CS480
Translators
Top-down Parsing
Chap. 4
Quiz #6

• What do we need to do to our grammar to use top-down parsing? Is it LL(1)?
Defining an LL Grammar

- Need two definitions:
- **First** and **Follow**

![Diagram](image)

**Figure 4.15:** Terminal $c$ is in $\text{FIRST}(A)$ and $a$ is in $\text{FOLLOW}(A)$
First(\(\alpha\))

- If \(\alpha\) is any string in grammar, First(\(\alpha\)) is set of terminals that begin strings derived from \(\alpha\).

  *  

- If \(\alpha \Rightarrow \varepsilon\), then \(\varepsilon\) is in First(\(\alpha\)).

- What does it mean if \(A \rightarrow \alpha | \beta\), and First(\(\alpha\)) and First(\(\beta\)) are disjoint?
Follow(A)

• If $A$ is a nonterminal in grammar, $\text{Follow}(A)$ is set of terminals that can appear immediately to the right of $A$.
• If $A$ can be the rightmost symbol, then $\$\$ is in $\text{Follow}(A)$.
• What is $\$\$?
Compute First(X) for all symbols

• If X is a terminal, then First(X) = {X}
• If X is a nonterminal and \( X \rightarrow Y_1Y_2...Y_k \) is a production, then place a in First(X) if for some \( i \), a is in First(Y_\( i_\)) and \( \varepsilon \) is in all First(Y_\( 1_\)), ..., First(Y_\( i-1_\)). If \( \varepsilon \) is in First(Y_\( j_\)) for all \( j=1, 2, ..., k \), then add \( \varepsilon \) First(X).
• If \( X \rightarrow \varepsilon \), then \( \varepsilon \) is in First(X)
Compute Follow(A) for nonterminals

- Place $ in Follow(S), where S is start symbol and $ is the input endmarker.
- If there is a production $A \rightarrow \alpha B \beta$, then everything in First(\beta), except \epsilon, is in Follow(B).
- If there is a production $A \rightarrow \alpha B$ or $A \rightarrow \alpha B \beta$, where \epsilon is in First(\beta), then everything in Follow(A) is Follow(B).
Example First and Follow

\[ E \rightarrow T \ E' \]
\[ E' \rightarrow + \ T \ E' \mid \varepsilon \]
\[ T \rightarrow F \ T' \]
\[ T' \rightarrow * \ F \ T' \mid \varepsilon \]
\[ F \rightarrow ( \ E ) \mid \text{id} \]

- First(E), First(E’), First(T), First(T’), First(F)?
- Follow(E), Follow(E’), Follow(T), Follow(T’), Follow(F)?
Predictive Parsing Table

• For each production $A \rightarrow \alpha$ in the grammar:
  – For each terminal $a$ in $\text{First}(\alpha)$, add $A \rightarrow \alpha$ to $M[A, a]$.
  – If $\epsilon$ is in $\text{First}(\alpha)$, then for each terminal $b$ in $\text{Follow}(A)$, add $A \rightarrow \alpha$ to $M[A, b]$. If $\$ is in $\text{Follow}(A)$, add $A \rightarrow \alpha$ to $M[A, \$]$ as well.

<table>
<thead>
<tr>
<th>Non-terminal</th>
<th>Input symbol</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$E$</td>
<td>id</td>
<td>$+$</td>
<td>$\ast$</td>
<td>$($</td>
<td>$)$</td>
</tr>
<tr>
<td>$E'$</td>
<td>$E \rightarrow TE'$</td>
<td>$E' \rightarrow +TE'$</td>
<td>$E \rightarrow TE'$</td>
<td>$E' \rightarrow \epsilon$</td>
<td>$E' \rightarrow \epsilon$</td>
</tr>
<tr>
<td>$T$</td>
<td>$T \rightarrow FT'$</td>
<td>$T' \rightarrow \epsilon$</td>
<td>$T \rightarrow FT'$</td>
<td>$T' \rightarrow \epsilon$</td>
<td>$T' \rightarrow \epsilon$</td>
</tr>
<tr>
<td>$T'$</td>
<td></td>
<td>$T' \rightarrow \ast FT'$</td>
<td></td>
<td>$T' \rightarrow \epsilon$</td>
<td>$T' \rightarrow \epsilon$</td>
</tr>
<tr>
<td>$F$</td>
<td>$F \rightarrow \text{id}$</td>
<td></td>
<td>$F \rightarrow (E)$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What happens here?

\[ S \rightarrow iEtSS' \mid a \]
\[ S' \rightarrow eS \mid \epsilon \]
\[ E \rightarrow b \]

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<tr>
<td>( S )</td>
<td>( S \rightarrow a )</td>
</tr>
<tr>
<td>( S' )</td>
<td>( S' \rightarrow \epsilon )</td>
</tr>
<tr>
<td>( E )</td>
<td>( E \rightarrow b )</td>
</tr>
</tbody>
</table>
Quiz #6

• For each grammar below, calculate First and Follow sets for each nonterminal and construct a parsing table.

(a) $S \rightarrow 0 S'$
   $S' \rightarrow S \ 1 \mid 1$

(b) $S \rightarrow ( S ) S \mid \varepsilon$