CSC-257
Theory Of Computation
(BSc CSIT, TU)

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Greibach Normal Form (GNF)

- A grammar G = (V, T, P, S) is said to be in Greibach Normal Form, if all the productions of the grammar are of the form :

  A → aβ, where a ∈ T(a is a terminal) and β ∈ V* (zero or more number of non terminals). i.e. α ∈ V* So we can rewrite as:

- A CFG is said to be in GNF if the right-hand sides of all the production rules start with a terminal symbol, and optionally followed by some variables(non terminals)

- This form is called Greibach Normal Form, after Sheila Greibach.

- So there can be two types of productions in GNF as :

  A → a, where a ∈ T and

  A → aβ, where β is a string of one or more not terminals(β ∈ V*)

Conversion of CFG into GNF

- To convert a grammar into GNF we need to :

- Convert the grammar into CNF at first
- Remove any direct / indirect left recursions
- Let, the left recursion tree ordering is A_1, A_2, A_3, ... A_p
- Let, A_p is in GNF
- Substitute A_p in first symbol of A_{p-1}, if A_{p-1} contains A_p. Then A_{p-1} is also in GNF
- Similarly, substitute first symbol of A_{p-2} by A_{p-1} production and A_p production and son on….
- Finally, grammar will be in GNF.

Conversion of CFG into GNF

- **Example :** Convert the following grammar in GNF

  $S \rightarrow AA \mid 0$

  $A \rightarrow SS \mid 1$

- **Solution :** This grammar is already in CNF.
- Now to remove left recursion, first replace symbol of A-production by S-production (since we do not have immediate left recursion) as :

  $S \rightarrow AA \mid 0$

  $A \rightarrow AAS \mid 0S \mid 1$ where suppose, $\alpha 1 = AS$, $\beta 1 = 0S$ and $\beta 2 = 1$

- Now, removing the immediate left recursion, we get :

  $S \rightarrow AA \mid 0$

  $A \rightarrow 0SA' \mid 1A'$

  $A' \rightarrow ASA' \mid \in$

Conversion of CFG into GNF

- After removing ∈-production, we get :

  $S \rightarrow AA \mid 0$

  $A' \rightarrow ASA' \mid AS$

  $A \rightarrow 0SA' \mid 1A' \mid 0S \mid 1$

- Here, production $A \rightarrow 0SA' \mid 1A' \mid 0S \mid 1$ is already in GNF, so replacing first symbol of S-productions by A-production as :

  $S \rightarrow 0SA'A \mid 1A'A \mid 0SA \mid 1A \mid 0$

  $A' \rightarrow ASA' \mid AS$

  $A \rightarrow 0SA' \mid 1A' \mid 0S \mid 1$

Conversion of CFG into GNF

- Again, replacing first symbol of A′-productions by A-production as :

  S → 0SA′A | 1A′A | 0SA | 1A | 0

  A′ → 0SA′SA′ | 1A′SA′ | 0SSA′ | 1SA′ | 0SA′S | 1A′S | 0SS| 1S

  A → 0SA′ | 1A′ | 0S | 1

- Now, above grammar is in GNF.

Conversion of CFG into GNF

- **Exercise :** Convert the following grammars into GNF

  $S \rightarrow XY \mid Xn \mid p$

  $X \rightarrow mX \mid m$

  $Y \rightarrow Xn \mid o$