Parsing Beyond CFG
Homework 9: EPDA and TA

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Question 1 (EPDA)

Give an EPDA M that recognizes the copy language $\{ww|w \in \{a,b\}^*\}$ with an empty stack.

Solution:

$M = \langle \{q_0, q_1, q_2, q_3\}, \{a, b\}, \{\#, A, B\}, \delta, q_0, \{q_3\}, \# \rangle$ mit

$\delta(q_0, \epsilon, \#) = \{(q_3, \epsilon, \epsilon, \epsilon), (q_1, \epsilon, \#, \epsilon)\}$
$\delta(q_1, a, X) = \{(q_1, \epsilon, XA, \epsilon)\}$ for all $X \in \{A, B, \#\}$
$\delta(q_1, b, X) = \{(q_1, \epsilon, XB, \epsilon)\}$ for all $X \in \{A, B, \#\}$
$\delta(q_1, \epsilon, X) = \{(q_2, \epsilon, X, \epsilon)\}$ for all $X \in \{A, B, \#\}$
$\delta(q_2, \epsilon, A) = \{(q_2, \ddagger A, \epsilon, \epsilon)\}$
$\delta(q_2, \epsilon, B) = \{(q_2, \ddagger B, \epsilon, \epsilon)\}$
$\delta(q_2, \epsilon, \#) = \{(q_3, \epsilon, \epsilon, \epsilon)\}$
$\delta(q_3, a, A) = \{(q_3, \epsilon, \epsilon, \epsilon)\}$
$\delta(q_3, b, B) = \{(q_3, \epsilon, \epsilon, \epsilon)\}$

Question 2 (EPDA)

Consider the following EPDA M:

$M = \langle \{q_0, q_1, q_2\}, \{a, b, c, d\}, \{\#, B, C, D\}, \delta, q_0, \{q_2\}, \# \rangle$ *mit*

$\delta(q_0, a, \#) = \{(q_0, \epsilon, B, \epsilon)\}$
$\delta(q_0, a, B) = \{(q_0, \epsilon, BB, \epsilon)\}$
$\delta(q_0, b, B) = \{(q_1, \ddagger C, \epsilon, \epsilon)\}$
$\delta(q_1, b, B) = \{(q_1, \ddagger C, \epsilon, \epsilon)\}$
$\delta(q_1, c, C) = \{(q_2, \epsilon, \epsilon, \ddagger D)\}$
$\delta(q_2, d, D) = \{(q_2, \epsilon, \epsilon, \epsilon)\}$
$\delta(q_2, c, C) = \{(q_2, \epsilon, \epsilon, \ddagger D)\}$

1. *Which language is the language $N(M)$?*

2. *Give the trace, i.e., the sequence of configurations (of tuples of state, stack, already processed input, remaining input) that one obtains for the input word $w = aabbcdcd$.*

Solution:

1. $L_3 = \{a^n b^n (cd)^n | n \geq 1\}$

2. $(q_0, \ddagger\#, \epsilon, aabbcdcd)$
   $\vdash (q_0, \ddagger B, a, abbcdcd)$
   $\vdash (q_0, \ddagger BB, aa, bbcdcd)$
   $\vdash (q_1, \ddagger C \ddagger B, aab, bcdcd)$
   $\vdash (q_1, \ddagger C \ddagger C, aabb, cdcd)$
   $\vdash (q_2, \ddagger C \ddagger D, aabbc, dcd)$
   $\vdash (q_2, \ddagger C, aabbcd, cd)$
   $\vdash (q_2, \ddagger D, aabbcdc, d)$
   $\vdash (q_2, \epsilon, aabbcdcd, \epsilon)$

Question 3 (TA)

Let $M = \langle N, T, S, F, \kappa, \mathcal{K}, \delta, \mathcal{U}, \Theta \rangle$ be a TA, with $N = \{S, S, SA, SB, A, B, ret\}$, $T = \{a, b\}$, $K = N$ and κ the identity, $\sigma(S) = \sigma(A) = \sigma(SA) = \sigma(B) = \sigma(SB) = 1$, $\sigma(ret) = \perp$ and the following transitions:

$S \rightarrow [S]S'$,

$S' \xrightarrow{a} A_2$, $\quad S' \xrightarrow{a} S_A$, $\qquad S_A \rightarrow [S_A]S'$,

$S' \xrightarrow{b} B_2$, $\quad S' \xrightarrow{b} S_B$, $\qquad S_B \rightarrow [S_B]S'$,

$A_2 \xrightarrow{a} ret$, $\quad [S_A]ret \rightarrow A_2$,

$B_2 \xrightarrow{b} ret$, $\quad [S_B]ret \rightarrow B_2$

1. Which string language is accepted by M?

2. Give the thread sets (only successful items) that are generated for the word abba.

Solution:

1. The language is $L = \{ww^R \mid w \in \{a, b\}^+\}$.

2.

thread set	rem. input	operation
$\varepsilon : \boldsymbol{S}$	abba	
$\varepsilon : S, \boldsymbol{1 : S'}$	abba	$S \rightarrow [S]S'$
$\varepsilon : S, \boldsymbol{1 : S_A}$	bba	$S' \xrightarrow{a} S_A$
$\varepsilon : S, 1 : S_A, \boldsymbol{11 : S'}$	bba	$S_A \rightarrow [S_A]S$
$\varepsilon : S, 1 : S_A, \boldsymbol{11 : B_2}$	ba	$S' \xrightarrow{b} B_2$
$\varepsilon : S, 1 : S_A, \boldsymbol{11 : ret}$	a	$B_2 \xrightarrow{b} ret$
$\varepsilon : S, \boldsymbol{1 : A_2}$	a	$[S_A]ret \rightarrow A_2$
$\varepsilon : S, \boldsymbol{1 : ret}$	ϵ	$A_2 \xrightarrow{a} ret$