Reactive Systems Verification
alias
Model Checking I

Assignment 3

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Instructions

Reply to all questions justifying your answers as clearly as possible. Send an electronic (also handwritten and scanned, but readable) version to

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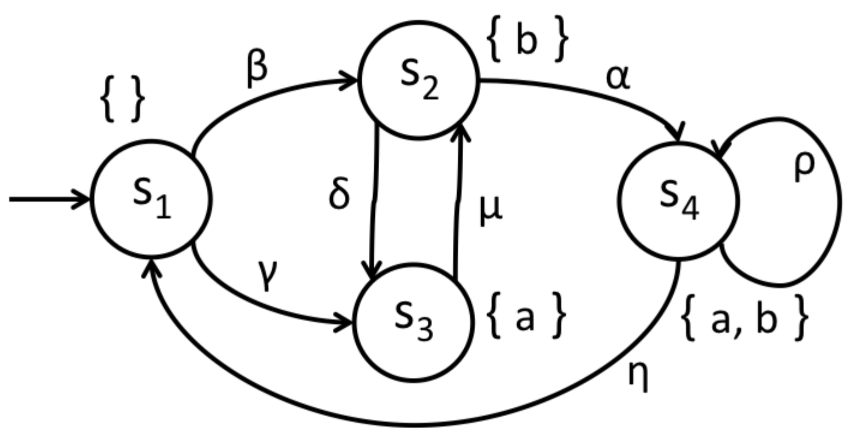
by

24th June 2016 23.59

Exercise 1

Consider the following LTS where the set of atomic propositions is $\mathrm{AP} = \{a, b\}$.



1. Specify formally the set of all the traces on the alphabet 2^{AP}.
2. For each of the following fairness conditions:
   (a) $\mathcal{F}_1 = \{\{\}, \{\}, \{\eta\}\}$
   (b) $\mathcal{F}_2 = \{\{\}, \{\eta\}, \{\}\}$
   (c) $\mathcal{F}_3 = \{\{\eta\}, \{\}, \{\}\}$

(d) $\mathcal{F}_4 = \{\{\}, \{\}, \{\alpha\}\}$

(e) $\mathcal{F}_5 = \{\{\}, \{\alpha\}, \{\}\}$

(f) $\mathcal{F}_6 = \{\{\alpha\}, \{\}, \{\}\}$

(g) $\mathcal{F}_7 = \{\{\}, \{\delta\}, \{\eta\}\}$

(h) $\mathcal{F}_8 = \{\{\delta\}, \{\}, \{\eta\}\}$

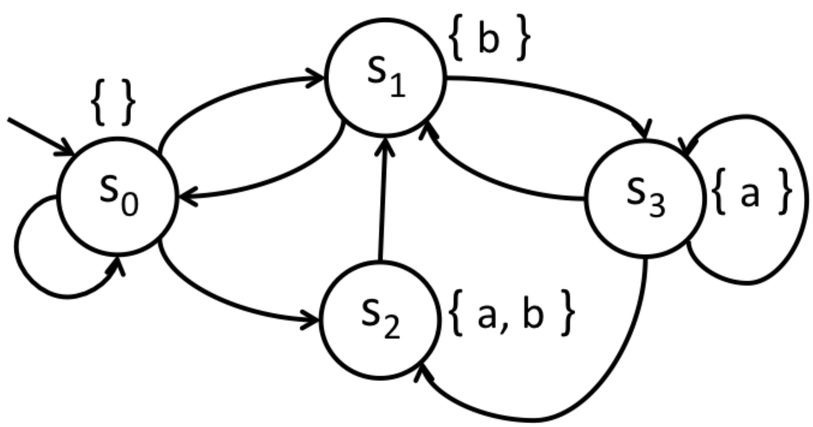
(i) $\mathcal{F}_9 = \{\{\eta\}, \{\delta\}, \{\}\}$

(j) $\mathcal{F}_{10} = \{\{\delta, \eta\}, \{\}, \{\}\}$

determine if the fairness condition is realizable and, if yes, specify the corresponding set of *fair* traces.

Exercise 2

Consider the following transition system TS.

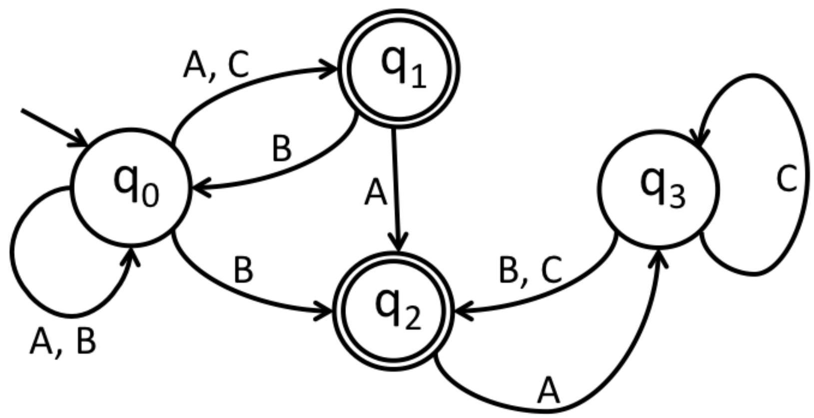


Consider a set of atomic propositions $\mathrm{AP} = \{a, b\}$ and the following safety property P_{safe}: "whenever a holds then after one step b holds and a does not hold".

1. Draw a NFA A that accepts the set of *minimal bad prefixes* for P_{safe}.
2. Decide if $\mathrm{TS} \models P_{\mathrm{safe}}$ by using the product $\mathrm{TS} \otimes A$. In case $\mathrm{TS} \not\models P_{\mathrm{safe}}$, provide a counterexample.

Exercise 3

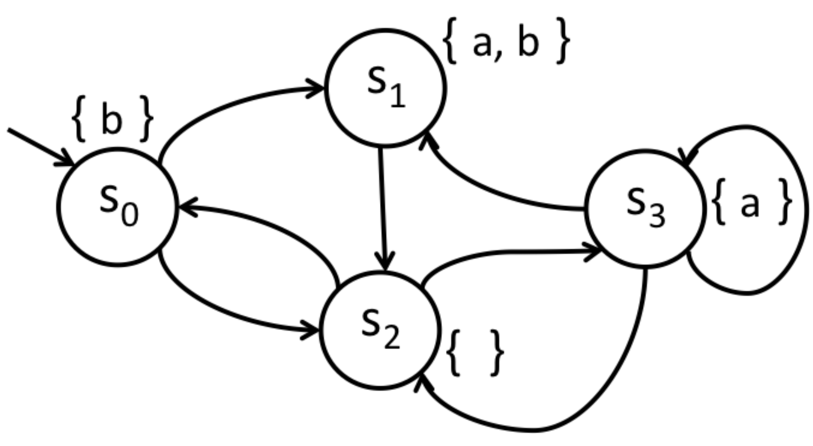
1. Write an ω-regular expression that denotes exactly the ω-regular language accepted by the following non-deterministic Büchi automaton:



2. Draw two non-deterministic Büchi automata A_1 and A_2 such $\mathcal{L}(A_1)$ is the ω-regular language denoted by the ω-regular expression $(A{+}B)^*(CB{+}CA)(A{+}C)^\omega$ and $\mathcal{L}(A_2)$ is the ω-regular language denoted by the ω-regular expression $(AB)^+C(A+B)^*A^\omega$. Then, apply the product construction (using GNBA) to obtain an NBA A with $\mathcal{L}(A) = \mathcal{L}(A_1) \cap \mathcal{L}(A_2)$.

Exercise 4

Consider a set of atomic propositions $\text{AP} = \{a, b\}$ and the following transition system TS.



Consider the following liveness property P_{live}: "whenever a holds then b will eventually hold".

1. Draw a NBA A that accepts the set of *bad behaviours* for P_{live}.

2. Decide if $\text{TS} \models P_{\text{live}}$ by using the product $\text{TS} \otimes A$. In case $\text{TS} \not\models P_{\text{live}}$, provide a counterexample.