



Tutorials for Cyber-Physical Systems I - Model Checking Exercise sheet 3

Choose **one** of the following exercises:

Exercise 1: Trace Inclusion

Let $\mathcal{T} = (S, Act, \rightarrow, I, AP, L)$ be a transition system. \mathcal{T} is called *AP-deterministic* whenever the following conditions hold for all $A \subseteq AP$:

- (a) for all states $s \in S$ it holds that: $|\{s' \in Post(s) \mid L(s') = A\}| \leq 1$
- (b) $|\{s_0 \in I \mid L(s_0) = A\}| \leq 1$

Let \mathcal{T} and \mathcal{T}' be transition systems with the same set of atomic propositions AP and without terminal states. Prove the following relationship between trace-inclusion and finite-trace-inclusion:

- (a) If \mathcal{T}' is *AP-deterministic* then:

$$Traces_{fin}(\mathcal{T}) \subseteq Traces_{fin}(\mathcal{T}') \implies Traces(\mathcal{T}) \subseteq Traces(\mathcal{T}')$$

- (b) Give concrete examples of \mathcal{T} and \mathcal{T}' (without terminal states, but maybe infinitely large) where at least one of the transition systems is not *AP-deterministic*, but

$$Traces(\mathcal{T}) \not\subseteq Traces(\mathcal{T}') \text{ and } Traces_{fin}(\mathcal{T}) = Traces_{fin}(\mathcal{T}')$$

Exercise 2: LT properties

- (a) Assume $AP = \{a, b\}$. Give a mathematical definition for the following properties as a set of traces (as in the lecture). If “state” is mentioned in the property, we mean a state in an execution of the transition system, not an arbitrary (possibly unreachable) state of the transition system. For example, the three states in the fourth property may also be the same state visited three times.
- (i) Every state satisfies a or b .
 - (ii) There is no state satisfying b before the first occurrence of a .
 - (iii) Every a will be eventually followed by an b .
 - (iv) Exactly three states satisfy a .
 - (v) If there are infinitely many a there are infinitely many b .
 - (vi) There are only finitely many a .
- (b) Which of the properties are invariants, which are safety properties, and which are neither?

OPTIONAL: Give us your feedback.

Exercise 3: Lecture evaluation

We would like to make sure you are following the lecture and having fun at the same time.

- (a) What can we improve about the lecture?
- (b) Briefly name the main concepts that you have found interesting and what you have learned about them during the last lectures.