

Objectives

Follow Sets

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- Explain the purpose of the follow set.
- Be able to compute a follow set.

Follow Sets

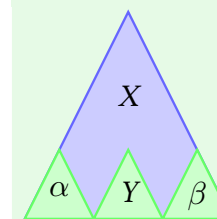
- Given a non-terminal symbol S , what terminal symbols could come after strings that are derived from S ?

The Algorithm:

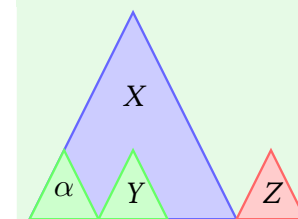
- 1 Put $\$$ in $FOLLOW(S)$, where S is the start symbol.
 $\$$ represents the “end of input.”
- 2 If there is a production $X \rightarrow \alpha Y \beta$, then add $FIRST(\beta)$ (but not ϵ) to $FOLLOW(Y)$.
- 3 If there is a production $X \rightarrow \alpha Y$, or if there is a production $X \rightarrow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

$B \rightarrow C E D$
 $First(D) = \{a, b\}$
Follow set of D is $\{y\}$.
Follow set of E is $\{a, b\}$.

Example 2

$A \rightarrow q B$
Follow set of B is also $\{y\}$

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

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 $FOLLOW(S)$

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

$$\begin{aligned}
 S &\rightarrow \text{if } E \text{ then } S ; \\
 S &\rightarrow \text{print } E ; \\
 E &\rightarrow E + E \\
 E &\rightarrow P \text{ id } P \Leftarrow \\
 P &\rightarrow * P \\
 P &\rightarrow \epsilon
 \end{aligned}$$

Result

$$\begin{aligned}
 S &= \{ \$, ; \} \\
 E &= \{ \text{then}, ,, + \} \\
 P &= \{ \text{id} \}
 \end{aligned}$$

Action

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

Follow Set Example

Grammar

$$\begin{aligned}
 S &\rightarrow \text{if } E \text{ then } S ; \\
 S &\rightarrow \text{print } E ; \\
 E &\rightarrow E + E \\
 E &\rightarrow P \text{ id } P \Leftarrow \\
 P &\rightarrow * P \\
 P &\rightarrow \epsilon
 \end{aligned}$$

Result

$$\begin{aligned}
 S &= \{ \$, ; \} \\
 E &= \{ \text{then}, ,, + \} \\
 P &= \{ \text{id}, \text{then}, ,, + \}
 \end{aligned}$$

Action

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

Follow Set Example

Grammar

$$\begin{aligned}
 S &\rightarrow \text{if } E \text{ then } S ; \\
 S &\rightarrow \text{print } E ; \\
 E &\rightarrow E + E \\
 E &\rightarrow P \text{ id } P \\
 P &\rightarrow * P \\
 P &\rightarrow \epsilon
 \end{aligned}$$

Result

$$\begin{aligned}
 S &= \{ \$, ; \} \\
 E &= \{ \text{then}, ,, + \} \\
 P &= \{ \text{id}, \text{then}, ,, + \}
 \end{aligned}$$

Action

Done.

Another Follow Set Example

Grammar

$$\begin{aligned}
 S &\rightarrow Ax \\
 S &\rightarrow By \\
 S &\rightarrow z \\
 A &\rightarrow 1CB \\
 A &\rightarrow 2B \\
 B &\rightarrow 3B \\
 B &\rightarrow C \\
 C &\rightarrow 4 \\
 C &\rightarrow \epsilon
 \end{aligned}$$

Result

$$\begin{aligned}
 S &= \{ \$ \} \\
 A &= \{ \} \\
 B &= \{ \} \\
 C &= \{ \}
 \end{aligned}$$

Action

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

Another Follow Set Example

Grammar

$$\begin{aligned}
 S &\rightarrow Ax \quad \leftarrow \\
 S &\rightarrow By \\
 S &\rightarrow z \\
 A &\rightarrow 1CB \\
 A &\rightarrow 2B \\
 B &\rightarrow 3B \\
 B &\rightarrow C \\
 C &\rightarrow 4 \\
 C &\rightarrow \epsilon
 \end{aligned}$$

Result

$$\begin{aligned}
 S &= \{ \$ \} \\
 A &= \{ x \} \\
 B &= \{ \} \\
 C &= \{ \}
 \end{aligned}$$

Action

Add x to $Follow(A)$.

Another Follow Set Example

Grammar

$$\begin{aligned}
 S &\rightarrow Ax \\
 S &\rightarrow By \quad \leftarrow \\
 S &\rightarrow z \\
 A &\rightarrow 1CB \\
 A &\rightarrow 2B \\
 B &\rightarrow 3B \\
 B &\rightarrow C \\
 C &\rightarrow 4 \\
 C &\rightarrow \epsilon
 \end{aligned}$$

Result

$$\begin{aligned}
 S &= \{ \$ \} \\
 A &= \{ x \} \\
 B &= \{ y \} \\
 C &= \{ \}
 \end{aligned}$$

Action

Add y to $Follow(B)$.

Another Follow Set Example

Grammar

$$\begin{aligned}
 S &\rightarrow Ax \\
 S &\rightarrow By \\
 S &\rightarrow z \quad \leftarrow \\
 A &\rightarrow 1CB \\
 A &\rightarrow 2B \\
 B &\rightarrow 3B \quad \leftarrow \\
 B &\rightarrow C \\
 C &\rightarrow 4 \quad \leftarrow \\
 C &\rightarrow \epsilon \quad \leftarrow
 \end{aligned}$$

Result

$$\begin{aligned}
 S &= \{ \$ \} \\
 A &= \{ x \} \\
 B &= \{ y \} \\
 C &= \{ \}
 \end{aligned}$$

Action

These productions add nothing.

Another Follow Set Example

Grammar

$$\begin{aligned}
 S &\rightarrow Ax \\
 S &\rightarrow By \\
 S &\rightarrow z \\
 A &\rightarrow 1CB \quad \leftarrow \\
 A &\rightarrow 2B \\
 B &\rightarrow 3B \\
 B &\rightarrow C \\
 C &\rightarrow 4 \\
 C &\rightarrow \epsilon
 \end{aligned}$$

Result

$$\begin{aligned}
 S &= \{ \$ \} \\
 A &= \{ x \} \\
 B &= \{ y \} \\
 C &= \{ 3, 4 \}
 \end{aligned}$$

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.