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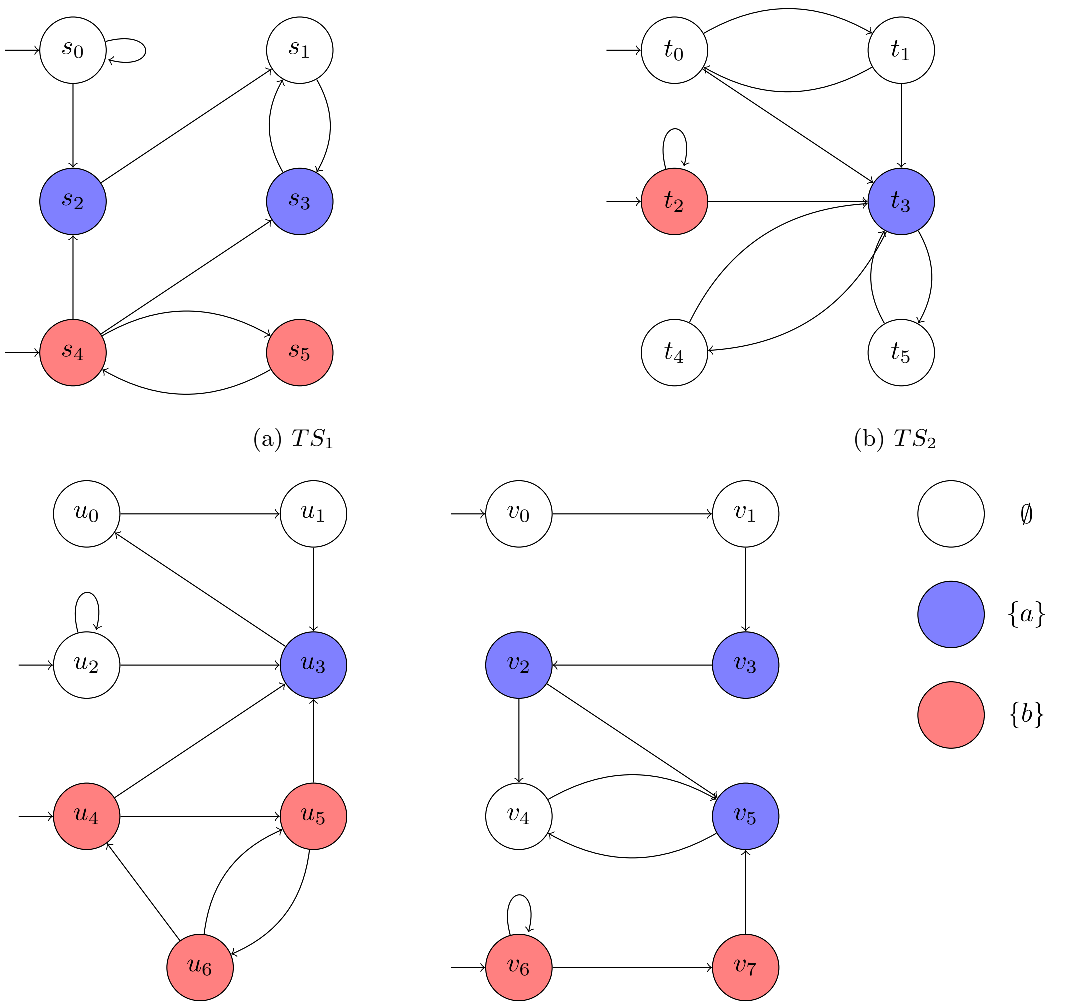
Model Checking (Winter Term 2019/2020)

— Exercise Sheet 8 (due 10 January) —

We wish you happy holidays, and all the best for 2020.

Exercise 1

Consider the transition systems from Figure 8.1.



(a) TS_1 (b) TS_2 (c) TS_3 (d) TS_4 (e) Legend

Figure 8.1: Transition systems

For each $i, j \in \{1 \dots 4\} \times \{1 \dots 4\}$, $i \neq j$ determine whether

(a) $TS_i \sim TS_j$

(b) $TS_i \approx TS_j$

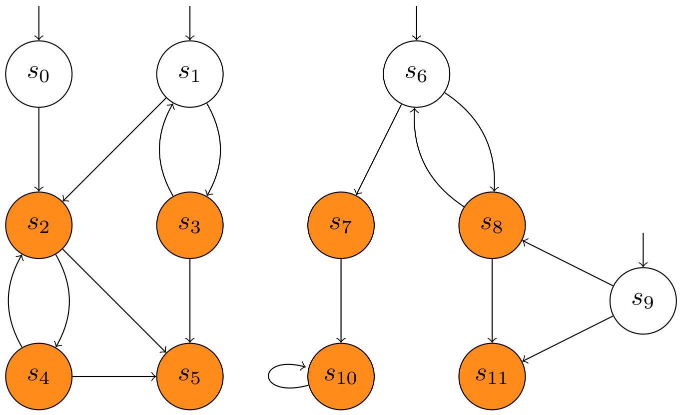
(c) $TS_i \approx^{div} TS_j$

(d) $TS_i \equiv_{\text{sttrace}} TS_j$

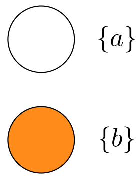
holds. Justify your answers.

Exercise 2

Consider the following transition system.



(a) TS



(b) Legend

Determine the bisimulation quotient system $TS/\sim$ by using the

(a) Kanellakis-Smolka algorithm

(b) Paige-Tarjan algorithm

Sketch the first four (outer) iteration steps respectively, if they exist.

Exercise 3

Let $TS_i = (S_i, Act_i, \rightarrow_i, I_i, AP, L_i), i = 1, 2$ be two finite transition systems. A stutter simulation for (TS_1, TS_2) is a relation $\mathcal{R} \subseteq S_1 \times S_2$ such that:

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

(B) For all $(s_1, s_2) \in \mathcal{R}$ the following conditions hold:

1. $L_1(s_1) = L_2(s_2)$.
2. If $s_1' \in Post(s_1)$ with $(s_1', s_2) \notin \mathcal{R}$, then there exists a finite path fragment $s_2\ u_1 \ldots u_n\ s_2'$ with $n \geq 0$ and $(s_1, u_i) \in \mathcal{R}$, $i = 1, \ldots, n$ and $(s_1', s_2') \in \mathcal{R}$.

TS_1 is said to be stutter simulated by TS_2, denoted $TS_1 \preceq_{st} TS_2$, iff there exists a stutter simulation for (TS_1, TS_2).

(a) Provide example transition systems TS_1, TS_2, such that $TS_1 \npreceq TS_2$ but $TS_1 \preceq_{st} TS_2$.

(b) Provide example transition systems TS_1, TS_2, such that $TS_1 \trianglelefteq TS_2$ but $TS_1 \npreceq_{st} TS_2$.

(c) Provide example transition systems TS_1, TS_2, such that $TS_1 \ntrianglelefteq TS_2$ but $TS_1 \preceq_{st} TS_2$.

(d) Provide example transition systems TS_1, TS_2, such that $TS_1 \not\approx TS_2$ but $TS_1 \preceq_{st} TS_2$ and $TS_2 \preceq_{st} TS_1$.