Middle East Technical University Department of Computer Engineering

CENG 280

Formal Languages and Abstract Machines

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Homework 5

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Answer for Q1

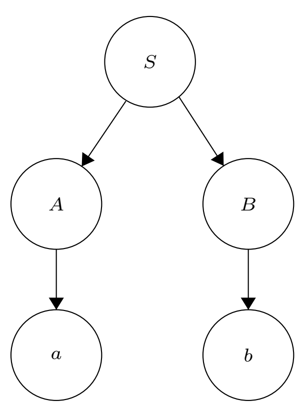
a. Strings that have equal number of 1s and 0s.

b. Yes, it is ambiguous. We can prove this by giving a simple example. If we consider the empty string for this language, it is obvious that it can be produced by both the rule A and B which leads to different parse trees. So, we can say that the language G_1 is ambiguous.

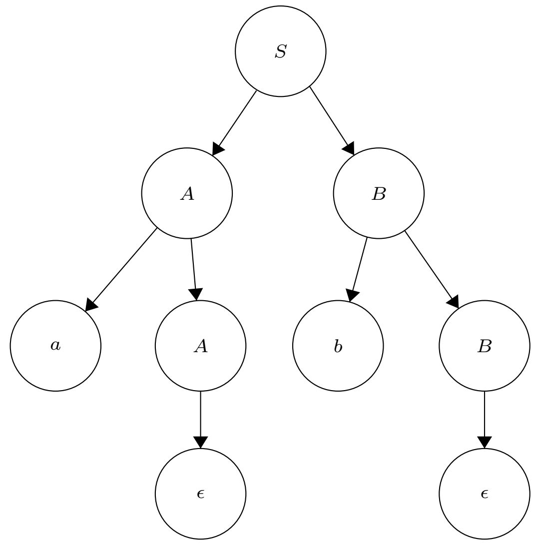
Answer for Q2

a. We can give an example string and analyze its parse trees, in order to conclude if the given grammar is ambiguous or not.
Let's pick the string 'ab', this string has different parse trees:

First One:



Second One:



It can be seen that the grammar G_2 is ambiguous.

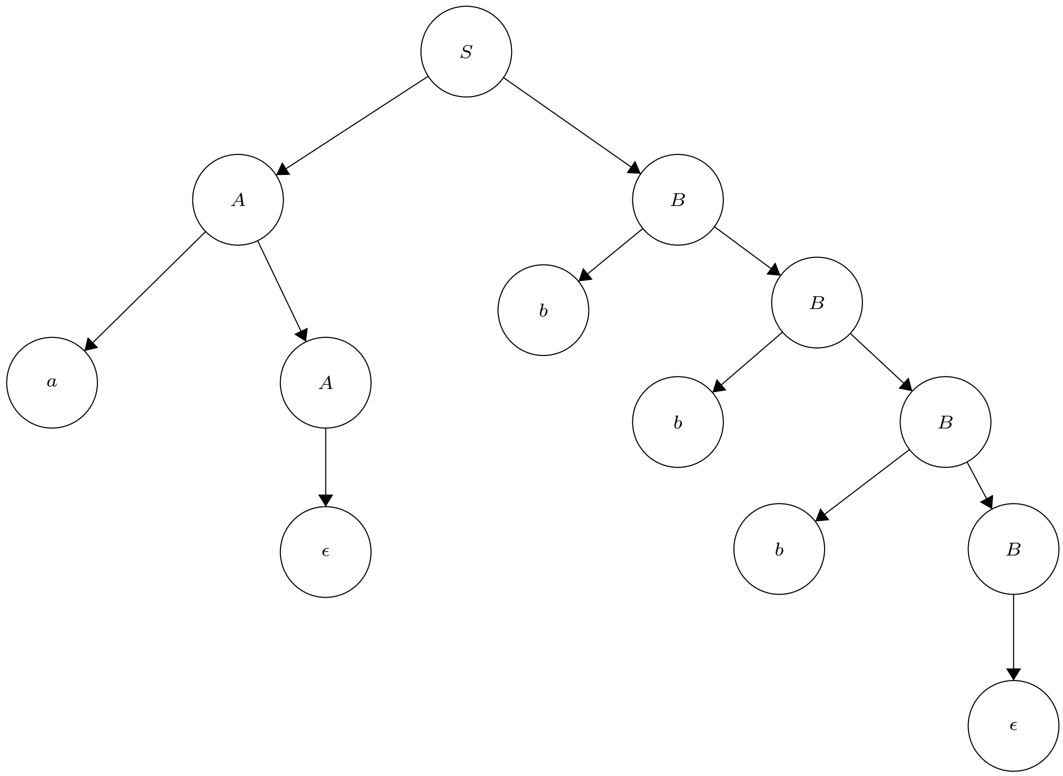
b. In order to make the grammar G_2 unambiguous, we must tweak the grammar a little bit.

One version of the unambiguous grammar G_2 is:

G_2 = (V, $\sum$, R, S) where V = (a, b, S, A, B), $\sum$ = (a, b) and R is;
S $\rightarrow$ AB
A $\rightarrow$ aA | ϵ
B $\rightarrow$ bB | ϵ

With these adjustments, there are no controversial parsings left in the grammar.

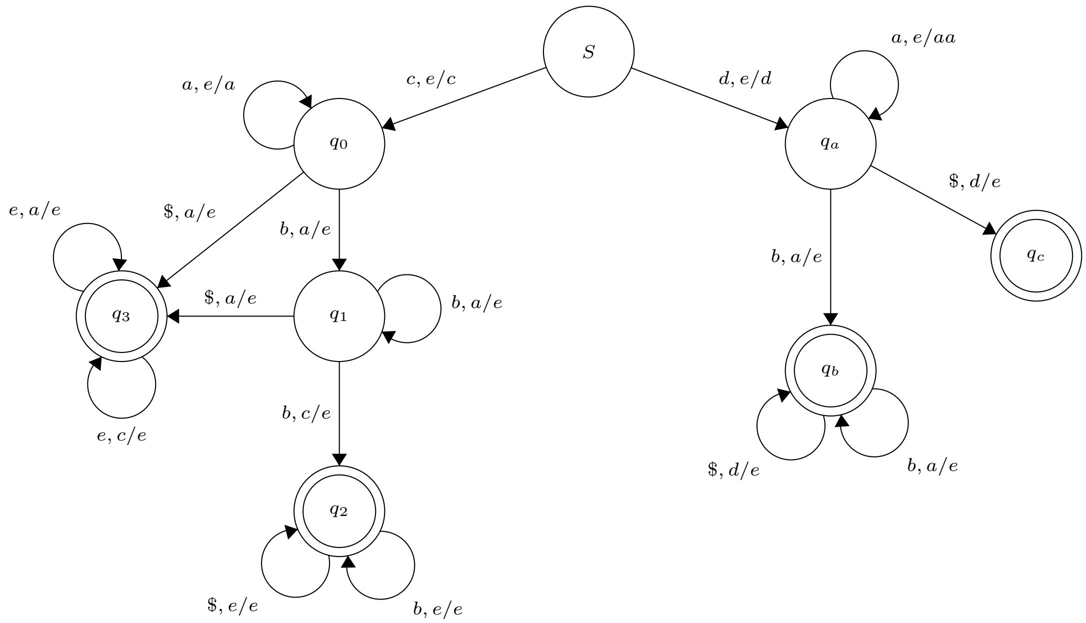
c. $S \rightarrow AB \rightarrow aAB \rightarrow aB \rightarrow abB \rightarrow abbB \rightarrow abbbB \rightarrow abbb$



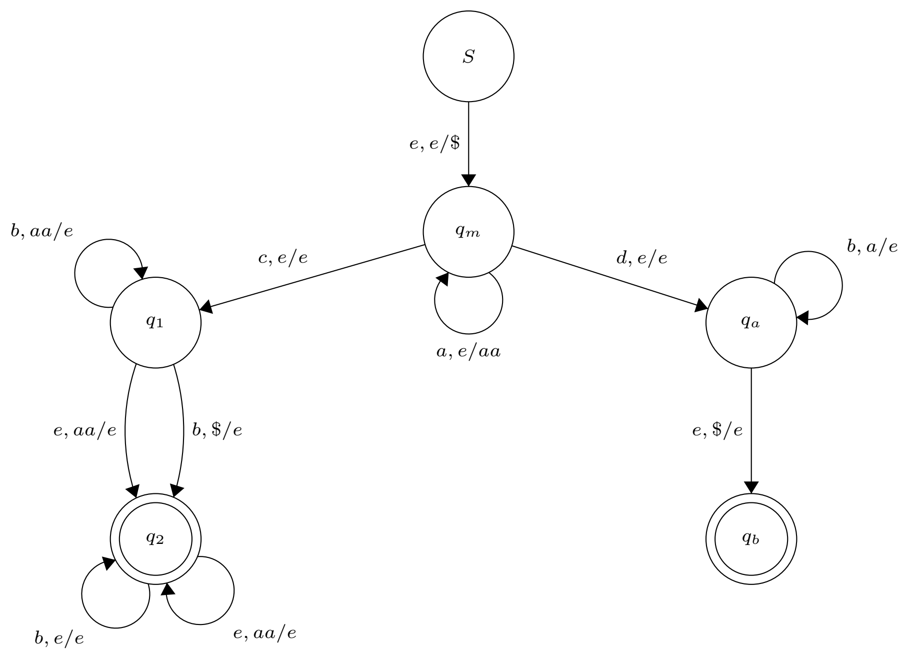
Answer for Q3

a. In order to prove that L_1 and L_2 are deterministic context-free languages, we will construct the dpda's of them.

Dpda of L_1:



Dpda of L_2:



b. Let's s represent the given languages with:

Regular = R
Context-free = C
The class of the complements of context-free languages = CC
Deterministic context-free = D

The things we must consider when constructing the Venn Diagram:
− Every regular language is a context-free language. So regular languages are a proper subset of context-free languages.

− Every regular language is a deterministic context-free language. So regular languages are a proper subset of deterministic context-free languages.

− Every deterministic context-free language is a deterministic context-free language. So deterministic context-free are a proper subset of context-free languages. An example for this proposition can be; L = (wwR), which is a context-free language but not deterministic, and L = (wcwR), which is both a deterministic context-free language and a context free language.

− In order to find the relation of complement with the other ones, we must look for closure rules of the other ones. Both regular and deterministic context-free languages are closed under complementation, so they are both proper subsets of the class of the complements of context-free languages. However, context-free languages are not closed under complementation which means there are context-free languages that are not in the class of the complements of context-free languages.

Thus, if we consider all of the propositions above, we will get a Venn Diagram which looks like: