Objectives

Objectives

Follow Sets

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

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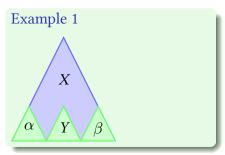
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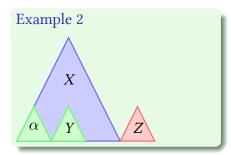
• Given a non-terminal symbol *S*, what terminal symbols could come after strings that are derived from *S*?

The Algorithm:

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

Diagram





- If there is a production $X \to \alpha Y\beta$, then add $FIRST(\beta)$ (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 $\epsilon \in FIRST(\beta)$ then add FOLLOW(X) to FOLLOW(Y).

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Small Examples

Follow Set Example

Example 1

 $S \rightarrow x A \gamma$

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 $\{a,b,y\}$.

Grammar

 $S \rightarrow \text{if } E \text{ then } S$;

$$S \rightarrow \text{print } E$$
;

$$E \rightarrow E + E$$

$$E o P$$
 id P

$$P \rightarrow *P$$

$$P \rightarrow \epsilon$$

Result

Action

Make a chart, add \$ to S.

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Follow Set Example

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Follow Set Example

Grammar

$$S \rightarrow \text{if } E \text{ then } S; \Leftarrow$$

$$S \rightarrow \operatorname{print} E$$
;

$$E \rightarrow E + E$$

$$E o P$$
 id P

$$P \rightarrow *P$$

 $P \rightarrow \epsilon$

Result

$$S=\{\$, ;\}$$

 $E=\{ then \}$

Grammar

$$S \rightarrow \text{if } E \text{ then } S$$
;

$$S \rightarrow \mathsf{print}\,E; \Leftarrow$$

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

$$E \to P \operatorname{id} P$$

$$P \rightarrow *P$$

$$P \rightarrow \epsilon$$

Result

$$S = \{\$, ;\}$$

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

Follow Sets

Action

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

Action

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



Objectives Objectives

Follow Set Example

Follow Set Example

Grammar

$$S
ightarrow$$
 if E then S ; $S
ightarrow$ print E ; $E
ightarrow E + E$ $E
ightarrow P$ id $P
ightharpoonup P$ $ightharpoonup P
ightharpoonup P$

Result

$$S = \{\$, ;\}$$

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

Grammar

$$S
ightarrow$$
 if E then S ; $S
ightarrow$ print E ; $E
ightarrow E + E$ $E
ightarrow P$ id $P
ightharpoonup P
ightarrow P$ $P
ightharpoonup \epsilon$

Result

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

Action

Check productions: add id to FOLLOW(P)

Action

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

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Follow Set Example

Another Follow Set Example

Grammar

```
S 
ightarrow 	ext{if $E$ then $S$}; \ S 
ightarrow 	ext{print $E$}; \ E 
ightarrow E + E \ E 
ightarrow P 	ext{id $P$} \ P 
ightarrow * P \ P 
ightarrow \epsilon
```

Result

$$S = \{\$, ;\}$$

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

Follow Sets

Grammar

$$S o Ax$$

 $S o By$
 $S o z$
 $A o 1CB$
 $A o 2B$
 $B o 3B$
 $B o C$
 $C o 4$
 $C o \epsilon$

Result

Action

Done.

Action

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



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Another Follow Set Example

Another Follow Set Example

Grammar

$$S \rightarrow Ax \Leftarrow$$

$$S \rightarrow By$$

$$S \rightarrow z$$

$$A \rightarrow 1CB$$

$$B\to C$$

$$C \rightarrow$$
 4

$$C \rightarrow \epsilon$$

Grammar

$$S \rightarrow Ax$$

$$S \rightarrow By \Leftarrow$$

$$S \rightarrow z$$

$$A \rightarrow 1CB$$

$$B \to C$$

$$C \rightarrow 4$$

$$C \rightarrow \epsilon$$

Result

$$S = { \$ }$$

$$A=\{x\}$$

$$B = \{ y \}$$

$$C=\{\}$$

Action

Add x to Follow(A).

Action

Add y to Follow(B).

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Another Follow Set Example

Another Follow Set Example

Grammar

$$S \rightarrow Ax$$

$$S \rightarrow B_{V}$$

$$S \rightarrow z \Leftarrow$$

$$A \rightarrow 1CB$$

$$B \rightarrow 3B \Leftarrow$$

$$B \rightarrow C$$

$$C \rightarrow 4 \Leftarrow$$

 $C \rightarrow \epsilon \Leftarrow$

Result

Result

 $S = { \$ }$

 $A = \{ x \}$

 $B = \{\}$

 $C=\{\}$

$$S = \{ \$ \}$$

$$A = \{x\}$$

$$B = \{y\}$$

$$C={}$$

Follow Sets

Grammar

$$S \rightarrow Ax$$

$$S o B$$
y

$$S \rightarrow z$$

$$A \rightarrow 1CB \Leftarrow$$

$$B o$$
 3 B

$$B \rightarrow C$$

$$C \rightarrow 4$$

$$C \rightarrow \epsilon$$

Result

$$S = { \$ }$$

$$A=\{x\}$$

$$B = {y}$$

$$C = \{ 3, 4 \}$$

Action

These productions add nothing.

Action

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

Another Follow Set Example

Another Follow Set Example

Grammar

$$S \rightarrow Ax$$

$$S \rightarrow By$$

$$S \rightarrow z$$

$$A \rightarrow 1CB \Leftarrow$$

$$A
ightarrow 2B \Leftarrow$$

$$B \rightarrow C$$

$$C \rightarrow 4$$

$$C \rightarrow \epsilon$$

Result

$$S = { \$ }$$

Objectives

$$A=\{x\}$$

$$B = \{ x, y \}$$

$$C = \{3, 4\}$$

Grammar

$$S \rightarrow Ax$$

$$S \rightarrow By$$

$$S o \mathsf{z}$$

$$A \rightarrow 1CB \Leftarrow$$

$$A o$$
 2 B

$$B \rightarrow 3E$$
 $B \rightarrow C$

$$C \rightarrow 4$$

$$C \rightarrow \epsilon$$

Result

Objectives

$$S = { \$ }$$

$$A=\{x\}$$

$$B = \{x, y\}$$

$$C = \{ x, 3, 4 \}$$

Action

Add Follow(A) to Follow(B).



Action

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

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Another Follow Set Example

Grammar

$$S \rightarrow Ax$$

$$S \rightarrow By$$

$$A \rightarrow 1CB$$

$$B \rightarrow 3B$$

$$B \rightarrow C \Leftarrow$$

$$C \rightarrow 4$$

$$C \rightarrow \epsilon$$

Result

$$S = \{ \$ \}$$

$$A=\{x\}$$

$$B=\{x, y\}$$

$$C = \{x, y, 3, 4\}$$

Action

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