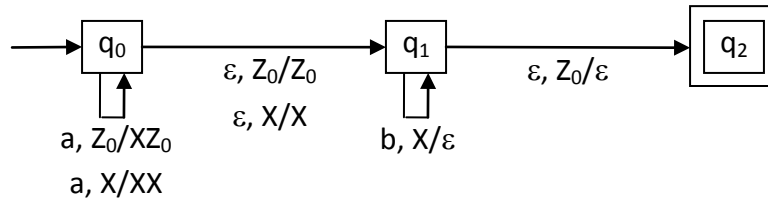


## Converting a PDA into an equivalent CFG

Example:  $\{a^n b^n\}$



$S \rightarrow [q_0 Z_0 q_2]$

$[q_1 Z_0 q_2] \rightarrow \epsilon$

$[q_1 X q_1] \rightarrow b$

$[q_0 Z_0 q_0] \rightarrow [q_1 Z_0 q_0]$

$[q_0 Z_0 q_1] \rightarrow [q_1 Z_0 q_1]$

$[q_0 Z_0 q_2] \rightarrow [q_1 Z_0 q_2]$

$[q_0 X q_0] \rightarrow [q_1 X q_0]$

$[q_0 X q_1] \rightarrow [q_1 X q_1]$

$[q_0 X q_2] \rightarrow [q_1 X q_2]$

$[q_0 Z_0 q_0] \rightarrow a [q_0 X q_0] [q_0 Z_0 q_0] \mid a [q_0 X q_1] [q_1 Z_0 q_0] \mid a [q_0 X q_2] [q_2 Z_0 q_0]$

$[q_0 Z_0 q_1] \rightarrow a [q_0 X q_0] [q_0 Z_0 q_1] \mid a [q_0 X q_1] [q_1 Z_0 q_1] \mid a [q_0 X q_2] [q_2 Z_0 q_1]$

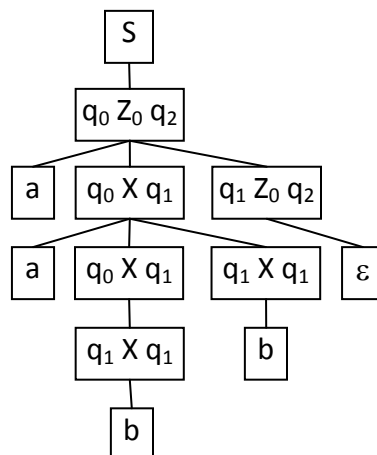
$[q_0 Z_0 q_2] \rightarrow a [q_0 X q_0] [q_0 Z_0 q_2] \mid a [q_0 X q_1] [q_1 Z_0 q_2] \mid a [q_0 X q_2] [q_2 Z_0 q_2]$

$[q_0 X q_0] \rightarrow a [q_0 X q_0] [q_0 X q_0] \mid a [q_0 X q_1] [q_1 X q_0] \mid a [q_0 X q_2] [q_2 X q_0]$

$[q_0 X q_1] \rightarrow a [q_0 X q_0] [q_0 X q_1] \mid a [q_0 X q_1] [q_1 X q_1] \mid a [q_0 X q_2] [q_2 X q_1]$

$[q_0 X q_2] \rightarrow a [q_0 X q_0] [q_0 X q_2] \mid a [q_0 X q_1] [q_1 X q_2] \mid a [q_0 X q_2] [q_2 X q_2]$

Input string: aabb



**We can rename the variables of the grammar:**

$S \rightarrow E$

$H \rightarrow \epsilon$

$R \rightarrow b$

$C \rightarrow F$

$D \rightarrow G$

$E \rightarrow H$

$J \rightarrow Q$

$K \rightarrow R$

$L \rightarrow T$

$C \rightarrow a J C \mid a K F \mid a L M$

$D \rightarrow a J D \mid a K G \mid a L N$

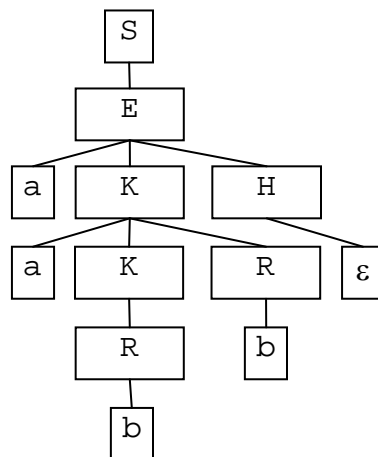
$E \rightarrow a J E \mid a K H \mid a L P$

$J \rightarrow a J J \mid a K Q \mid a L U$

$K \rightarrow a J K \mid a K R \mid a L V$

$L \rightarrow a J L \mid a K T \mid a L W$

Input string: aabb



**The above grammar contains useless symbols:**

C, D, F, G, J, L, M, N, P, Q, T, U, V, W