \rightarrow C_b B$$

$$\textcircled{15} B \rightarrow \cancel{B} A b A \longrightarrow B \rightarrow C_b A$$

$$\textcircled{16} B \rightarrow b \longrightarrow B \rightarrow b$$

CFG is cnf is $(V \cup T \cup S)$ P: as shown above

$$V = \{S, A, B, C_a, C_b, C_1, C_2, C_3, C_4\}$$

$$T = \{a, b\} \quad S = S.$$