

**Compiler Design (KCS-502)**  
**3<sup>rd</sup> year (Semester – V)**  
**Session – 2020 - 21**  
**Unit – II**  
**Notes – 3**

**Anil Singh**  
**Asst. Prof.**  
**CSE Dept.**  
**UCEM, Prayagraj**

# FIRST and FOLLOW

- The construction of a predictive parser is aided by two functions associated with a grammar  $G$ .
- These functions, FIRST and FOLLOW, allow us to fill in the entries of a predictive parsing table for  $G$ , whenever possible.

# FIRST function

- We define a function  $\text{FIRST}(\alpha)$ , where  $\alpha$  is in  $(V \cup \Sigma)^*$ , as follows:
  - $\text{FIRST}(\alpha)$  is the set of terminal symbols that are first symbols appearing at R.H.S. in derivation of  $\alpha$ .
  - If  $\alpha = XYZ$ , then  $\text{FIRST}(\alpha)$  is computed as
    - $\text{FIRST}(\alpha) = \text{FIRST}(XYZ)$   
     $= \{X\}$ , if  $X$  is terminal  
    otherwise
    - $\text{FIRST}(\alpha) = \text{FIRST}(X)$ , if  $X$  does not derive to an empty string i.e., if  $\text{FIRST}(X)$  does not contain  $\epsilon$   
    otherwise
    - If  $\text{FIRST}(X)$  contains  $\epsilon$ , then
      - $\text{FIRST}(\alpha) = \text{FIRST}(XYZ) = \text{FIRST}(X) - \{\epsilon\} \cup \text{FIRST}(YZ)$   
    and  $\text{FIRST}(YZ)$  is computed as follows:
        - $\text{FIRST}(YZ) = \{Y\}$ , if  $Y$  is terminal  
    otherwise  
     $= \text{FIRST}(Y)$ , if  $Y$  does not derive to an empty string  
    otherwise  
     $= \text{FIRST}(Y) - \{\epsilon\} \cup \text{FIRST}(Z)$

# FIRST function

## Example:

Consider a grammar

$$S \rightarrow ACB \mid CbB \mid Ba$$
$$A \rightarrow da \mid BC$$
$$B \rightarrow g \mid \epsilon$$
$$C \rightarrow f \mid \epsilon$$

# FIRST function

## Solution:

$$\text{FIRST}(S) = \text{FIRST}(ACB) \cup \text{FIRST}(CbB) \cup \text{FIRST}(Ba)$$

$$\text{FIRST}(A) = \text{FIRST}(da) \cup \text{FIRST}(BC)$$

$$\text{FIRST}(B) = \text{FIRST}(g) \cup \text{FIRST}(\epsilon) = \{g, \epsilon\}$$

$$\text{FIRST}(C) = \text{FIRST}(f) \cup \text{FIRST}(\epsilon) = \{f, \epsilon\}$$

$$\text{Now, FIRST}(BC) = \text{FIRST}(B) - \{\epsilon\} \cup \text{FIRST}(C)$$

$$= \{g, \epsilon\} - \{\epsilon\} \cup \{f, \epsilon\}$$

$$= \{g\} \cup \{f, \epsilon\}$$

$$= \{g, f, \epsilon\}$$

$$\text{and FIRST}(da) = \{d\}$$

$$\text{Therefore, FIRST}(A) = \text{FIRST}(da) \cup \text{FIRST}(BC)$$

$$= \{d\} \cup \{g, f, \epsilon\}$$

$$= \{d, g, f, \epsilon\}$$

# FIRST function

$$\begin{aligned}\text{Now, FIRST(ACB)} &= \text{FIRST(A)} - \{\epsilon\} \cup \text{FIRST(CB)} \\ &= \{d, g, f, \epsilon\} - \{\epsilon\} \cup \text{FIRST(CB)}\end{aligned}$$

$$\begin{aligned}\text{and FIRST(CB)} &= \text{FIRST(C)} - \{\epsilon\} \cup \text{FIRST(B)} \\ &= \{f, \epsilon\} - \{\epsilon\} \cup \{g, \epsilon\} \\ &= \{f, g, \epsilon\}\end{aligned}$$

$$\begin{aligned}\text{Therefore, FIRST(ACB)} &= \{d, g, f\} \cup \{f, g, \epsilon\} \\ &= \{d, g, f, \epsilon\}\end{aligned}$$

# FIRST function

$$\begin{aligned}\text{Similarly, FIRST}(CbB) &= \text{FIRST}(C) - \{\epsilon\} \cup \text{FIRST}(bB) \\ &= \{f, \epsilon\} - \{\epsilon\} \cup \{b\} \\ &= \{f, b\}\end{aligned}$$

$$\begin{aligned}\text{and FIRST}(Ba) &= \text{FIRST}(B) - \{\epsilon\} \cup \text{FIRST}(a) \\ &= \{g, \epsilon\} - \{\epsilon\} \cup \{a\} \\ &= \{a, g\}\end{aligned}$$

$$\begin{aligned}\text{Therefore, FIRST}(S) &= \{d, f, g, \epsilon\} \cup \{f, b\} \cup \{a, g\} \\ &= \{a, b, d, f, g, \epsilon\}\end{aligned}$$

# FOLLOW function

- We define a function FOLLOW(A), where A is a non-terminal as follows:
  - FOLLOW(A) = set of terminals that immediately follow A in any string occurring on the right side of productions of the grammar.
  - The rules for computing FOLLOW function are as follows:
    - 1) FOLLOW(S) = { \$ } // where S is the starting Non-Terminal
    - 2) If  $A \rightarrow pBq$  is a production, where p, B and q are any grammar symbols, then everything in FIRST(q) except  $\epsilon$  is in FOLLOW(B).
    - 3) If  $A \rightarrow pB$  is a production, then everything in FOLLOW(A) is in FOLLOW(B).
    - 4) If  $A \rightarrow pBq$  is a production and FIRST(q) contains  $\epsilon$ , then FOLLOW(B) contains { FIRST(q) –  $\epsilon$  }  $\cup$  FOLLOW(A)
  - **Note:**
    - If FOLLOW(A) can be computed from different productions with different values then union of all FOLLOW(A) from all productions will give FOLLOW(A).



# FOLLOW function

## Example 1:

Consider the following grammar

$$S \rightarrow aABb$$

$$A \rightarrow c \mid \epsilon$$

$$B \rightarrow d \mid \epsilon$$

# FOLLOW function

## Solution:

$$\text{FIRST}(S) = \text{FIRST}(aABb) = \{a\}$$

$$\text{FIRST}(A) = \text{FIRST}(c) \cup \text{FIRST}(\epsilon) = \{c, \epsilon\}$$

$$\text{FIRST}(B) = \text{FIRST}(d) \cup \text{FIRST}(\epsilon) = \{d, \epsilon\}$$

Since  $S$  is the start symbol, so place  $\$$  in  $\text{FOLLOW}(S)$ . Also  $S$  is not present in R.H.S.,

$$\text{Therefore, } \text{FOLLOW}(S) = \{\$\}$$

$$\text{FOLLOW}(A) = \text{FIRST}(Bb)$$

$$= \text{FIRST}(B) - \{\epsilon\} \cup \text{FIRST}(b)$$

$$= \{d, b\}$$

$$\text{and } \text{FOLLOW}(B) = \text{FIRST}(b) = \{b\}$$

# FOLLOW function

## Example 2:

### Production Rules:

$$S \rightarrow ACB \mid Cbb \mid Ba$$
$$A \rightarrow da \mid BC$$
$$B \rightarrow g \mid \epsilon$$
$$C \rightarrow h \mid \epsilon$$

# FOLLOW function

**Solution:**

**FIRST set:**

$\text{FIRST}(S) = \text{FIRST}(A) \cup \text{FIRST}(B) \cup \text{FIRST}(C) = \{ d, g, h, b, a, \epsilon \}$

$\text{FIRST}(A) = \{ d \} \cup \text{FIRST}(B) = \{ d, g, h, \epsilon \}$

$\text{FIRST}(B) = \{ g, \epsilon \}$

$\text{FIRST}(C) = \{ h, \epsilon \}$

**FOLLOW Set:**

$\text{FOLLOW}(S) = \{ \$ \}$

$\text{FOLLOW}(A) = \{ h, g, \$ \}$

$\text{FOLLOW}(B) = \{ a, \$, h, g \}$

$\text{FOLLOW}(C) = \{ b, g, \$, h \}$

# FOLLOW function

## Example 3:

Consider the following grammar

$$E \rightarrow TE'$$

$$E' \rightarrow +TE' \mid \epsilon$$

$$T \rightarrow FT'$$

$$T' \rightarrow *FT' \mid \epsilon$$

$$F \rightarrow (E) \mid \text{id}$$

Find the FIRST and FOLLOW functions for the above grammar.

# FOLLOW function

**Solution:**

**FIRST set:**

$\text{FIRST}(E) = \{ (, \text{id} \}$

$\text{FIRST}(E') = \{ +, \epsilon \}$

$\text{FIRST}(T) = \{ (, \text{id} \}$

$\text{FIRST}(T') = \{ *, \epsilon \}$

$\text{FIRST}(F) = \{ (, \text{id} \}$

**FOLLOW set:**

$\text{FOLLOW}(E) = \{ ), \$ \}$

$\text{FOLLOW}(E') = \{ ), \$ \}$

$\text{FOLLOW}(T) = \{ +, ), \$ \}$

$\text{FOLLOW}(T') = \{ +, ), \$ \}$

$\text{FOLLOW}(F) = \{ *, +, ), \$ \}$