Grammars and languages (II)

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1 Grammar class and generated language

Assign to a grammar $G = (V_T, V_N, P, S)$ corresponding **Chomsky's class** (*unrestricted*, *context-sensitive*, *context-free*, *regular*) and **explain your choice**. Then **describe the language** $L(G)$ generated by this grammar G. Only a set of rule P is given. S is always a *start rule*. V_T and V_N are derived from the set of rules P.

1.

$$S \to aA$$
$$A \to baA \mid aA \mid ba \mid a$$

Answers:

- Grammar class: *context-free*
- Language L consists of words over alphabet $\{a, b\}$ with a at the begin and end. In the middle there are a and b mixed up, but every b is separated by a from both sides:
  $L = \{\mathbf{a}(a^*(ab)^*)^*(b\mathbf{a}|\mathbf{a})\}$ or
  $L = \{\mathbf{a}\{a, ab\}^*(b\mathbf{a}|\mathbf{a})\}$
  These two notations are equivalent.

2.

$$S \to aS \mid aSb \mid \epsilon$$

Answers:

- Grammar class: *context-free*
- Language L consists of words over alphabet $\{a, b\}$ with a repeated n-times followed by b repeated m-times, where $n \geq m$:
  $L = \{a^n b^m | n \geq 0, m \geq 0, n \geq m\}$

3.

$$S \to SS \mid aSb \mid bSa \mid ab \mid ba$$

Answers:

- Grammar class: *context-free*
- Language L consists of words over alphabet $\{a, b\}$ with a and b mixed up freely, but with the same number of a and b:
  $L = \{\{a, b\}^* \mid numOfOccurences(a) == numOfOccurences(b)\}$

2 Grammar creation

Given a description of a language L create grammar $G = (V_T, V_N, P, S)$ that generates this language $L(G)$. List a set of production rules P.

1. $L = \{abb, abbaab, abbaababb, abbaababbaab, ...\}$

   Answers:

   - Grammar class: *context-free*

   $$S \to abb \mid abbA$$
   $$A \to aab \mid aabS$$

2. $L = \{ab^n c^{2n+m} a | n \geq 1, m \geq 1\}$

   Answers:

   - Grammar class: *context-free*

   $$S \to aAa$$
   $$A \to bAcc \mid bBcc$$
   $$B \to cB \mid c$$

3. $L = \{ba^i cb^{i+1} | i \geq 1\}$

   Answers:

   - Grammar class: *context-free*

   $$S \to bAb$$
   $$A \to aAb \mid acb$$