

4. Transform the grammar with productions $S \rightarrow baAB$,

$$B \rightarrow BAq \mid A \mid \lambda$$

into Chomsky normal form.

Remove λ :

$$\begin{aligned}
 S &\rightarrow ba \mid baA \mid baB \mid baAB \\
 A &\rightarrow b \mid bA \mid bB \mid bAB \\
 B &\rightarrow a \mid Ba \mid Aa \mid BAa \\
 &\quad \mid b \mid bA \mid bB \mid bAB
 \end{aligned}$$

$$\Rightarrow \begin{array}{l} S \rightarrow V_b V_A \mid V_o A \mid V_o B \mid V_o V_i \\ V_o \rightarrow V_b V_A \quad , \quad V_i \rightarrow AB \\ V_A \rightarrow a \quad , \quad V_b \rightarrow b \end{array}$$

$$\begin{array}{l} A \rightarrow b | V_b A | V_b B | V_b V, \\ B \rightarrow a | BV_a | AV_a | V_a V_a \\ \quad | b | V_b A | V_b B | V_b V, \\ V_a \rightarrow BA \end{array}$$

5. Convert the grammar $S \rightarrow AB \mid aB$,

$$A \rightarrow abb \mid \lambda,$$

$$B \rightarrow bbA$$

into Chomsky normal form.

Remove λ:

$$\begin{array}{l} S \rightarrow B | AB | aB \\ A \rightarrow abb \\ B \rightarrow bb | bba \end{array}$$

Remove unit production

$$\begin{aligned} S &\rightarrow bb \mid bbA \mid AB \mid aB \\ A &\rightarrow abb \\ B &\rightarrow bb \mid bbA \end{aligned}$$

$S \rightarrow V_b V_b | V_b A | AB | V_B$

$$A \rightarrow 1/6\,16_1$$

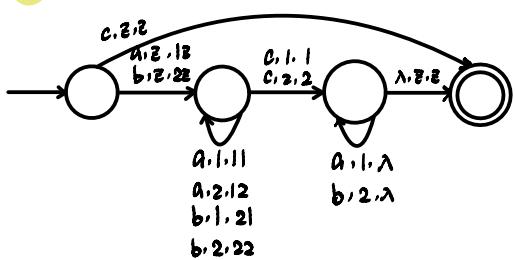
$\mu \rightarrow \nu \bar{\nu} \nu \bar{\nu}$

$$V_L \rightarrow a, V_R \rightarrow b, V_{LR} \rightarrow V_b V_b$$

6. Construct npda's that accept the following languages on $\Sigma = \{a, b, c\}$:

1. Give a formal definition of a two-tape Turing machine; then write programs that accept the languages below. Assume that $\Sigma = \{a, b, c\}$

- (a) $L = \{a^n b^n c^n\}$, $n \geq 1$.
 (b) $L = \{a^n b^n c^m\}$, $m > n$.
 (c) $L = \{ww : w \in \{a, b\}^*\}$.
(d) $L = \{wzvzR_{zw} : wz \in \{a, b\}^*\}$



6. Show that the language $L = \{a^{n^2} : n \geq 0\}$ is not context free.

Pick $w = g^{m^2} = uvkyz \in L$. Assume that L is context free.

$$|vxg| \leq m, |vy| \geq 1. \text{ Let } V = g^{k_1}, Y = g^{k_2}$$

$w = uv^ixy^iz$, pick $j \in ?$, then $w \in Q^{m+k+k_0}$

$$k_1 + k_2 \leq m \Rightarrow m^2 + k_1 + k_2 \leq m^2 + m \leq m^2 + 2m + 1 = (m+1)^2$$

$\rightarrow m^2 + k_1 + k_2$ 不是完全平方数 $\rightarrow w \notin L \rightarrow L$ is not context free.

2. Write programs for nondeterministic Turing machines that accept the languages below. In each case, explain if and how the nondeterminism simplifies the task.

- (a) $L = \{ww : w \in \{a, b\}^+\}$.

