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MS. SHWETA TIWARI
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PREPARED FOR
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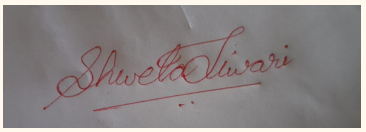

INSTRUCTOR: Ms. SHWETA TIWARI
shwetatiwari08@recabn.ac.in
shwetatiwari08aug@gmail.com

CD: COMPILER DESIGN

TOPIC On : Left Recursion-Left Recursion Elimination

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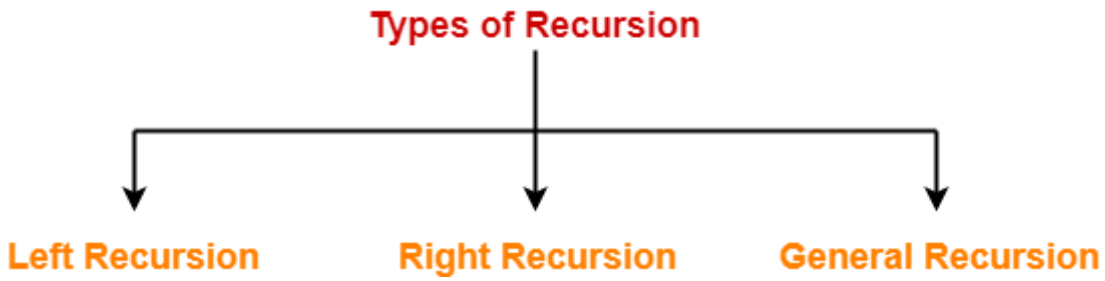
By SHWETA TIWARI

Under On: Basic Parsing Techniques

TOPIC On : Left Recursion-Left Recursion Elimination

Recursion-

Recursion can be classified into following three types-



1. Left Recursion
2. Right Recursion
3. General Recursion

1. Left Recursion-

- A production of grammar is said to have **left recursion** if the leftmost variable of its RHS is the same as the variable of its LHS.
- A grammar containing a production having left recursion is called Left Recursive Grammar.

Example-

$S \rightarrow Sa / \in$

(**Left Recursive Grammar**)

- Left recursion is considered to be a problematic situation for Top down parsers.
- Therefore, left recursion has to be eliminated from the grammar.

Elimination of Left Recursion

Left recursion is eliminated by converting the grammar into a right recursive grammar.

If we have the left-recursive pair of productions-

$$\mathbf{A \rightarrow A\alpha / \beta}$$

(Left Recursive Grammar)

where β does not begin with an A.

Then, we can eliminate left recursion by replacing the pair of productions with-

$$\mathbf{A \rightarrow \beta A'}$$

$$\mathbf{A' \rightarrow \alpha A' / \in}$$

(Right Recursive Grammar)

This right recursive grammar functions the same as left recursive grammar.

2. Right Recursion-

- A production of grammar is said to have **right recursion** if the rightmost variable of its RHS is the same as the variable of its LHS.
- A grammar containing a production having right recursion is called Right Recursive Grammar.

Example-

$S \rightarrow aS / \in$

(**Right Recursive Grammar**)

- Right recursion does not create any problem for the Top down parsers.
- Therefore, there is no need of eliminating right recursion from the grammar.

3. General Recursion-

- The recursion which is neither left recursion nor right recursion is called a general recursion.

Example-

$S \rightarrow aSb / \in$

PRACTICE PROBLEMS BASED ON LEFT RECURSION ELIMINATION-

Problem-01:

Consider the following grammar and eliminate left recursion-

$A \rightarrow ABd / Aa / a$

$B \rightarrow Be / b$

Solution-

The grammar after eliminating left recursion is-

$A \rightarrow aA'$

$A' \rightarrow BdA' / aA' / \in$

$B \rightarrow bB'$

$B' \rightarrow eB' / \in$

Problem-02:

Consider the following grammar and eliminate left recursion-

$E \rightarrow E + E / E \times E / a$

Solution-

The grammar after eliminating left recursion is-

$E \rightarrow aA$

$A \rightarrow +EA / xEA / \in$

Problem-03:

Consider the following grammar and eliminate left recursion-

$E \rightarrow E + T / T$

$T \rightarrow T x F / F$

$F \rightarrow id$

Solution-

The grammar after eliminating left recursion is-

$E \rightarrow TE'$

$E' \rightarrow +TE' / \in$

$T \rightarrow FT'$

$T' \rightarrow xFT' / \in$

$F \rightarrow id$

Problem-04:

Consider the following grammar and eliminate left recursion-

$S \rightarrow (L) / a$

$L \rightarrow L , S / S$

Solution-

The grammar after eliminating left recursion is-

$S \rightarrow (L) / a$

$L \rightarrow SL'$

$L' \rightarrow ,SL' / \in$

Problem-05:

Consider the following grammar and eliminate left recursion-

$S \rightarrow S0S1S / 01$

Solution-

The grammar after eliminating left recursion is-

$S \rightarrow 01A$

$A \rightarrow 0S1SA / \in$

Problem-06:

Consider the following grammar and eliminate left recursion-

$S \rightarrow A$

$A \rightarrow Ad / Ae / aB / ac$

$B \rightarrow bBc / f$

Solution-

The grammar after eliminating left recursion is-

$S \rightarrow A$

$A \rightarrow aBA' / acA'$

$A' \rightarrow dA' / eA' / \in$

$B \rightarrow bBc / f$

Problem-07:

Consider the following grammar and eliminate left recursion-

$A \rightarrow AA\alpha / \beta$

Solution-

The grammar after eliminating left recursion is-

$A \rightarrow \beta A'$

$A' \rightarrow A\alpha A' / \in$

Problem-08:

Consider the following grammar and eliminate left recursion-

$A \rightarrow Ba / Aa / c$

$B \rightarrow Bb / Ab / d$

Solution-

This is a case of indirect left recursion.

Step-01:

First let us eliminate left recursion from A → Ba / Aa / c

Eliminating left recursion from here, we get-

A → BaA' / cA'

A' → aA' / ∈

Now, given grammar becomes-

A → BaA' / cA'

A' → aA' / ∈

B → Bb / Ab / d

Step-02:

Substituting the productions of A in B → Ab, we get the following grammar-

A → BaA' / cA'

A' → aA' / ∈

B → Bb / BaA'b / cA'b / d

Step-03:

Now, eliminating left recursion from the productions of B, we get the following grammar-

A → BaA' / cA'

A' → aA' / ∈

B → cA'bB' / dB'

B' → bB' / aA'bB' / ∈

This is the final grammar after eliminating left recursion.

Problem-09:

Consider the following grammar and eliminate left recursion-

$X \rightarrow XSb / Sa / b$

$S \rightarrow Sb / Xa / a$

Solution-

This is a case of indirect left recursion.

Step-01:

First let us eliminate left recursion from $X \rightarrow XSb / Sa / b$

Eliminating left recursion from here, we get-

$X \rightarrow SaX' / bX'$

$X' \rightarrow SbX' / \in$

Now, given grammar becomes-

$X \rightarrow SaX' / bX'$

$X' \rightarrow SbX' / \in$

$S \rightarrow Sb / Xa / a$

Step-02:

Substituting the productions of X in S → Xa, we get the following grammar-

X → SaX' / bX'

X' → SbX' / ∈

S → Sb / SaX'a / bX'a / a

Step-03:

Now, eliminating left recursion from the productions of S, we get the following grammar-

X → SaX' / bX'

X' → SbX' / ∈

S → bX'aS' / aS'

S' → bS' / aX'aS' / ∈

This is the final grammar after eliminating left recursion.

Problem-10:

Consider the following grammar and eliminate left recursion-

S → Aa / b

A → Ac / Sd / ∈

Solution-

This is a case of indirect left recursion.

Step-01:

First let us eliminate left recursion from $S \rightarrow Aa / b$

This is already free from left recursion.

Step-02:

Substituting the productions of S in $A \rightarrow Sd$, we get the following grammar-

$S \rightarrow Aa / b$

$A \rightarrow Ac / Aad / bd / \in$

Step-03:

Now, eliminating left recursion from the productions of A, we get the following grammar-

$S \rightarrow Aa / b$

$A \rightarrow bdA' / A'$

$A' \rightarrow cA' / adA' / \in$

This is the final grammar after eliminating left recursion.

To gain better understanding about Left Recursion Elimination,