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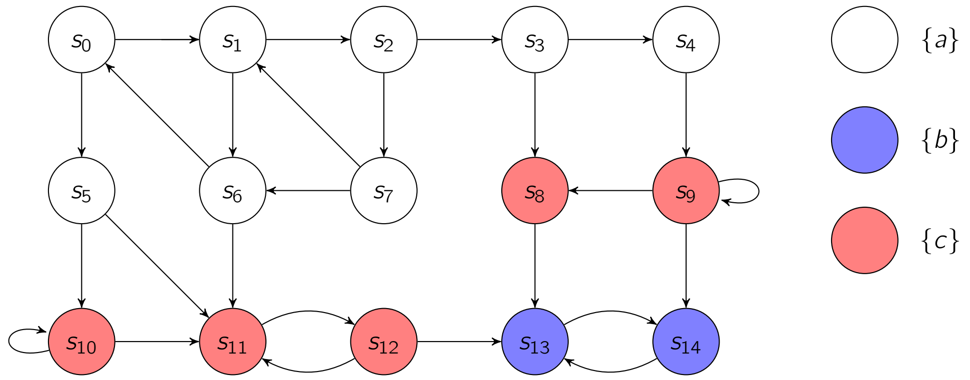
Exercise 1 (Stutter bisimulation quotient): (1+3+1 points)

Consider the following transition system TS.



(a) TS (b) Legend

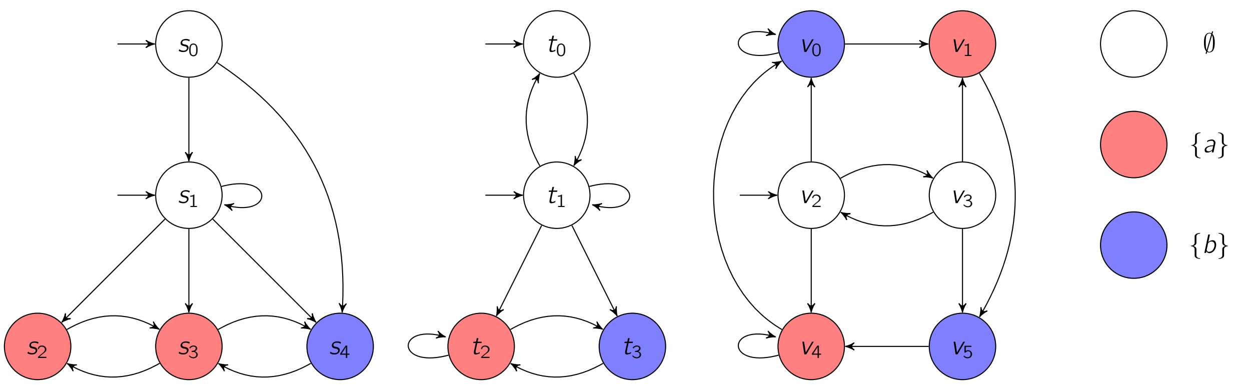
(a) Depict the divergence-sensitive expansion $\overline{TS}$.

(b) Determine the divergence-stutter-bisimulation quotient $\overline{TS}/\approx$. Apply the algorithm and give for each iteration the partition of the state space.

(c) Depict $TS/{\approx^{div}}$.

Exercise 2 (Simulation relation): (3 points)

Consider the given transition systems.



(c) TS_1 (d) TS_2 (e) TS_3 (f) Legend

For each $i, j \in \{1..3\} \times \{1..3\}, i \neq j$ determine whether $TS_i \preceq TS_j$. Justify your answer (e.g. by giving the simulation relation).

Exercise 3 (Stutter simulation): (0.5+0.5+0.5+0.5 points)

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 $TS_1 \not\preceq TS_2$ but $TS_1 \preceq_{st} TS_2$.

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

(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 $TS_2 \preceq_{st} TS_1$.