AMERICAN INTERNATIONAL UNIVERSITY-BANGLADESH

Faculty of Science and Technology

AIUB

DEPARTMENT OF COMPUTER SCIENCE

CSC3113: THEORY OF COMPUTATION

Final Assignment

0 Use ONLY your student ID and do the following steps to answer this question. 2

I. Take your student ID and get the middle (5 digits) part within the hyphens. [example: 18-**49057**-3 → **49057**].

II. Now, divide each 5 digits of this middle part by **3** individually and get the **5** *REMAINDER*s from left to right. [example: **49057** → **4**%3, **9**%3, **0**%3, **5**%3, **7**%3 → **1, 0, 0, 2, 1**]

III. Replace each **0** with **a**, **1** with **b**, **2** with **c**. [example: **1, 0, 0, 2, 1** → **b, a, a, c, b**]

IV. Count the total number of **a**, **b**, and **c**. [example: **b, a, a, c, b** → 2 **a**, 2 **b**, and 1 **c**]

V. Now organize the symbols **a**, **b**, and **c** as string $\mathbf{a}^i\mathbf{b}^j\mathbf{c}^k$, where ***i, j, k*** is the total number of **a**, **b**, and **c** from step iv. [example: 2 **a**, 2 **b**, and 1 **c** → $\mathbf{a}^2\mathbf{b}^2\mathbf{c}$]

VI. Write this string from your ID which will be used for following questions.

1 Let us consider a PDA with ***two Stacks*** where we can use two stacks instead of one simultaneously. The formal definition would be –

PDA $\mathbf{P} = (\mathbf{Q}, \Sigma, \Gamma_2, \delta, \mathbf{q_0}, \mathbf{F})$ where

$\mathbf{Q}$ is the set of states,

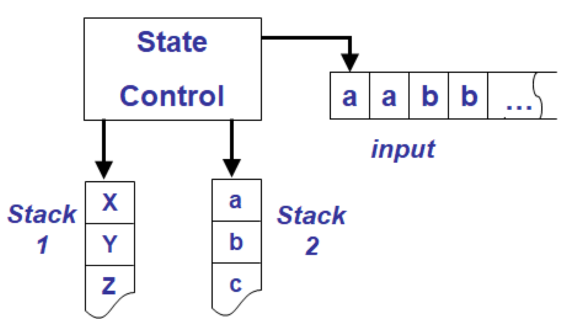
Σ is the set of alphabet, $\Sigma_\varepsilon = \Sigma \cup \{\varepsilon\}$

Γ_2 is the stack alphabet, where Γ_i for stack i and $\Gamma_{i\varepsilon} = \Gamma_i \cup \{\varepsilon\}$, for $i = 1, 2$.

$\delta : \mathbf{Q} \times \Sigma_\varepsilon \times \Gamma_{1\varepsilon} \times \Gamma_{2\varepsilon} \to \mathbf{P}(\mathbf{Q} \times \Gamma_{1\varepsilon} \times \Gamma_{2\varepsilon})$ is the transition function

$\mathbf{q_0} \in \mathbf{Q}$ is the start state, and

$\mathbf{F} \subseteq \mathbf{Q}$ is the set of accept states



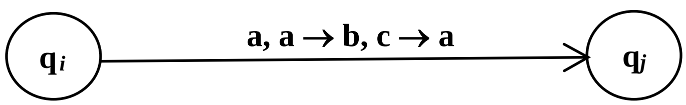
Let us consider the following transition function –

δ ($\mathbf{q}_i$, **a**, **a**, **c**) = {$\mathbf{q}_j$, **b**, **a**)

This interprets –

- Current State: $\mathbf{q}_i$
- Current input symbol; **a**
- Next State: $\mathbf{q}_j$, only if stack 1 has symbol **a** and stack 2 has symbol **c** on top
  NOTES:
    [for δ ($\mathbf{q}_i$, **a**, **ε**, **c**), only if stack 2 has symbol **c** (Stack 2 top symbol not considered)]
    [for δ ($\mathbf{q}_i$, **a**, **a**, **ε**), only if stack 1 has symbol **a** (Stack 1 top symbol not considered)]
    [for δ ($\mathbf{q}_i$, **a**, **ε**, **ε**), none of the stacks top symbols are considered]
- stack 1: *pop* symbol **a**; *push* symbol **b**
- stack 2: *pop* symbol **c**; *push* symbol **a**

The state diagram for this would be as follows –



Where, the label has 3 segments separated by coma –

Segment 1: input symbol (here **a**) [if **ε** then no input is SCANNED, if ∅ then input ENDED]

Segment 2: Stack 1 *pop* → *push* (here **a** → **b**) [if *pop* = **ε** then NO pop, if *push* = **ε** then NO push]

Segment 3: Stack 2 *pop* → *push* (here **c** → **a**) [if *pop* = **ε** then NO pop, if *push* = **ε** then NO push]

Now, we have already designed a ***nondeterministic*** PDA for the following language in our class lecture (Lecture-10, Slide-12) –

$\mathbf{L = \{a^i b^j c^k \mid i,\ j,\ k \geq 0 \text{ and } i = j \text{ or } i = k\}}$

Design a ***deterministic*** PDA for this language **L** using **2-Stacks** as explained above.

(i) Explain the design paradigm (the process/steps using 2-stacks for the input) 4

(ii) Draw the State diagram for language **L** according to the design in (i). 7

(iii) Use the string from question 0 as input and Show the Stack Simulation. 4

2 For the same language $\mathbf{L = \{a^i b^j c^k \mid i,\ j,\ k \geq 0 \text{ and } i = j \text{ or } i = k\}}$, Design a Turing machine **M1**.

(i) Give the Implementation level description for **M1**. 7

(ii) Draw the state diagram for **M1**. 6

(iii) Use the string from question 0 as input and Show the Configuration Simulation. 5

3 Prove that, **A$_{TM}$ = {⟨M, w⟩| M is a TM and M accepts w}**, is undecidable using the diagonalization method. 15

NOTE:

You will have a viva on this assignment. Please take your time to complete the assignment thoroughly.
If you require any help, you may knock me at TEAMS, anytime.

YOU MUST SUBMIT THE ASSIGNMENT BY SEPTEMBER 12, 2020