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LEHRSTUHL FÜR INFORMATIK II
RWTH Aachen · D-52056 Aachen
http://www-i2.informatik.rwth-aachen.de/

Prof. Dr. Ir. J.-P. Katoen
M. Neuhäußer

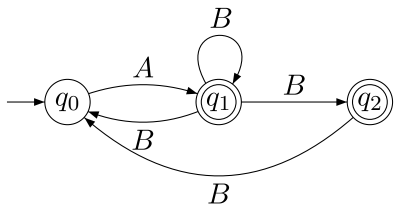
Introduction to Model Checking
Summer term 2007

– Series 6 –

Hand in on May 18 before the exercise class.

Exercise 1 **(2 points)**

Consider the GNBA outlined on the right with acceptance sets $F_1 = \{q_1\}$ and $F_2 = \{q_2\}$. Construct an equivalent NBA using the transformation introduced in the lecture.



Exercise 2 **(3 points)**

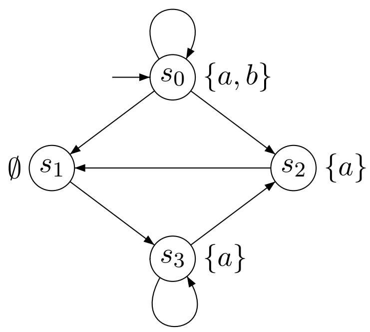
Provide NBA $\mathcal{A}_1$ and $\mathcal{A}_2$ for the languages given by the expressions $(AC + B)^* B^\omega$ and $(B^* AC)^\omega$ and apply the product construction (using GNBA) to obtain an NBA $\mathcal{A}$ with $\mathcal{L}_\omega(\mathcal{A}) = \mathcal{L}_\omega(\mathcal{A}_1) \cap \mathcal{L}_\omega(\mathcal{A}_2)$. Justify, why $\mathcal{L}_\omega(\mathcal{G}) = \emptyset$ where $\mathcal{G}$ denotes the GNBA accepting the intersection.

Exercise 3 **$(1 + 2 + 2 + 1$ points)**

We consider model checking of ω–regular LT properties which are defined by LTL formulas. Therefore let φ_1 and φ_2 be as follows:

$$\varphi_1 = \Box\Diamond a \rightarrow \Box\Diamond b \qquad \text{and}$$
$$\varphi_2 = \Diamond(a \wedge \bigcirc a).$$

Further, our model is represented by the transition system TS over $AP = \{a, b\}$ which is given as outlined on the right. We check whether $TS \models \varphi_i$ for $i = 1, 2$ using the nested depth–first search algorithm from the lecture. Therefore proceed as follows:



a) Derive an NBA $\mathcal{A}_i$ for the LTL formula $\neg\varphi_i$ (for $i = 1, 2$).
More precisely, for $\mathcal{A}_i$ it must hold $\mathcal{L}_\omega(\mathcal{A}_i) = \mathcal{L}_\omega(\neg\varphi_i)$.
Hint: Four, respectively three states suffice.

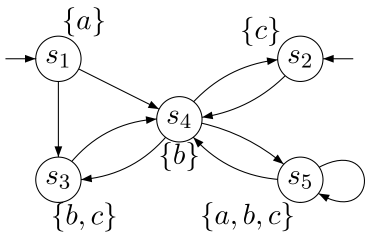
b) Outline the reachable fragment of the product transition system $TS \otimes \mathcal{A}_i$.

c) Sketch the main steps of the nested depth–first search algorithm for the persistency check on $TS \otimes \mathcal{A}_i$.

d) Provide the counterexample computed by the algorithm if $TS \not\models \varphi_i$.

Exercise 4 **(3 points)**

Consider the transition system TS over the set of atomic propositions $AP = \{a, b, c\}$:



Decide for each of the LTL formulas φ_i below, whether $TS \models \varphi_i$ holds. Justify your answers! If $TS \not\models \varphi_i$, provide a path $\pi \in Paths(TS)$ such that $\pi \not\models \varphi_i$.

$$\varphi_1 = \Diamond\Box c \qquad \varphi_4 = \Box a$$
$$\varphi_2 = \Box\Diamond c \qquad \varphi_5 = a \mathsf{U} \Box(b \vee c)$$
$$\varphi_3 = \bigcirc\neg c \rightarrow \bigcirc\bigcirc c \qquad \varphi_6 = (\bigcirc\bigcirc\, b) \mathsf{U} (b \vee c)$$