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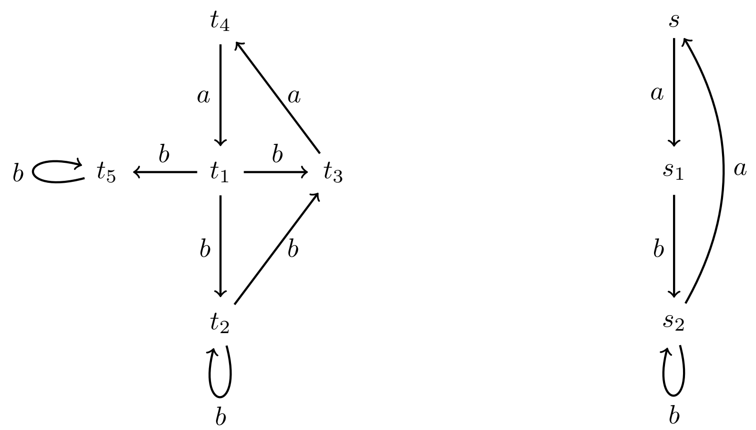
Concurrency Theory WS 2019/2020
— Exercise 8 —

Hand in until December 5th before the exercise class.

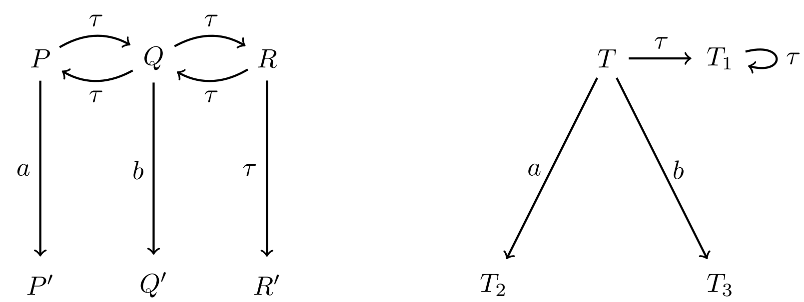
Exercise 1 **(30 Points)**

Decide whether $s \sim t_4$ holds in the LTS depicted below. For that, either give a universal winning strategy for the attacker or for the defender. In case $s \sim t_4$ holds, define a strong bisimulation $\mathcal{R}$ with $s \mathrel{\mathcal{R}} t_4$. In case $s \not\sim t_4$ holds, provide an HML formula distinguishing s and t_4.



Exercise 2 **(20 Points)**

Consider the following LTS:



Prove or disprove that P and T are weakly bisimilar.

Exercise 3 **(30 Points)**

Prove Milner's τ laws for weak bisimilarity, i.e., prove the following for all $P, Q \in \mathsf{Prc}$ and all $\alpha \in \mathsf{Act}$:

1. $\alpha.\tau.P \;\approx\; \alpha.P$.
2. $P + \tau.P \;\approx\; \tau.P$.
3. $\alpha.(P + \tau.Q) \;\approx\; \alpha.(P + \tau.Q) + \alpha.Q$.

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Exercise 4 (30 Points)

A binary relation $\mathcal{R}$ over the set of states of an LTS is a *branching bisimulation* if and only if it is symmetric and, whenever $P \mathrel{\mathcal{R}} Q$ holds, then for all $\alpha \in \mathit{Act}$ (including τ) it holds: if $P \xrightarrow{\alpha} P'$ then either $\alpha = \tau$ and $P' \mathrel{\mathcal{R}} Q$ or there is a $k \geq 0$ and a sequence of transitions

$$Q \;=\; Q_0 \xrightarrow{\tau} Q_1 \xrightarrow{\tau} \ldots \xrightarrow{\tau} Q_k \xrightarrow{\alpha} Q'$$

such that $P \mathrel{\mathcal{R}} Q_j$ holds for each $j \in \{1, \ldots, k\}$ and $P' \mathrel{\mathcal{R}} Q'$.

Two states P and Q are *branching bisimilar* if and only if there is a branching bisimulation $\mathcal{R}$ such that $P \mathrel{\mathcal{R}} Q$. The largest branching bisimulation $\approx_{\mathrm{BB}}$ is called *branching bisimilarity.*

1. Prove or disprove: If P and Q are branching bisimilar, then P and Q are weakly bisimilar.
2. Prove or disprove: If P and Q are branching bisimilar, then P and Q are strongly bisimilar.
3. Prove or disprove: If P and Q are weakly bisimilar, then P and Q are branching bisimilar.