

Productions and Derivation

Chapter - 1: Introduction

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Basics of Grammar

A grammar G is defined as:

$$G = (V, \Sigma, P, S)$$

Where:

- V = Set of variables (non-terminals)
- Σ = Set of terminals (alphabet symbols)
- P = Set of production rules
- S = Start symbol

What are Productions?

Productions (P):

Rules used to replace variables (non-terminals) with other variables or terminal strings.

General Form:

$$A \rightarrow \alpha$$

Where:

- A is a non-terminal (from V)
- α is a string from $(V \cup \Sigma)^*$

Example:

- $S \rightarrow aSb$
- $S \rightarrow \epsilon$

What is Derivation?

Derivation:

The process of repeatedly applying production rules to derive a string from the start symbol.

Goal:

Generate strings belonging to the language of the grammar.

Notation:

$\alpha \Rightarrow \beta$ (one step derivation)

$\alpha \Rightarrow^* \beta$ (zero or more steps)

$\alpha \Rightarrow^n \beta$ (n steps)

Derivation Example – Step by Step

- Finite Language: Has a limited number of strings
- Infinite Language: Has unlimited strings (e.g., $L = \{a^n \mid n \geq 0\}$)

Given $G = (\{S\}, \{a, b\}, \{S \rightarrow aSb, S \rightarrow \epsilon\}, S)$

Let's derive aabb:

S

$\Rightarrow aSb$

$\Rightarrow aaSbb$

$\Rightarrow aa\epsilon bb$

$= aabb$

Therefore, $aabb \in L(G)$

Leftmost and Rightmost Derivation

Leftmost Derivation:

Always replace the leftmost non-terminal first.

Rightmost Derivation:

Always replace the rightmost non-terminal first.

Example:

Grammar:

• $S \rightarrow aSb \mid ab$

Leftmost Derivation for aabb:

1. S

2. $\Rightarrow aSb$

3. $\Rightarrow aaSbb$

4. $\Rightarrow aabb$

Rightmost Derivation:

1. S

2. $\Rightarrow aSb$

3. $\Rightarrow aabSb$

4. $\Rightarrow aabb$

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