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Tutorial for Cyber-Physical Systems - Discrete Models

Exercise Sheet 8

Exercise 1: Linear-Time Properties 7 Points

The goal of this exercise is to help you better understand the representation of properties as sets of traces, as well as the notion of satisfaction by a transition system.

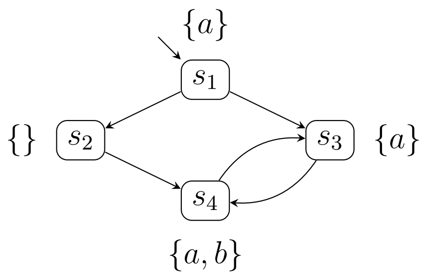
Assume $AP = \{a, b\}$. For each of the properties P_i, complete the following tasks:

(a) Formalize P as a set of traces using set comprehension.
For example: "always a" can be formalized as $\{A_0 A_1 A_2 \cdots \mid \forall i.\, a \in A_i\}$.

(b) Give an example of a trace that satisfies P.

(c) Give an example of a trace that does not satisfy P.

(d) State whether or not the transition system below satisfies P.



(P_1) Always (at any point of time) a or b holds.

(P_2) Always (at any point of time) a and b holds.

(P_3) Never b holds before a holds.

(P_4) Every time a holds there will be eventually a point of time where b holds.

(P_5) At exactly three points of time, a holds.

(P_6) If there are infinitely many points of time where a holds, then there are infinitely many points of time where b holds.

(P_7) There are only finitely many points of time where a holds.

Exercise 2: Arbiter with 3-way Synchronization 4 Points

The goal of this exercise is to gain an understanding how the different parallel composition operators behave.

In the lecture (November 25th, slide 27) we considered a system for mutual exclusion with an arbiter. The system was composed of two transition systems $\mathcal{T}_1$ and $\mathcal{T}_2$ as well a transition system *Arbiter*, and we considered the parallel composition $(\mathcal{T}_1 \mathbin{|||} \mathcal{T}_2) \parallel_{Syn} \mathit{Arbiter}$ where $Syn = \{\texttt{enter}, \texttt{release}\}$. In this exercise, we will consider alternative ways to compose these components.

(a) Draw the parallel composition $(\mathcal{T}_1 \parallel_{Syn} \mathcal{T}_2) \parallel_{Syn} \mathit{Arbiter}$, where Syn is as above. How many component systems can synchronize on a single transition (i.e., change their state together in one step) in this system? Does the system ensure mutual exclusion?

(b) Is the parallel composition $\mathcal{T}_1 \parallel \mathcal{T}_2 \parallel \mathit{Arbiter}$ allowed? Why/why not?

Exercise 3: Synchronization 2 Points

The goal of this exercise is to gain an understanding how the different parallel composition operators behave.

Given two transition systems $\mathcal{T} = (S, Act, \rightarrow, S_0, AP, L)$ and $\mathcal{T}' = (S', Act', \rightarrow', S_0', AP', L')$

(a) Give a set Syn such that $\mathcal{T} \parallel \mathcal{T}'$ and $\mathcal{T} \parallel_{Syn} \mathcal{T}'$ are always equivalent.

(b) Give a set Syn such that $\mathcal{T} \mathbin{|||} \mathcal{T}'$ and $\mathcal{T} \parallel_{Syn} \mathcal{T}'$ are always equivalent.