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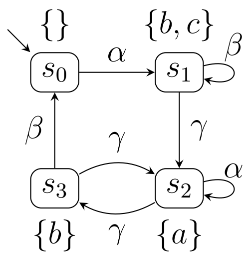
16:15 via the post boxes
Discussion: December 21st, 2016

Tutorial for Cyber-Physical Systems - Discrete Models
Exercise Sheet 9

Exercise 1: Checking regular safety properties 3 Points

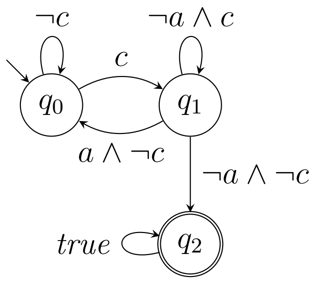
Consider the following transition system TS over the atomic propositions $AP = \{a, b, c\}$.



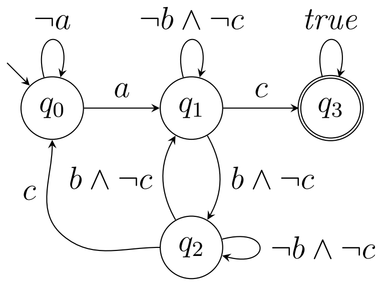
In the lecture we have seen an algorithm for checking regular safety properties. The safety property E was given as an NFA $\mathcal{A}$ that was accepting the bad prefixes of E.
The algorithm first computes the product $TS \otimes \mathcal{A}$ and then checks whether the invariant $\neg F$ holds, where F is the set of final states of $\mathcal{A}$.
If the invariant holds for $TS \otimes \mathcal{A}$, then the property E holds for TS. Otherwise, the property E does not hold and the algorithm returns a sequence of states of TS as an error indication.

Apply the algorithm for the properties that are given by the following NFA.

(a) $\mathcal{A}_1$:

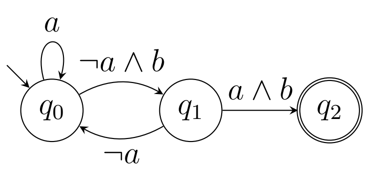


(b) $\mathcal{A}_2$:



Exercise 2: Non-blocking symbolic NFA 1 Point

Consider the following DFA (i.e., deterministic NFA) $\mathcal{A}$ over the alphabet $\Sigma = 2^{AP}$, where $AP = \{a, b, c\}$.

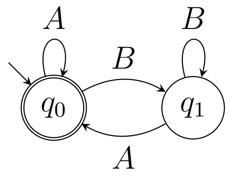


Give a non-blocking DFA $\mathcal{A}'$ such that both automata accept the same language (i.e., $\mathcal{L}(\mathcal{A}') = \mathcal{L}(\mathcal{A})$).

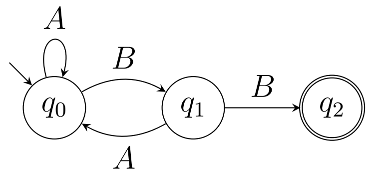
Exercise 3: Büchi automata I 2 Points

Describe the ω-languages of the following Büchi automata over the alphabet $\Sigma = \{A, B\}$. You may use ω-regular expressions or natural language.

(a)



(b)



Exercise 4: Büchi automata II 1 Point

Construct a Büchi automaton over the alphabet $\Sigma = \{A, B\}$ whose language consists of all ω-words that contain only finitely many A.

Exercise 5: Minimal bad prefixes 1 Point

Provide an example for a regular safety property P_{safe} over some set of atomic propositions AP and an NFA $\mathcal{A}$ for its *minimal* bad prefixes such that

$$L_\omega(\mathcal{A}) \neq \left(2^{AP}\right)^\omega \setminus P_{\text{safe}}$$

when $\mathcal{A}$ is viewed as a Büchi automaton.

Exercise 6*: Inclusion** 1 Point

In the algorithm for checking regular safety properties we exploited the following equivalence for languages $L_1, L_2 \subseteq \Sigma^*$ for some alphabet Σ.

$$L_1 \subseteq L_2 \text{ iff } L_1 \cap \overline{L_2} = \emptyset$$

Here, we use $\overline{L_2}$ to denote the complement $\Sigma^* \setminus L_2$.

Show that this equivalence holds.