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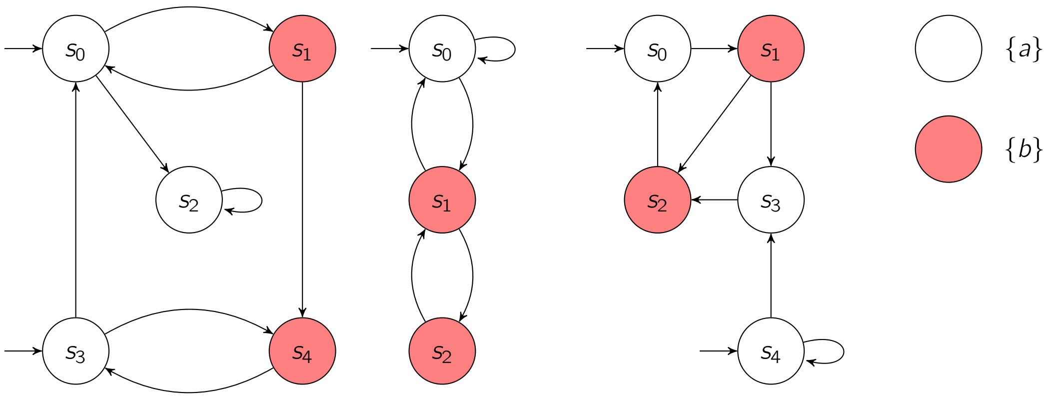
Exercise 1 (Stutter trace inclusion): (2 points)

Consider the following transition systems.

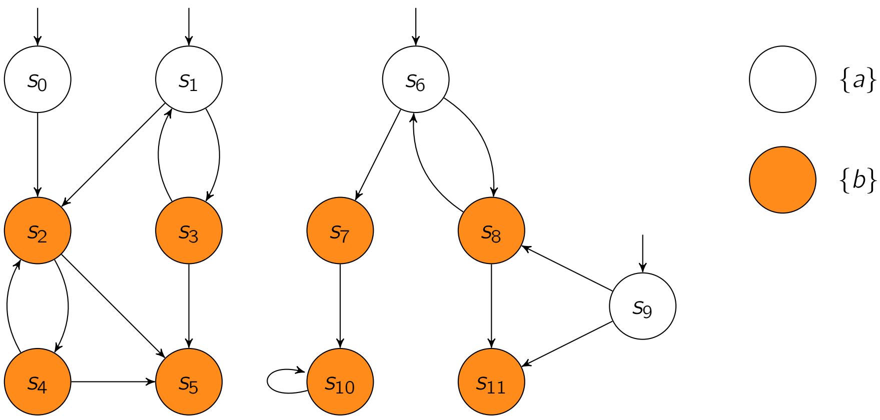


(a) TS_1 (b) TS_2 (c) TS_3 (d) Legend

For each $i, j \in \{1 \ldots 3\} \times \{1 \ldots 3\}$, $i \neq j$, determine whether $TS_i \trianglelefteq TS_j$ or $TS_i \ntrianglelefteq TS_j$. Justify your answer.

Exercise 2 (Bisimulation quotienting algorithms): (2+2 points)

Consider the following transition system.



(e) TS_1 (f) 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 (Stutter trace equivalence): (1+3 points)

(a) We consider *stutter-free* traces.

Definition 1: A trace σ is *stutter-free* if either

(i) $\sigma[i] \neq \sigma[i+1]$ for $i \geq 0$ or

(ii) there exists a $k \geq 0$ such that $\sigma[i] \neq \sigma[i+1]$ for $i < k$ and $\sigma[k] = \sigma[k+1] = \sigma[k+2] = \dots$

Show that there is exactly one stutter-free trace in each class of stutter-equivalent traces.

(a) Let ϕ be an LTL formula such that $Word(\phi)$ is stutter insensitive.

Show that ϕ is equivalent to some $\text{LTL}_{\setminus\bigcirc}$ formula ψ.