Exam - Compilers

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1 Top-Down Parsing for if-then-else

1.1 Left-factorization of the grammar

$$
\begin{array}{lcl}
S & \rightarrow & \text{if } B S S_* \\
S & \rightarrow & \text{return NUM;} \\
S_* & \rightarrow & \varepsilon \\
S_* & \rightarrow & \text{else } S \\
B & \rightarrow & (\,\text{NUM}\,)
\end{array}
$$

1.2 Nullablility and First sets

First we find if terminals and nonterminals are *nullable*.

Right-hand side	Init	First Iter	Sec Iter
if $BSS*$	*false*	*false*	*false*
return NUM;	*false*	*false*	*false*
ε	*false*	*true*	*true*
else S	*false*	*false*	*false*
(NUM)	*false*	*false*	*false*
Nonterminal			
S	*false*	*false*	*false*
S_*	*false*	*true*	*true*
B	*false*	*false*	*false*

Then we derive the $FIRST$-sets:

Right-hand side	Init	First Iter	Sec Iter
if BSS_*	$\emptyset$	{if}	{if}
return NUM;	$\emptyset$	{return}	{return}
ε	$\emptyset$	$\emptyset$	$\emptyset$
else S	$\emptyset$	{else}	{else}
(NUM)	$\emptyset$	{(}	{(}
Nonterminal			
S	$\emptyset$	{if,return}	{if,return}
S_*	$\emptyset$	{else}	{else}
B	$\emptyset$	{(}	{(}

1.3 Calculate Follow sets for all nonterminals

By following the procedure on page 59 in the book, we find the following table. To handle the end-of-string condition we add the production

$$S' \rightarrow S\$$$

to the production

Production	Constraints
$S' \rightarrow S\$$	$\{\$\} \subseteq FOLLOW(S)$
$S \rightarrow \text{if } BSS_*$	$\{\text{return}, \text{if}\} \subseteq FOLLOW(B)$, $FOLLOW(S) \subseteq FOLLOW(S_*)$, $\{\text{else}\} \subseteq FOLLOW(S)$
$S \rightarrow \text{return NUM;}$	
$S_* \rightarrow \varepsilon$	
$S_* \rightarrow \text{else } S$	$FOLLOW(S_*) \subseteq FOLLOW(S)$
$B \rightarrow (\text{ NUM })$	

We first use the constraints $\{\$\} \subseteq FOLLOW(S)$ and constraints of the form $FIRST(\dots) \subseteq FOLLOW(\dots)$ to get the initial sets.

$$\begin{aligned} FOLLOW(S) &\subseteq \{\text{else}, \$\} \\ FOLLOW(S_*) &\subseteq \{\emptyset\} \\ FOLLOW(B) &\subseteq \{\text{if}, \text{return}\} \end{aligned}$$

and then use the constrains on the form $FOLLOW(\dots) \subseteq FOLLOW(\dots)$:

$$\begin{aligned} FOLLOW(S) &\subseteq \{\text{else}, \$\} \\ FOLLOW(S_*) &\subseteq \{\text{else}, \$\} \\ FOLLOW(B) &\subseteq \{\text{if}, \text{return}\} \end{aligned}$$

1.4 Look-aheads sets

From the lecture slides the look ahead set is defined as

$$la(X \to \alpha) = \begin{cases} FIRST(\alpha) \cup FOLLOW(X) & \text{, if } NULLABLE(\alpha) \\ FIRST(\alpha) & \text{, otherwise} \end{cases}$$

Below the lookahead sets for our productions are shown.

$$\begin{array}{lcl} LA(S \to \text{if } BSS_*) & = & \{\text{if}\} \\ LA(S \to \text{return NUM;}) & = & \{\text{return}\} \\ LA(S_* \to \varepsilon) & = & \{\text{else,\$}\} \\ LA(S_* \to \text{else } S) & = & \{\text{else}\} \\ LA(B \to (\,\text{NUM}\,)) & = & \{(\} \end{array}$$

No, the grammar is not LL1.