German University in Cairo
Department of Computer Science
Assoc. Prof. Haythem O. Ismail

CSEN 1003 Compiler, Spring Term 2020
Practice Assignment 3

Discussion: 12.02.19 - 19.02.19

Exercise 3-1

CFG's

Give a context-free grammar (CFG) for each of the following languages:

a) $L = \{\mathtt{a}^m\mathtt{b}^n\mathtt{c}^k \mid k = m + n \text{ and } m, n, k \geq 0\}$ over the alphabet $\Sigma = \{\mathtt{a}, \mathtt{b}, \mathtt{c}\}$.

b) $L = \{\mathtt{a}^m\mathtt{b}^n \mid n \neq m\}$ over the alphabet $\Sigma = \{\mathtt{a}, \mathtt{b}\}$.

c) $L = \{w \mid w \text{ is a palindrome }\}$ over the alphabet $\Sigma = \{\mathtt{a}, \mathtt{b}, \mathtt{c}\}$. (Note: A palindrome is a string that reads the same backwards as forwards.)

Exercise 3-2

Parse trees

Cosider the grammar:

$$\begin{array}{lcl} S & \rightarrow & A\mathtt{1}B \\ A & \rightarrow & \mathtt{1}A \mid \mathtt{0} \\ B & \rightarrow & \mathtt{0}B \mid \varepsilon \end{array}$$

Give a parse tree for each of the following strings:

a) `11101`

b) `1010`

c) `0100`

[0]Some exercises are due to Dr. Carmen Gervet

Exercise 3-3

Ambiguous grammars

For the following grammars, first show that the grammar is ambiguous, then provide an equivalent unambiguous grammar.

a) $S \rightarrow \texttt{1}S\texttt{0} \mid \texttt{1}S \mid \varepsilon$

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

Exercise 3-4

Leftmost and rightmost derivations

Consider the following context-free grammar:

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

and the string: `aa+a*`

a) Give a leftmost derivation for the string. Show the sequence of derivation rules applied.

b) Give a rightmost derivation for the string. Show the sequence of derivation rules applied.

c) Give a parse tree for the string.

d) Is this grammar ambiguous? Justify your answer.

Exercise 3-5

Unambiguous grammars

The following context-free grammar generates prefix expressions with operands `0` and `1` and binary operators `+`, `-`, and `*`:

$S \rightarrow \texttt{+}SS \mid \texttt{-}SS \mid \texttt{*}SS \mid \texttt{0} \mid \texttt{1}$

a) Find leftmost and rightmost derivations together with a parse tree for the string `*+-0101`.

b) Prove that this grammar is unambiguous.

Exercise 3-6

Grammar Correctness

a) Consider the CFG G_1:

$$S \longrightarrow \texttt{0}S\texttt{11} \mid \texttt{0}S\texttt{111} \mid \varepsilon$$

Prove that $L(G_1) = \{\texttt{0}^m\texttt{1}^n \mid 2m \leq n \leq 3m \text{ and } n, m \geq 0\}$

b) Consider the CFG G_2:

$$\begin{aligned} S &\longrightarrow AC \\ A &\longrightarrow \texttt{a}A\texttt{b} \mid \varepsilon \\ C &\longrightarrow \texttt{c}C \mid \varepsilon \end{aligned}$$

Prove that $L(G_2) = \{\texttt{a}^m\texttt{b}^m\texttt{c}^n \mid m, n \geq 0\}$