FOLLOW Sets

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Objectives

▶ 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*?
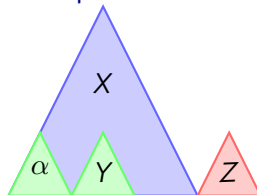
The algorithm:

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*(β) then add *FOLLOW*(*X*) to *FOLLOW*(*Y*).

Diagram

Example 1
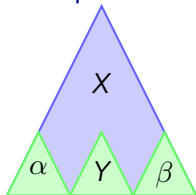
Example 2

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}.

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

$S \rightarrow$ if E then S ;

$S \rightarrow$ print E;

$E \rightarrow E + E$

$E \rightarrow P$ id P

$P \rightarrow * P$

$P \rightarrow \epsilon$

Result

S={ $\$$}

E={}

P={}

Action

Make a chart, add $\$$ to S.

FOLLOW Set Example

Grammar

$S \rightarrow$ if E then S ; $\Leftarrow$
$S \rightarrow$ print E;
$E \rightarrow E + E$
$E \rightarrow P$ id P
$P \rightarrow * P$
$P \rightarrow \epsilon$

Result

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

Action

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

FOLLOW Set Example

Grammar

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

Result

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

Action

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

FOLLOW Set Example

Grammar

$S \rightarrow$ if E then S ;
$S \rightarrow$ print E;
$E \rightarrow E + E$
$E \rightarrow P$ id $P \Leftarrow$
$P \rightarrow * P$
$P \rightarrow \epsilon$

Result

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

Action

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

FOLLOW Set Example

Grammar

$S \rightarrow$ if E then S ;
$S \rightarrow$ print E;
$E \rightarrow E + E$
$E \rightarrow P$ id P $\Leftarrow$
$P \rightarrow * P$
$P \rightarrow \epsilon$

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

$S \rightarrow$ if E then S ;
$S \rightarrow$ print E;
$E \rightarrow E + E$
$E \rightarrow P$ id P
$P \rightarrow * P$
$P \rightarrow \epsilon$

Result

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

Action

Done.

Another FOLLOW Set Example

Grammar

$S \rightarrow A\text{x}$
$S \rightarrow B\text{y}$
$S \rightarrow \text{z}$
$A \rightarrow 1CB$
$A \rightarrow 2B$
$B \rightarrow 3B$
$B \rightarrow C$
$C \rightarrow 4$
$C \rightarrow \epsilon$

Result

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

Action

Another FOLLOW Set Example

Grammar

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

Result

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

Action

Another FOLLOW Set Example

Grammar

$S \rightarrow A\text{x}$
$S \rightarrow B\text{y} \Leftarrow$
$S \rightarrow \text{z}$
$A \rightarrow 1CB$
$A \rightarrow 2B$
$B \rightarrow 3B$
$B \rightarrow C$
$C \rightarrow 4$
$C \rightarrow \epsilon$

Result

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

Action

Another FOLLOW Set Example

Grammar

$S \rightarrow A\text{x}$

$S \rightarrow B\text{y}$

$S \rightarrow \text{z} \quad \Leftarrow$

$A \rightarrow 1CB$

$A \rightarrow 2B$

$B \rightarrow 3B \quad \Leftarrow$

$B \rightarrow C$

$C \rightarrow 4 \quad \Leftarrow$

$C \rightarrow \epsilon \quad \Leftarrow$

Result

$S = \{ \$ \}$

$A = \{x\}$

$B = \{y\}$

$C = \{\}$

Action

Another FOLLOW Set Example

Grammar

$S \rightarrow A\text{x}$
$S \rightarrow B\text{y}$
$S \rightarrow \text{z}$
$A \rightarrow 1CB \Leftarrow$
$A \rightarrow 2B$
$B \rightarrow 3B$
$B \rightarrow C$
$C \rightarrow 4$
$C \rightarrow \epsilon$

Result

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

Action

Another FOLLOW Set Example

Grammar

$S \rightarrow A$x
$S \rightarrow B$y
$S \rightarrow$ 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

Another FOLLOW Set Example

Grammar

$S \rightarrow A\text{x}$
$S \rightarrow B\text{y}$
$S \rightarrow \text{z}$
$A \rightarrow 1CB \Leftarrow$
$A \rightarrow 2B$
$B \rightarrow 3B$
$B \rightarrow C$
$C \rightarrow 4$
$C \rightarrow \epsilon$

Result

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

Action

Another FOLLOW Set Example

Grammar

$S \rightarrow A\text{x}$
$S \rightarrow B\text{y}$
$S \rightarrow \text{z}$
$A \rightarrow 1CB$
$A \rightarrow 2B$
$B \rightarrow 3B$
$B \rightarrow C \Leftarrow$
$C \rightarrow 4$
$C \rightarrow \epsilon$

Result

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

Action

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