

Objectives

FOLLOW Sets

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- Compute the FOLLOW sets for the nonterminal symbols of a grammar.

FOLLOW Sets

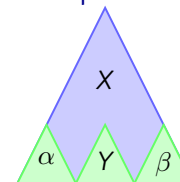
- Given a non terminal symbol S , what terminal symbols could come after strings that are derived from S ?

The algorithm:

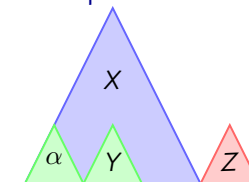
1. Put $\$$ in $FOLLOW(S)$, where S is the start symbol.
 $\$$ represents the "end of input."
2. If there is a production $X \rightarrow \alpha Y \beta$, then add $FIRST(\beta)$ (but not ϵ) to $FOLLOW(Y)$.
3. If there is a production $X \rightarrow \alpha Y$, or if there is a production $X \rightarrow \alpha Y \beta$, where $\epsilon \in FIRST(\beta)$ then add $FOLLOW(X)$ to $FOLLOW(Y)$.

Diagram

Example 1



Example 2



1. If there is a production $X \rightarrow \alpha Y \beta$, then add $FIRST(\beta)$ (but not ϵ) to $FOLLOW(Y)$.
2. If there is a production $X \rightarrow \alpha Y$, or if there is a production $X \rightarrow \alpha Y \beta$, where $\epsilon \in FIRST(\beta)$ then add $FOLLOW(X)$ to $FOLLOW(Y)$.

Small Examples

Example 1
 $S \rightarrow x A y$
 FOLLOW set of A is $\{y\}$.

Example 2
 $A \rightarrow q B$
 FOLLOW set of B is also $\{y\}$.

Example 3
 $B \rightarrow C E D$
 $FIRST(D) = \{a, b\}$
 FOLLOW set of D is $\{y\}$.
 FOLLOW set of E is $\{a, b, y\}$.

Example 4
 $B \rightarrow C E D$
 $FIRST(D) = \{a, b, \epsilon\}$
 FOLLOW set of D is $\{y\}$.
 FOLLOW set of E is $\{a, b, y\}$.

FOLLOW Set Example

Grammar
 $S \rightarrow \text{if } E \text{ then } S ;$
 $S \rightarrow \text{print } E ;$
 $E \rightarrow E + E$
 $E \rightarrow P \text{ id } P$
 $P \rightarrow * P$
 $P \rightarrow \epsilon$

Result
 $S = \{ \$ \}$
 $E = \{ \}$
 $P = \{ \}$

Action
 Make a chart, add \$ to S.

FOLLOW Set Example

Grammar
 $S \rightarrow \text{if } E \text{ then } S ; \leftarrow$
 $S \rightarrow \text{print } E ;$
 $E \rightarrow E + E$
 $E \rightarrow P \text{ id } P$
 $P \rightarrow * P$
 $P \rightarrow \epsilon$

Result
 $S = \{ \$, ; \}$
 $E = \{ \text{then} \}$
 $P = \{ \}$

Action
 Check productions: add then to FOLLOW(E), and ; to FOLLOW(S).

FOLLOW Set Example

Grammar
 $S \rightarrow \text{if } E \text{ then } S ;$
 $S \rightarrow \text{print } E ; \leftarrow$
 $E \rightarrow E + E \leftarrow$
 $E \rightarrow P \text{ id } P$
 $P \rightarrow * P$
 $P \rightarrow \epsilon$

Result
 $S = \{ \$, ; \}$
 $E = \{ \text{then}, ;, + \}$
 $P = \{ \}$

Action
 Check productions: add ; and + to FOLLOW(E).

FOLLOW Set Example

Grammar

```

S → if E then S ;
S → print E;
E → E + E
E → P id P ⇐
P → * P
P → ε

```

Result

```

S={$, ;}
E={then, ,, +}
P={ id}

```

Action

Check productions: add id to $FOLLOW(P)$.



FOLLOW Set Example

Grammar

```

S → if E then S ;
S → print E;
E → E + E
E → P id P ⇐
P → * P
P → ε

```

Result

```

S={$, ;}
E={then, ,, +}
P={id, then, ,, +}

```

Action

Check endings: P ends this rule, so add $FOLLOW(E)$ to $FOLLOW(P)$.



FOLLOW Set Example

Grammar

```

S → if E then S ;
S → print E;
E → E + E
E → P id P
P → * P
P → ε

```

Result

```

S={$, ;}
E={then, ,, +}
P={id, then, ,, +}

```

Action

Done.



Another FOLLOW Set Example

Grammar

```

S → Ax
S → By
S → z
A → 1CB
A → 2B
B → 3B
B → C
C → 4
C → ε

```

Result

```

S={ $ }
A={}
B={}
C={}

```

Action

Create a table, and add \$ to $FOLLOW(S)$.



Another FOLLOW Set Example

Grammar

$S \rightarrow Ax$ \leftarrow
 $S \rightarrow By$
 $S \rightarrow z$
 $A \rightarrow 1CB$
 $A \rightarrow 2B$
 $B \rightarrow 3B$
 $B \rightarrow C$
 $C \rightarrow 4$
 $C \rightarrow \epsilon$

Result

$S = \{ \$ \}$
 $A = \{ x \}$
 $B = \{ \}$
 $C = \{ \}$

Action

Add x to $FOLLOW(A)$.

Another FOLLOW Set Example

Grammar

$S \rightarrow Ax$
 $S \rightarrow By$ \leftarrow
 $S \rightarrow z$
 $A \rightarrow 1CB$
 $A \rightarrow 2B$
 $B \rightarrow 3B$
 $B \rightarrow C$
 $C \rightarrow 4$
 $C \rightarrow \epsilon$

Result

$S = \{ \$ \}$
 $A = \{ x \}$
 $B = \{ y \}$
 $C = \{ \}$

Action

Add y to $FOLLOW(B)$.

Another FOLLOW Set Example

Grammar

$S \rightarrow Ax$
 $S \rightarrow By$
 $S \rightarrow z$ \leftarrow
 $A \rightarrow 1CB$
 $A \rightarrow 2B$
 $B \rightarrow 3B$ \leftarrow
 $B \rightarrow C$
 $C \rightarrow 4$ \leftarrow
 $C \rightarrow \epsilon$ \leftarrow

Result

$S = \{ \$ \}$
 $A = \{ x \}$
 $B = \{ y \}$
 $C = \{ \}$

Action

These productions add nothing.

Another FOLLOW Set Example

Grammar

$S \rightarrow Ax$
 $S \rightarrow By$
 $S \rightarrow z$
 $A \rightarrow 1CB$ \leftarrow
 $A \rightarrow 2B$
 $B \rightarrow 3B$
 $B \rightarrow C$
 $C \rightarrow 4$
 $C \rightarrow \epsilon$

Result

$S = \{ \$ \}$
 $A = \{ x \}$
 $B = \{ y \}$
 $C = \{ 3, 4 \}$

Action

Add $FIRST(B)$ to $FOLLOW(C)$.

Another FOLLOW Set Example

Grammar

$S \rightarrow Ax$
 $S \rightarrow By$
 $S \rightarrow z$
 $A \rightarrow 1CB \leftarrow$
 $A \rightarrow 2B \leftarrow$
 $B \rightarrow 3B$
 $B \rightarrow C$
 $C \rightarrow 4$
 $C \rightarrow \epsilon$

Result

$S = \{ \$ \}$
 $A = \{ x \}$
 $B = \{ x, y \}$
 $C = \{ 3, 4 \}$

Action

Add FOLLOW(A) to FOLLOW(B).

Another FOLLOW Set Example

Grammar

$S \rightarrow Ax$
 $S \rightarrow By$
 $S \rightarrow z$
 $A \rightarrow 1CB \leftarrow$
 $A \rightarrow 2B$
 $B \rightarrow 3B$
 $B \rightarrow C$
 $C \rightarrow 4$
 $C \rightarrow \epsilon$

Result

$S = \{ \$ \}$
 $A = \{ x \}$
 $B = \{ x, y \}$
 $C = \{ x, 3, 4 \}$

Action

B can become ϵ , so add FOLLOW(A) to FOLLOW(C).

Another FOLLOW Set Example

Grammar

$S \rightarrow Ax$
 $S \rightarrow By$
 $S \rightarrow z$
 $A \rightarrow 1CB$
 $A \rightarrow 2B$
 $B \rightarrow 3B$
 $B \rightarrow C \leftarrow$
 $C \rightarrow 4$
 $C \rightarrow \epsilon$

Result

$S = \{ \$ \}$
 $A = \{ x \}$
 $B = \{ x, y \}$
 $C = \{ x, y, 3, 4 \}$

Action

Add FOLLOW(B) to FOLLOW(C). Now we're done.