

Syntax analysis

First & Follow

FIRST()

- FIRST (α) is set of terminal symbol that are the first symbol appearing in R.H.S in derivation of α
- If $\alpha \rightarrow \epsilon$ then ϵ is also in FIRST (α)
 - If the terminal symbol a the $FIRST(a) = \{a\}$
 - If there is a rule $X \rightarrow \epsilon$ then $FIRST(X) = \{\epsilon\}$
 - For the rule $A \rightarrow X_1X_2X_3X_4...X_k$ $FIRST(A) = (FIRST(X_1) \cup FIRST(X_2) \cup FIRST(X_3) ... FIRST(X_k))$
 - Where $k \leq n$ such that $1 \leq j \leq k - 1$

FIRST of Grammar

Example 1

- $A \rightarrow BC$
- $B \rightarrow Ax \mid x$
- $C \rightarrow yC \mid y$

Solution

- In $A \rightarrow BC$
 $\text{FIRST}(A) = \{\text{FIRST}(B) \cup \text{FIRST}(C)\}$ if $B \rightarrow \epsilon$ is true
- $\text{FIRST}(A) = \{\text{FIRST}(B)\}$ if $B \rightarrow \epsilon$ is false
- $\text{FIRST}(A) = \{x\}$
- $\text{FIRST}(B) = \{x\}$
- $\text{FIRST}(C) = \{y\}$

FIRST of Grammar

Example 2:

$$E \rightarrow TE'$$

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

$$T \rightarrow FT'$$

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

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

Solution:

- $\text{FIRST}(E) = \text{FIRST}(T) = \text{FIRST}(F) = \{ (, \text{id} \}$
- $\text{FIRST}(E') = \{ +, \varepsilon \}$
- $\text{FIRST}(T) = \text{FIRST}(F) = \{ (, \text{id} \}$
- $\text{FIRST}(T') = \{ *, \varepsilon \}$
- $\text{FIRST}(F) = \{ (, \text{id} \}$

FOLLOW()

- FOLLOW(A) is defined as the set of terminal symbols that appear immediately to the right of A

- In other words

$\text{FOLLOW}(A) = \{a \mid S \rightarrow \alpha A a \beta \text{ where } \alpha \text{ and } \beta \text{ are some grammar symbols may be terminal or non terminal}\}$

- The rules for computing FOLLOW function are as follows
 - For the start symbol S place \$ in FOLLOW(S)
 - If there is a production $A \rightarrow \alpha B \beta$ then everything in FIRST(β) without ϵ is to be placed in FOLLOW(B)
 - If there is a production $A \rightarrow \alpha B \beta$ or $A \rightarrow \alpha B$ and the FIRST(β) = $\{\epsilon\}$ then FOLLOW(A) = FOLLOW(B) or FOLLOW(B) = FOLLOW(A)
 - That means everything in FOLLOW(A) is in FOLLOW(B)

Follow of Grammar

Rule 1:

Place \$ in FOLLOW (S) where S is the start symbol and \$ is the input right endmarker

Rule 2:

If there is a production $A \rightarrow \alpha B \beta$ then everything in $\text{FIRST}(\beta)$ except ϵ is in FOLLOW (B)

Rule 3:

If there is a production $A \rightarrow \alpha B$ or
a production $A \rightarrow \alpha B \beta$ where $\text{FIRST}(\beta)$ contains ϵ
then everything in FOLLOW (A) is in FOLLOW (B)

APPLY ABOVE RULES UNTIL THERE IS NO UPDATION IN FOLLOW LIST

Follow of Grammar

	FIRST	FOLLOW
E	(, id	\$,)
E'	+ , ϵ	\$,)
T	(, id	
T'	* , ϵ	
F	(, id	

Example 1:

$$E \rightarrow TE'$$

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

$$T \rightarrow FT'$$

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

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

Solution:

1. FOLLOW (E) = { \$,) }

Since E is start symbol so \$

For Production Rule $F \rightarrow (E)$ First()) = {) }

2. FOLLOW (E') = FOLLOW (E) = { \$,) }

By Rule 3: if E' contains ϵ then everything in FOLLOW(E') will be in FOLLOW(E) i.e FOLLOW (E') = FOLLOW (E)

Follow of Grammar

	FIRST	FOLLOW
E	(, id	\$,)
E'	+ , ϵ	\$,)
T	(, id	+ , \$,)
T'	* , ϵ	+ , \$,)
F	(, id	

Example 1:

$E \rightarrow TE'$

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

$T \rightarrow FT'$

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

$F \rightarrow (E) \mid id$

Everything in First(E) except ϵ

Substituting ϵ in place of E',
we get : $E \rightarrow T$, so Follow(E)
needs to be obtained

Solution:

$$\begin{aligned} 3. \text{ FOLLOW } (T) &= \{ \text{FIRST } (E') \} \\ &= \{ + , \text{Follow}(E) \} \\ &= \{ + , \$,) \} \end{aligned}$$

$$\begin{aligned} 4. \text{ FOLLOW } (T') &= \text{FOLLOW } (T) \\ &= \{ + , \$,) \} \end{aligned}$$

Follow of Grammar

	FIRST	FOLLOW
E	(, id	\$,)
E'	+ , ϵ	\$,)
T	(, id	+ , \$,)
T'	* , ϵ	+ , \$,)
F	(, id	* , + , \$,)

Example 1:

$$E \rightarrow TE'$$

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

$$T \rightarrow FT'$$

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

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

Solution:

$$\begin{aligned} 5. \text{ FOLLOW } (F) &= \{ \text{FIRST } (T') \} \\ &= \{ * , \text{ FOLLOW } (T) \} \\ &= \{ * , + , \$,) \} \end{aligned}$$

Everything in First(T') except ϵ

Substituting ϵ in place of T',
we get : $T \rightarrow F$ so Follow(T)
needs to be obtained

Follow of Grammar

	FIRST	FOLLOW
A	x	\$, x
B	x	y
C	y	\$, x

Example 2:

$A \rightarrow BC$

$B \rightarrow Ax \mid x$

$C \rightarrow yC \mid y$

Solution:

1. $\text{FOLLOW}(A) = \{ \$ \} \cup \text{FIRST}(x) = \{ \$, x \}$

2. $\text{FOLLOW}(B) = \text{FIRST}(C)$

$= \{ y \}$

3. $\text{FOLLOW}(C) = \text{FOLLOW}(A)$

$= \{ \$, x \}$

Follow of Grammar

	FIRST	FOLLOW
S	d , g , h , ϵ , b , a	
A	d , g , h , ϵ	
B	g , ϵ	
C	h , ϵ	

Example 3:

$S \rightarrow ACB \mid Cbb \mid Ba$

$A \rightarrow da \mid BC$

$B \rightarrow g \mid \epsilon$

$C \rightarrow h \mid \epsilon$

Solution:

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

Follow of Grammar

Example 3:

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

Solution:

1. FOLLOW (S) = { \$ } ... Since S is start symbol

2. FOLLOW (A) = { FIRST (C) - ϵ } U { FIRST (B) - ϵ } U FOLLOW (S)
= { h , g , \$ }

3. FOLLOW (B) = FOLLOW(S) U FIRST (a) U { FIRST (C) - ϵ } U FOLLOW (A)
= { a , h , g , \$ }

3. FOLLOW (C) = FIRST (b) U { FIRST(B) - ϵ } U FOLLOW (A)
= { b , h , g , \$ }

	FIRST	FOLLOW
S	d , g , h , ϵ , b, a	\$
A	d , g , h , ϵ	h , g , \$
B	g , ϵ	a , h , g , \$
C	h , ϵ	b , h , g , \$

Follow of Grammar

	FIRST	FOLLOW
S	a , b , d , ϵ	
A	a , b , d , ϵ	
B	b , d , ϵ	
D	d , ϵ	

Example 4:

$S \rightarrow ABD$

$A \rightarrow a \mid BSB$

$B \rightarrow b \mid D$

$D \rightarrow d \mid \epsilon$

Solution:

- $\text{FIRST}(S) = \text{FIRST}(A)$
 $= \{a\} \cup \text{FIRST}(B)$
 $= \{a\} \cup \{b\} \cup \text{FIRST}(D)$
 $= \{a, b, d, \epsilon\}$
- $\text{FIRST}(A) = \{a\} \cup \text{FIRST}(B)$
 $= \{a\} \cup \{b\} \cup \text{FIRST}(D)$
 $= \{a, b, d, \epsilon\}$
- $\text{FIRST}(B) = \{b\} \cup \text{FIRST}(D)$
 $= \{b, d, \epsilon\}$
- $\text{FIRST}(D) = \{d, \epsilon\}$

Follow of Grammar

	FIRST	FOLLOW
S	a , b , d , ϵ	b , d , \$
A	a , b , d , ϵ	b , d , \$
B	b , d , ϵ	a , b , d , \$
D	d , ϵ	a , b , d , \$

Example 4:

$S \rightarrow ABD$

$A \rightarrow a \mid BSB$

$B \rightarrow b \mid D$

$D \rightarrow d \mid \epsilon$

Solution:

- $\text{FOLLOW}(S) = \{ \$ \} \cup \{ \text{FIRST}(B) - \epsilon \} \cup \text{FOLLOW}(A)$
 $= \{ \$, b , d \} \cup \{ \text{FIRST}(B) - \epsilon \} \cup \{ \text{FIRST}(D) - \epsilon \}$
 $= \{ b , d , \$ \}$
- $\text{FOLLOW}(A) = \{ \text{FIRST}(B) - \epsilon \} \cup \{ \text{FIRST}(D) - \epsilon \}$
 $= \{ b , d , \$ \}$
- $\text{FOLLOW}(B) = \{ \text{FIRST}(S) - \epsilon \} \cup \text{FOLLOW}(A)$
 $= \{ a , b , d , \$ \}$
- $\text{FOLLOW}(D) = \text{FOLLOW}(B)$
 $= \{ a , b , d , \$ \}$