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LEHRSTUHL FÜR INFORMATIK 2
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Introduction to Model Checking
Winter term 2011/2012

– Series 7 –

Hand in on December 7th before the exercise class.

Exercise 1 (3 points)

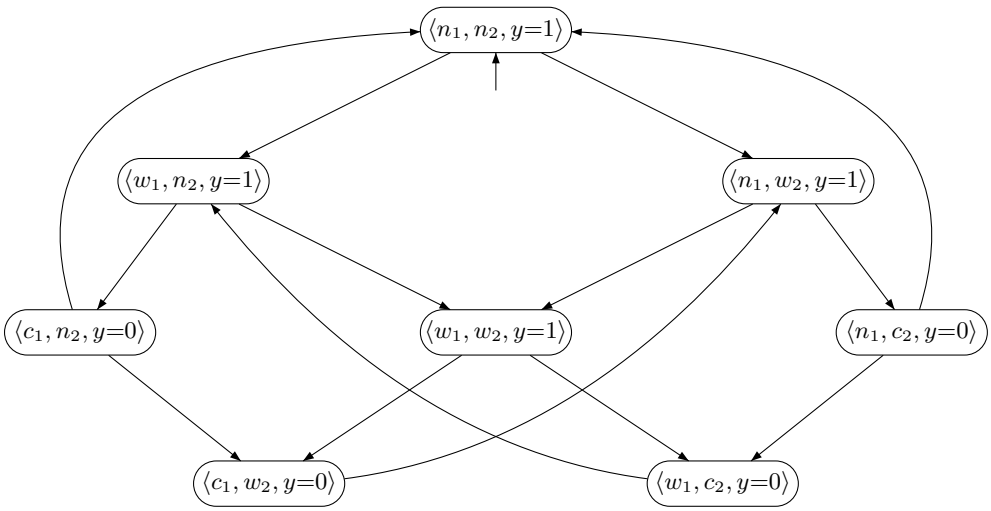


Figure 1: Mutual exclusion with semaphore (transition system representation).

Consider the transition system T_{Sem} for mutual exclusion with a semaphore. Let P_{live} be the following ω-regular property over $AP = \{ wait_1, crit_1 \}$:

> "whenever process 1 is in its waiting location then it will eventually enter its critical section"

a) Introduce the necessary labels in T_{Sem}.

b) Depict an NBA $\bar{\mathcal{A}}$ for the complement property $\bar{P}_{live} = \left(2^{AP}\right)^{\omega} \setminus P_{live}$.

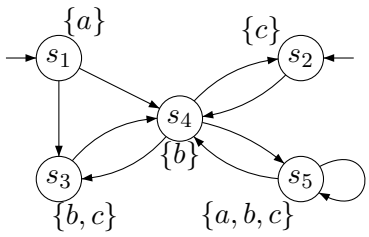
c) Check whether $\mathrm{T}_{Sem} \models P_{live}$. Therefore:

   (i) Depict the reachable fragment of the product $\mathrm{T}_{Sem} \otimes \bar{\mathcal{A}}$

   (ii) Sketch the main steps of the nested depth-first search applied to $\mathrm{T}_{Sem} \otimes \bar{\mathcal{A}}$ for the persistence property "eventually forever $\neg F$" where F is the acceptance set of $\bar{\mathcal{A}}$. In case the property is refuted, which counterexample is generated?

Exercise 2 ($6 \times 0.5 = 3$ 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 $\pi \not\models \varphi_i$.

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

Exercise 3 ($4 \times 1 = 4$ points)

Prove or disprove the following equivalences of LTL–formulas:

$$\Box\varphi \rightarrow \Diamond\psi \equiv \varphi \mathsf{U} (\psi \vee \neg\varphi) \qquad \Diamond\Box\varphi \rightarrow \Box\Diamond\psi \equiv \Box(\varphi \mathsf{U} (\psi \vee \neg\varphi))$$
$$\Box\Diamond\varphi \rightarrow \Box\Diamond\psi \equiv \Box(\varphi \rightarrow \Diamond\psi) \qquad \Diamond\,(\varphi \mathsf{U} \psi) \equiv \Diamond\psi$$