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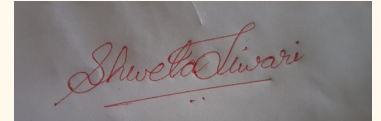
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CD: COMPILER DESIGN

TOPIC On : FIRST() AND FOLLOW()

By SHWETA TIWARI

Under On: Basic Parsing Techniques

TOPIC On : FIRST() AND FOLLOW()

First and Follow-

First and Follow sets are needed so that the parser can properly apply the needed production rule at the correct position.

First Function-

First(α) is a set of terminal symbols that begin in strings derived from α.

Example-

Consider the production rule-

$$A \rightarrow abc \ / \ def \ / \ ghi$$

Then, we have-

$$First(A) = \{ a , d , g \}$$

Rules For Calculating First Function-

Rule-01:

For a production rule $X \rightarrow \in$,

$$First(X) = \{ \in \}$$

Rule-02:

For any terminal symbol 'a',

$$First(a) = \{ a \}$$

Rule-03:

For a production rule $X \rightarrow Y_1Y_2Y_3$,

Calculating First(X)

- If $\in \notin First(Y_1)$, then $First(X) = First(Y_1)$
- If $\in \in First(Y_1)$, then $First(X) = \{ First(Y_1) - \in \} \cup First(Y_2Y_3)$

Calculating First(Y₂Y₃)

- If $\in \notin First(Y_2)$, then $First(Y_2Y_3) = First(Y_2)$
- If $\in \in First(Y_2)$, then $First(Y_2Y_3) = \{ First(Y_2) - \in \} \cup First(Y_3)$

Similarly, we can make expansion for any production rule $X \rightarrow Y_1Y_2Y_3.....Y_n$.

Follow Function-

Follow(α) is a set of terminal symbols that appear immediately to the right of α.

Rules For Calculating Follow Function-

Rule-01:

For the start symbol S, place $ in Follow(S).

Rule-02:

For any production rule A → αB,

$$Follow(B) = Follow(A)$$

Rule-03:

For any production rule A → αBβ,

- If ∈ ∉ First(β), then Follow(B) = First(β)
- If ∈ ∈ First(β), then Follow(B) = { First(β) – ∈ } ∪ Follow(A)

Important Notes-

Note-01:

- $\in$ may appear in the first function of a non-terminal.
- $\in$ will never appear in the follow function of a non-terminal.

Note-02:

- Before calculating the first and follow functions, eliminate **Left Recursion** from the grammar, if present.

Note-03:

- We calculate the follow function of a non-terminal by looking where it is present on the RHS of a production rule.

PRACTICE PROBLEMS BASED ON CALCULATING FIRST AND FOLLOW-

Problem-01:

Calculate the first and follow functions for the given grammar-

$$S \rightarrow aBDh$$

$$B \rightarrow cC$$

$$C \rightarrow bC \,/\in$$

$$D \rightarrow EF$$

$$E \rightarrow g\,/\in$$

$$F \rightarrow f\,/\in$$

Solution-

The first and follow functions are as follows-

First Functions-

- First(S) = { a }
- First(B) = { c }
- First(C) = { b , ∈ }
- First(D) = { First(E) – ∈ } ∪ First(F) = { g , f , ∈ }
- First(E) = { g , ∈ }
- First(F) = { f , ∈ }

Follow Functions-

- Follow(S) = { $ }
- Follow(B) = { First(D) – ∈ } ∪ First(h) = { g , f , h }
- Follow(C) = Follow(B) = { g , f , h }
- Follow(D) = First(h) = { h }

- Follow(E) = { First(F) – ∈ } ∪ Follow(D) = { f , h }
- Follow(F) = Follow(D) = { h }

Problem-02:

Calculate the first and follow functions for the given grammar-

$$S \rightarrow A$$

$$A \rightarrow aB / Ad$$

$$B \rightarrow b$$

$$C \rightarrow g$$

Solution-

We have-

- The given grammar is left recursive.
- So, we first remove left recursion from the given grammar.

After eliminating left recursion, we get the following grammar-

$$S \rightarrow A$$

$$A \rightarrow aBA'$$

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

$$B \rightarrow b$$

$$C \rightarrow g$$

Now, the first and follow functions are as follows-

First Functions-

- First(S) = First(A) = { a }
- First(A) = { a }
- First(A') = { d , ∈ }
- First(B) = { b }
- First(C) = { g }

Follow Functions-

- Follow(S) = { $ }
- Follow(A) = Follow(S) = { $ }
- Follow(A') = Follow(A) = { $ }
- Follow(B) = { First(A') − ∈ } ∪ Follow(A) = { d , $ }
- Follow(C) = NA

Problem-03:

Calculate the first and follow functions for the given grammar-

$$S \rightarrow (L) / a$$

$$L \rightarrow SL'$$

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

Solution-

The first and follow functions are as follows-

First Functions-

- First(S) = { (, a }
- First(L) = First(S) = { (, a }
- First(L') = { , , ∈ }

Follow Functions-

- Follow(S) = { $ } ∪ { First(L') – ∈ } ∪ Follow(L) ∪ Follow(L') = { $, , ,) }
- Follow(L) = {) }
- Follow(L') = Follow(L) = {) }

Problem-04:

Calculate the first and follow functions for the given grammar-

$$S \rightarrow AaAb \ / \ BbBa$$

$$A \rightarrow \in$$

$$B \rightarrow \in$$

Solution-

The first and follow functions are as follows-

First Functions-

- First(S) = { First(A) – ∈ } ∪ First(a) ∪ { First(B) – ∈ } ∪ First(b) = { a , b }
- First(A) = { ∈ }
- First(B) = { ∈ }

Follow Functions-

- Follow(S) = { $ }
- Follow(A) = First(a) ∪ First(b) = { a , b }
- Follow(B) = First(b) ∪ First(a) = { a , b }

Problem-05:

Calculate the first and follow functions for the given grammar-

$$E \rightarrow E + T \, / \, T$$

$$T \rightarrow T \, x \, F \, / \, F$$

$$F \rightarrow (E) \, / \, id$$

Solution-

We have-

- The given grammar is left recursive.
- So, we first remove left recursion from the given grammar.

After eliminating left recursion, we get the following grammar-

$$E \rightarrow TE'$$

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

$$T \rightarrow FT'$$

$$T' \rightarrow x \, FT' \, / \in$$

$$F \rightarrow (E) \, / \, id$$

Now, the first and follow functions are as follows-

First Functions-

- First(E) = First(T) = First(F) = { (, id }
- First(E') = { + , ∈ }
- First(T) = First(F) = { (, id }
- First(T') = { x , ∈ }
- First(F) = { (, id }

Follow Functions-

- Follow(E) = { $,) }
- Follow(E') = Follow(E) = { $,) }
- Follow(T) = { First(E') − ∈ } ∪ Follow(E) ∪ Follow(E') = { + , $,) }
- Follow(T') = Follow(T) = { + , $,) }
- Follow(F) = { First(T') − ∈ } ∪ Follow(T) ∪ Follow(T') = { x , + , $,) }

Problem-06:

Calculate the first and follow functions for the given grammar-

$$S \rightarrow ACB / CbB / Ba$$

$$A \rightarrow da / BC$$

$$B \rightarrow g / \in$$

$$C \rightarrow h / \in$$

Solution-

The first and follow functions are as follows-

First Functions-

- First(S) = { First(A) – ∈ } ∪ { First(C) – ∈ } ∪ First(B) ∪ First(b) ∪ { First(B) – ∈ } ∪ First(a) = { d , g , h , ∈ , b , a }
- First(A) = First(d) ∪ { First(B) – ∈ } ∪ First(C) = { d , g , h , ∈ }
- First(B) = { g , ∈ }
- First(C) = { h , ∈ }

Follow Functions-

- Follow(S) = { $ }
- Follow(A) = { First(C) – ∈ } ∪ { First(B) – ∈ } ∪ Follow(S) = { h , g , $ }
- Follow(B) = Follow(S) ∪ First(a) ∪ { First(C) – ∈ } ∪ Follow(A) = { $, a , h , g }
- Follow(C) = { First(B) – ∈ } ∪ Follow(S) ∪ First(b) ∪ Follow(A) = { g , $, b , h }

To gain better understanding about calculating first and follow functions,