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CSEN 1003 Compiler, Spring Term 2020
Practice Assignment 4

Discussion: 23.02.20 - 26.02.20

Exercise 4-1

Eliminating Left Recursion

Eliminate left-recursion from each of the following grammars:

a) $S \rightarrow S\texttt{a} \mid \texttt{b}$

Solution:

$$\begin{array}{lcl} S & \rightarrow & \texttt{b}S' \\ S' & \rightarrow & \texttt{a}S' \mid \varepsilon \end{array}$$

b) $S \rightarrow S\texttt{ab} \mid \texttt{cd}$

Solution:

$$\begin{array}{lcl} S & \rightarrow & \texttt{cd}S' \\ S' & \rightarrow & \texttt{ab}S' \mid \varepsilon \end{array}$$

c) $S \rightarrow S \cup S \mid S\ S \mid S* \mid (S) \mid \texttt{a}$

Solution:

$$\begin{array}{lcl} S & \rightarrow & \texttt{(}S\texttt{)}S' \mid \texttt{a}S' \\ S' & \rightarrow & \cup SS' \mid SS' \mid *S' \mid \varepsilon \end{array}$$

d)
$$\begin{array}{lcl} rexpr & \rightarrow & rexpr \cup rterm \mid rterm \\ rterm & \rightarrow & rterm\ rfactor \mid rfactor \\ rfactor & \rightarrow & rfactor* \mid rprimary \\ rprimary & \rightarrow & \mathbf{a} \mid \mathbf{b} \end{array}$$

Solution:

$$\begin{array}{lcl} rexpr & \rightarrow & rterm\ rexpr' \\ rexpr' & \rightarrow & \cup rterm\ rexpr' \mid \varepsilon \\ rterm & \rightarrow & rfactor\ rterm' \\ rterm' & \rightarrow & rfactor\ rterm' \mid \varepsilon \\ rfactor & \rightarrow & rprimary\ rfactor' \\ rfactor' & \rightarrow & *rfactor' \mid \varepsilon \\ rprimary & \rightarrow & \mathbf{a} \mid \mathbf{b} \end{array}$$

Alternative solution:

[0] Exercises are due to Dr. Carmen Gervet

$$
\begin{array}{lcl}
rexpr & \rightarrow & rterm \cup rexpr \mid rterm \\
rterm & \rightarrow & rfactor\ rterm \mid rfactor \\
rfactor & \rightarrow & rprimary\ rfactor' \\
rfactor' & \rightarrow & *rfactor' \mid \varepsilon \\
rprimary & \rightarrow & \mathbf{a} \mid \mathbf{b}
\end{array}
$$

e)
$$
\begin{array}{lcl}
A & \rightarrow & \mathtt{0} \mid T\mathtt{1} \\
T & \rightarrow & \mathtt{1} \mid A\mathtt{0}
\end{array}
$$

Solution:

$$
\begin{array}{lcl}
A & \rightarrow & \mathtt{0} \mid T\mathtt{1} \\
T & \rightarrow & \mathtt{1}T' \mid \mathtt{00}T' \\
T' & \rightarrow & \mathtt{10}T' \mid \varepsilon
\end{array}
$$

f)
$$
\begin{array}{lcl}
A & \rightarrow & BC \\
B & \rightarrow & Bb \mid \varepsilon \\
C & \rightarrow & AC \mid \mathtt{a}
\end{array}
$$

Solution:

$$
\begin{array}{lcl}
A & \rightarrow & BC \mid C \\
B & \rightarrow & \mathtt{b}B' \\
B' & \rightarrow & \mathtt{b}B' \mid \varepsilon \\
C & \rightarrow & \mathtt{b}B'CCC' \mid \mathtt{a}C' \\
C' & \rightarrow & CC' \mid \varepsilon
\end{array}
$$

Exercise 4-2

Left Factoring

Left-factor each of the following grammars:

a)
$$
\begin{array}{lcl}
S & \rightarrow & \mathtt{0}S\mathtt{1} \mid \mathtt{01}
\end{array}
$$

Solution:

$$
\begin{array}{lcl}
S & \rightarrow & \mathtt{0}S' \\
S' & \rightarrow & S\mathtt{1} \mid \mathtt{1}
\end{array}
$$

b)
$$
\begin{array}{lcl}
S & \rightarrow & \mathtt{abx} \mid \mathtt{aby} \mid \mathtt{acx} \mid \mathtt{acy}
\end{array}
$$

Solution:

$$
\begin{array}{lcl}
S & \rightarrow & \mathtt{a}S' \\
S' & \rightarrow & \mathtt{b}S'' \mid \mathtt{c}S'' \\
S'' & \rightarrow & \mathtt{x} \mid \mathtt{y}
\end{array}
$$

Exercise 4-3

Consider the following CFG:

$$
\begin{array}{lcl}
S & \rightarrow & \mathtt{(}L\mathtt{)} \mid \mathtt{a} \\
L & \rightarrow & L\mathtt{,}S \mid S
\end{array}
$$

Eliminate the left recursion.

Solution:

$$
\begin{array}{rcl}
S & \rightarrow & \texttt{(}L\texttt{)} \mid \texttt{a} \\
L & \rightarrow & \texttt{(}L\texttt{)}L' \mid \texttt{a}L' \\
L' & \rightarrow & \texttt{,}SL' \mid \varepsilon
\end{array}
$$

Exercise 4-4

Consider the following CFG:

$$S \rightarrow SS\texttt{+} \mid SS\texttt{*} \mid \texttt{a}$$

Left factor the grammar and eliminate left recursion.

Solution:

$$
\begin{array}{rcl}
S & \rightarrow & \texttt{a}S' \\
S' & \rightarrow & SXS' \mid \varepsilon \\
X & \rightarrow & \texttt{+} \mid \texttt{*}
\end{array}
$$