

# Parsing

## Homework 2 (CFG, PDA), due 04 May 2020

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### Question 1 (CFG)

1. Consider the CFG  $G_1$  with non-terminals  $\{S, A, B, C\}$ , terminals  $\{a, b, c\}$ , start symbol  $S$  and productions

$$S \rightarrow ASBC \quad S \rightarrow d \quad A \rightarrow a \quad B \rightarrow b \quad C \rightarrow c$$

Transform  $G_1$  into an equivalent CFG  $G'_1$  in Chomsky Normal Form.

2. Consider the CFG  $G_2$  with non-terminals  $\{S, T\}$ , terminals  $\{a, b, c, e\}$ , start symbol  $S$  and productions

$$S \rightarrow Tb \quad S \rightarrow a \quad T \rightarrow Sc \quad T \rightarrow Se$$

Transform  $G_2$  into an equivalent CFG  $G'_2$  without left recursion.

Solution:

1.  $S \rightarrow AX \quad X \rightarrow SY \quad Y \rightarrow BC \quad S \rightarrow d \quad A \rightarrow a \quad B \rightarrow b \quad C \rightarrow c$

2. We put indices on our non-terminals:  $S$  has index 1,  $T$  index 2:

$$S_1 \rightarrow T_2b \quad S_1 \rightarrow a \quad T_2 \rightarrow S_1c \quad T_2 \rightarrow S_1e$$

I Replace  $T_2 \rightarrow S_1c$  with  $T_2 \rightarrow T_2bc$  and  $T_2 \rightarrow ac$ , and  $T_2 \rightarrow S_1e$  with  $T_2 \rightarrow T_2be$  and  $T_2 \rightarrow ae$

$\leadsto$  new set of productions:  $S_1 \rightarrow T_2b \quad S_1 \rightarrow a \quad T_2 \rightarrow T_2bc \quad T_2 \rightarrow ac \quad T_2 \rightarrow T_2be \quad T_2 \rightarrow ae$

II Take a new non-terminal  $X$  and replace the  $T_2$ -productions with

$$\begin{array}{llll} T_2 \rightarrow ae & T_2 \rightarrow ac & T_2 \rightarrow aeX & T_2 \rightarrow acX \\ X \rightarrow bcX & X \rightarrow bc & X \rightarrow beX & X \rightarrow be \end{array}$$

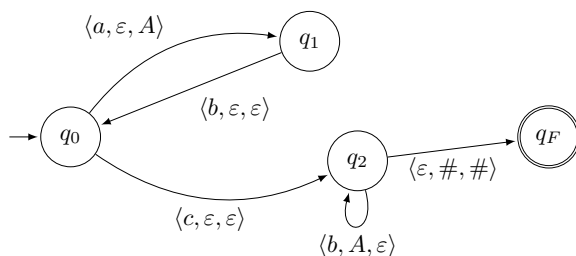
$\leadsto$  new set of productions:

$$\begin{array}{llll} S_1 \rightarrow T_2b & S_1 \rightarrow a & & \\ T_2 \rightarrow ae & T_2 \rightarrow ac & T_2 \rightarrow aeX & T_2 \rightarrow acX \\ X \rightarrow bcX & X \rightarrow bc & X \rightarrow beX & X \rightarrow be \end{array}$$

### Question 2 (PDA)

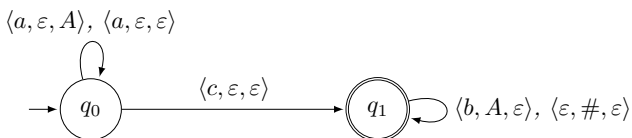
Give a PDA that recognizes the following language, acceptance with final state:  $\{(ab)^n cb^n \mid n \geq 0\}$ .

Solution: Initial stack symbol is #.



**Question 3 (PDA)**

Consider the following PDA  $M$ , initial stack symbol is  $\#$ .



Give  $L(M)$  and  $N(M)$ .

Solution:  $L(M) = N(M) = \{a^n cb^m \mid n \geq m\}$

**Question 4 (PDA)**

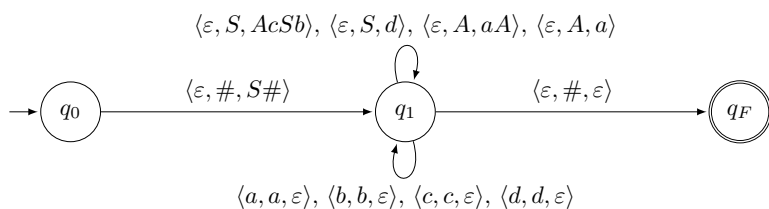
Consider the CFG  $G$  with non-terminals  $\{S, A\}$ , terminals  $\{a, b, c, d\}$ , start symbol  $S$  and productions

$S \rightarrow AcSb$   $S \rightarrow d$   $A \rightarrow aA$   $A \rightarrow a$

Give an LL-PDA and an LR-PDA for this CFG.

Solution:

LL-PDA ( $\#$  initial stack symbol):



LR-PDA ( $\#$  initial stack symbol):

