Compilers

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Today's Lecture

- First set. Indicates which terminals begin the strings derivable from a nonterminal.
- First(A). This is the set of terminals derivable from the nonterminal A.
- Calculate first sets for the following productions (lowercase are terminals):

$A \rightarrow stu \qquad string \\B \rightarrow xyz \qquad x is a tern$	ninal and begins the to it is in First(A) ninal and begins the to it is in First(B)
First(A) = { s } First(B) = { x }	
First Set	

- To find the first set of a nonterminal we must take into account ALL productions with the nonterminal on the LHS.
- Calculate first sets for the following productions:
- A \rightarrow stu A \rightarrow pq B \rightarrow xyz Check both A productions when calculating First(A). s begins one and p begins the other. Both s and p should be in the First(A)

First Set – Multiple Productions for Non-terminal

- To find the first set of a nonterminal we must take into account ALL productions with the nonterminal on the LHS.
- Calculate first sets for the following productions:

 $\begin{array}{c} A \rightarrow stu \\ A \rightarrow pq \\ B \rightarrow xyz \end{array} \begin{array}{c} \text{Check both A productions when calculating} \\ \begin{array}{c} \text{First}(A). \ s \ begins \ one \ and \ p \ begins \ the \ other.} \\ \begin{array}{c} \text{Both s and } p \ should \ be \ in \ the \ First(A) \end{array}$

ANSWER

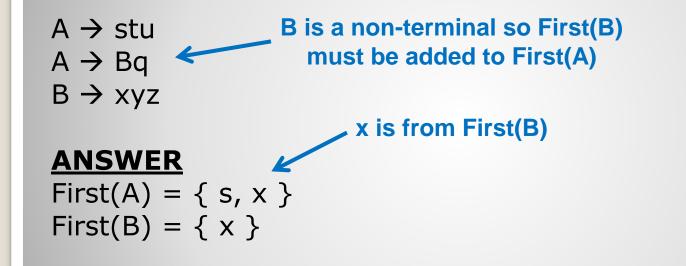
First(A) = { s, p } First(B) = { x }

First Set – Multiple Productions for Non-terminal

- If a non-terminal begins the RHS then you must add that non-terminal's first set.
- Calculate first sets for the following productions:
- $A \rightarrow stu$ B appears as the leftmost $A \rightarrow Bq$ symbol in an A production we $B \rightarrow xyz$ must include First(B) in First(A).

First Set – Non-terminals in RHS

- If a non-terminal begins the RHS then you must add that non-terminal's first set.
- Calculate first sets for the following productions:



First Set – Non-terminals in RHS

- If a non-terminal can derive an empty string (λ) then the empty string must be added to the first set.
- Calculate first sets for the following productions:

 $\begin{array}{c} A \rightarrow stu \\ A \rightarrow \lambda \\ B \rightarrow xyz \end{array} \qquad \qquad \begin{array}{c} A \text{ can derive the empty string } (\lambda) \\ so \lambda \text{ must be included in First}(A) \end{array}$

Note: Both lambda (λ) and epsilon (ϵ) can be used to signify an empty string.

First Set – Empty Strings

- If a non-terminal can derive an empty string (λ) then the empty string must be added to the first set.
- Calculate first sets for the following productions:

 $\begin{array}{ccc} A \rightarrow stu \\ A \rightarrow \lambda \\ B \rightarrow xyz \end{array} \qquad \qquad \begin{array}{c} A \text{ can derive the empty string } (\lambda) \\ so \lambda \text{ must be included in First}(A) \end{array}$

ANSWER

First(A) = { s, λ } First(B) = { x }

First Set – Empty Strings

- If the first RHS symbol is a non-terminal, and that nonterminal can derive λ then you must also include the first set of the next symbol minus λ.
- Calculate first sets for the following productions:
- $\begin{array}{l} \mathsf{A} \rightarrow \mathsf{Bstu} \\ \mathsf{B} \rightarrow \mathsf{xyz} \\ \mathsf{B} \rightarrow \lambda \end{array}$

First Set – Empty Strings

- If the first RHS symbol is a non-terminal, and that nonterminal can derive λ then you must also include the first set of the next symbol.
- Calculate first sets for the following productions:

A must include First(B)- λ . We must also take into account that B can derive λ . Since B can derive λ we must also include the first set of the symbol that follows B (this is the terminal s).

A → Bstu B → xyz B → λ

 $\frac{\text{ANSWER}}{\text{First}(A) = \{ s, x \}}$ First(B) = { x, \lambda } First(A) does NOT contain λ . This is because there is no way to derive λ from A.

In general, λ should only be included if ALL symbols in the rhs can derive λ .

First Set – Empty Strings

• What are the first sets for the nonterminals A, B, and C?

 $A \rightarrow BCdef$ $B \rightarrow mn$ $B \rightarrow \lambda$ $C \rightarrow qr$ $C \rightarrow \lambda$



- What are the first sets for the nonterminals A, B, and C?
- $A \rightarrow BCdef \iff$ $B \rightarrow mn$ $B \rightarrow \lambda$ $C \rightarrow qr$ $C \rightarrow \lambda$

Calculating First(A) B is a nonterminal so First(B) is included. B can derive λ so we must also include First(C)-λ. C can derive λ so we must include First(g) (g is a terminal so it only contains g).

Answer

First(A) = { m, q, d } First(B) = { m, λ } First(C) = { q, λ } First(A) does NOT contain λ . This is because there is no way to derive λ from A.

In general, λ should only be included if ALL symbols in the rhs can derive λ .

First Set – Example

- What are the first sets for the nonterminals A, B, C, and D?
- $A \rightarrow BCD$ $B \rightarrow mn$ $B \rightarrow \lambda$ $C \rightarrow qr$ $C \rightarrow \lambda$ $D \rightarrow st$ $D \rightarrow \lambda$



What are the first sets for the nonterminals A, B, C, and D?

