RHEINISCH-WESTFÄLISCHE TECHNISCHE HOCHSCHULE AACHEN

LEHRSTUHL FÜR INFORMATIK 2
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Advanced Model Checking
Winter term 2010/2011

– Series 7 –

Hand in on December 15'th before the exercise class.

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

Consider the following definition:

Definition 1 *Let $TS_i = (S_i, Act_i, \rightarrow_i, I_i, AP, L_i)$ be transition systems over AP. A* normed simulation *for (TS_1, TS_2) is a triple $(\mathcal{R}, \nu_1, \nu_2)$ consisting of a binary relation $\mathcal{R} \in S_1 \times S_2$ such that:*

$$\forall s_1 \in I_1 . \exists s_2 \in I_2 . (s_1, s_2) \in \mathcal{R}$$

and functions $\nu_1, \nu_2 : S_1 \times S_2 \rightarrow \mathbf{N}$ such that for all $(s_1, s_2) \in \mathcal{R}$:

(I) $L_1(s_1) = L_2(s_2)$

(II) For all $s_1' \in Post(s_1)$, at least one of the following three conditions holds:

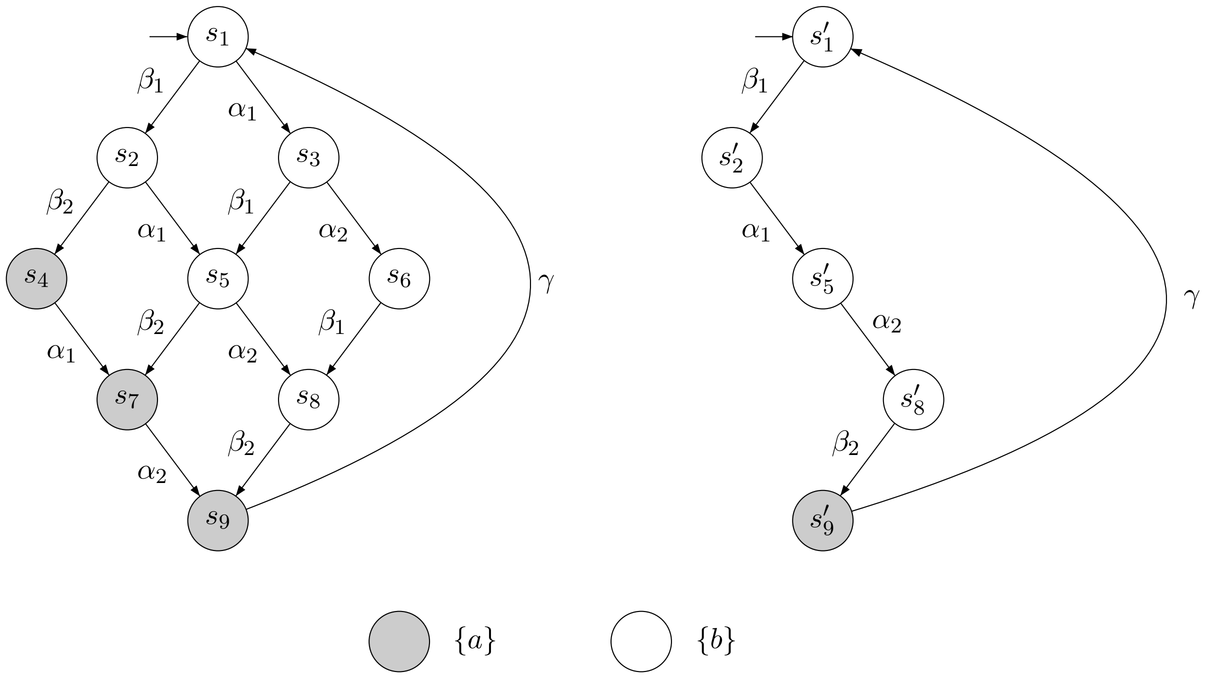
- *1)* $\exists s_2' \in Post(s_2).(s_1', s_2') \in \mathcal{R}$
- *2)* $(s_1', s_2) \in \mathcal{R}$ *and* $\nu_1(s_1', s_2) < \nu_1(s_1, s_2)$
- *3)* $\exists s_2' \in Post(s_2).(s_1, s_2') \in \mathcal{R}$ *and* $\nu_2(s_1, s_2') < \nu_2(s_1, s_2)$

A normed bisimulation *for (TS_1, TS_2) is a normed simulation $(\mathcal{R}, \nu_1, \nu_2)$ for (TS_1, TS_2) such that $(\mathcal{R}^{-1}, \nu_1^-, \nu_2^-)$ is a normed simulation for (TS_2, TS_1). Here ν_i^- denotes the function $S_2 \times S_1 \rightarrow \mathbf{N}$ that results from ν_i by swapping the arguments, i.e. $\nu_i^-(u, v) = \nu_i(v, u)$ for all $u \in S_2$ and $v \in S_1$.*

TS_1 and TS_2 are normed bisimilar*, denoted $TS_1 \approx^n TS_2$, if there exists a normed bisimulation for (TS_1, TS_2).*

Questions:

For two transition systems TS (left) and $\widehat{TS}$ (right) show that:



(a) The ample sets *ample*(.) which reduce TS to $\widehat{TS}$ satisfy conditions (A1)-(A5).

(b) Provide a normed bisimulation for $(TS, \widehat{TS})$.

Exercise 2 **(4 points)**

For the given function:

$$F(x_0, \ldots, x_{n-1}, a_0, \ldots, a_{k-1}) = x_{|a|}$$

where $n = 2^k$, $\forall i \in 0 \ldots n-1 \; : \; x_i = 0 \vee x_i = 1$, $\forall j \in 0 \ldots k-1 \; : \; a_j = 0 \vee a_j = 1$ and $|a| = \sum_{j=0}^{k-1} a_j 2^j$, provide two ROBDDs, considering the following two variable orderings:

$$a_0, \ldots, a_{k-1}, x_0, \ldots, x_{n-1}$$

and

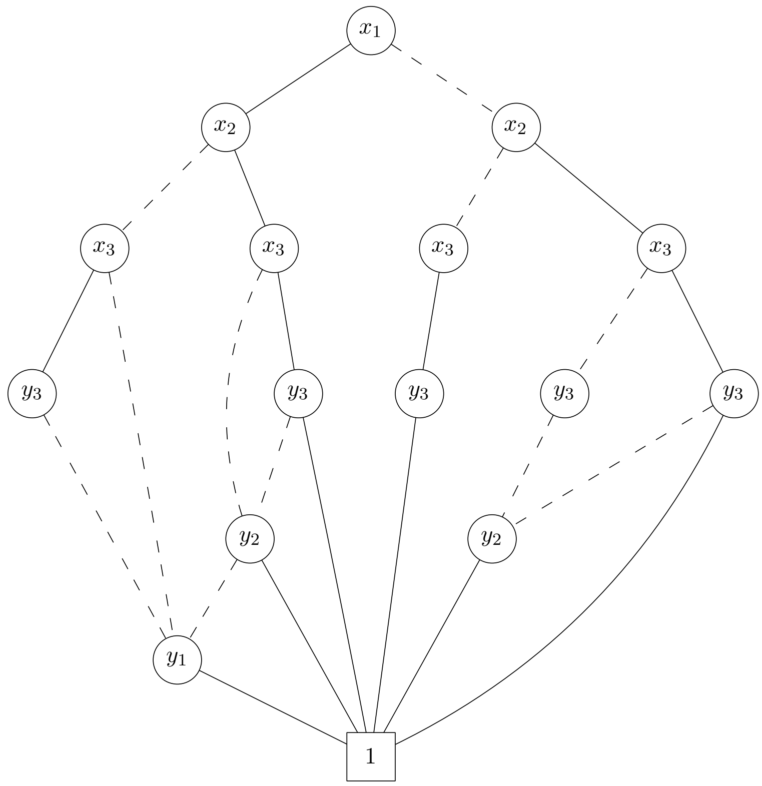
$$a_0, x_0, \ldots, a_{k-1}, x_{k-1}, x_k, \ldots, x_{n-1}$$

with $k = 3$.

Exercise 3 **(3 points)**

Given an ROBDD as follows, determine the boolean function $f(x_1, x_2, x_3, y_1, y_2, y_3)$ it represents.

(Hint: first to find a better variable ordering)



x_1
x_2
x_2
x_3
x_3
x_3
x_3
y_3
y_3
y_3
y_3
y_3
y_2
y_2
y_1
1