Follow Sets

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Objectives

- 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*?
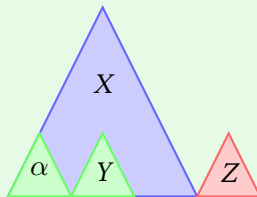
The Algorithm:

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

Diagram

Example 1

X

α Y β

Example 2

X

α Y Z
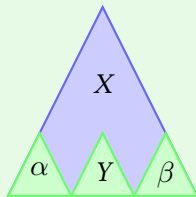
1. If there is a production $X \to \alpha Y \beta$, then add *FIRST*(β) (but not ϵ) to *FOLLOW*(Y).

2. If there is a production $X \to \alpha Y$, or if there is a production $X \to \alpha Y \beta$, where $\epsilon \in$ *FIRST*(β) then add *FOLLOW*(X) to *FOLLOW*(Y).

Small Examples

Example 1
$S \to x\,A\,y$
Follow set of A is $\{y\}$

Example 2
$A \to q\,B$
Follow set of B is also $\{y\}$

Example 3
$B \to C\,E\,D$
$First(D) = \{a, b\}$
Follow set of D is {y}.
Follow set of E is {a,b}.

Example 4
$B \to C\,E\,D$
$First(D) = \{a, b, \epsilon\}$
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

$S \rightarrow$ if E then S ;

$S \rightarrow$ print E; $\Leftarrow$

$E \rightarrow E + E$ $\Leftarrow$

$E \rightarrow P$ 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

$S \rightarrow Ax$

$S \rightarrow By$

$S \rightarrow z$

$A \rightarrow 1CB$

$A \rightarrow 2B$

$B \rightarrow 3B$

$B \rightarrow C$

$C \rightarrow 4$

$C \rightarrow \epsilon$

Result

S ={ $\$$ }

A={}

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

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

Result

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

Action

Add y to *Follow*(*B*).

Another Follow Set Example

Grammar

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

Result

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

Action

These productions add nothing.

Another Follow Set Example

Grammar

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

Result

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

Action

Add *First*(*B*) to *Follow*(*C*)

Another Follow Set Example

Grammar

$S \rightarrow A\mathsf{x}$

$S \rightarrow B\mathsf{y}$

$S \rightarrow \mathsf{z}$

$A \rightarrow \mathsf{1}CB \Leftarrow$

$A \rightarrow \mathsf{2}B \Leftarrow$

$B \rightarrow \mathsf{3}B$

$B \rightarrow C$

$C \rightarrow \mathsf{4}$

$C \rightarrow \epsilon$

Result

S ={ \$}

A={x}

B ={ x, y}

C={3, 4}

Action

Add *Follow*(*A*) to *Follow*(*B*).

Another Follow Set Example

Grammar

$S \rightarrow A\mathsf{x}$

$S \rightarrow B\mathsf{y}$

$S \rightarrow \mathsf{z}$

$A \rightarrow \mathsf{1}CB \Leftarrow$

$A \rightarrow \mathsf{2}B$

$B \rightarrow \mathsf{3}B$

$B \rightarrow C$

$C \rightarrow \mathsf{4}$

$C \rightarrow \epsilon$

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

$S \rightarrow A\mathsf{x}$

$S \rightarrow B\mathsf{y}$

$S \rightarrow \mathsf{z}$

$A \rightarrow \mathsf{1}CB$

$A \rightarrow \mathsf{2}B$

$B \rightarrow \mathsf{3}B$

$B \rightarrow C \Leftarrow$

$C \rightarrow \mathsf{4}$

$C \rightarrow \epsilon$

Result

S ={ \$}

A={x}

B ={x, y}

C={x, y, 3, 4}

Action

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