

Introduction to Model Checking (Summer Term 2018)

— Exercise Sheet 3 (due 14th May) —

General Remarks

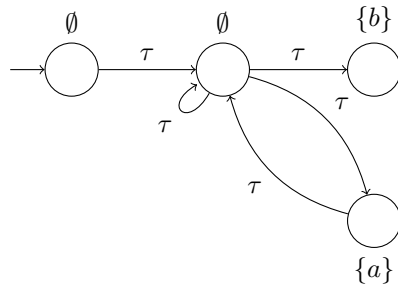
- The exercises are to be solved in groups of *three* students.
- You may hand in your solutions for the exercises just before the exercise class starts at 12:15 or by dropping them into the “Introduction to Model Checking” box at our chair *before 12:00*. Do *not* hand in your solutions via L2P or via e-mail.

Exercise 1

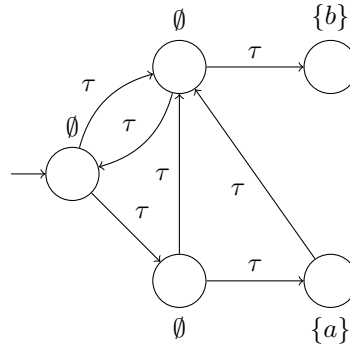
(1+1 Points)

Consider the following transition systems. Note that the transition systems might contain terminal states.

TS₁ :



TS₂ :



- Give the traces of TS₁, i.e., $Traces(TS_1)$.
- Are TS₁ and TS₂ trace equivalent?

Exercise 2★

(4+4 Points)

In the following we show that LT properties are not solely a theoretical concept but have a wide range of practical applications. As proof, we apply the concept of LT properties to movie/TV series quotes.

- We assume each following quote informally describes some property. Formulate these properties as LT properties over the given set AP of atomic propositions:
 - “**Winter is coming.**”
AP = {*winter*}.
winter will eventually be reached.
 - “**Everything is awesome.**”
AP = {*awesome*}.
awesome always holds.
 - “**I’ll be back.**”
AP = {*here*}.

I am currently *here* but at some point I will not be *here*. However, I will be *here* again at a later time.

- (iv) **“You either die a hero, or you live long enough to see yourself become the villain.”**
 $AP = \{live, hero\}$.
 In the beginning, you *live* and are a *hero*. You either cease to *live* and die, still being a *hero*, or you *live* but become the villain, i.e., you are not a *hero* anymore.
- (v) **“By night one way, by day another
 Thus shall be the norm
 Till you receive true love’s kiss
 then, take love’s true form.”**
 $AP = \{day, form_1, form_2, true_form, kiss\}$.
 You start by having $form_1$ at night, i.e., not *day*. You alternate between $form_1$ at night and $form_2$ by *day*. This alternation goes on till at some point you receive true love’s *kiss* and from there on have love’s *true_form*.
- (vi) **“A Lannister always pays his debts.”**
 $AP = \{in_debt\}$.
 Whenever a Lannister is *in_debt*, he will be *in_debt* as long as he has not payed back his debt. If he has payed back his debt, he is no longer *in_debt*. A Lannister can be *in_debt* arbitrarily (but finitely) many times.
- (vii) **“Anything is possible [if you just believe].”**
 $AP = \{ap_1, \dots, ap_n\}$.
 We do not consider the second part here and just concentrate on the fact, that everything is possible.
- (viii) **“It’s gonna be legen... wait for it... dary!”**
 $AP = \{legen, wait_for_it, dary\}$.
 In the beginning it is *legen*, then we have to *wait_for_it* for some time, and then it is *dary* at some point.

(b) Determine for all LT properties of (a) whether they are

- (i) safety properties *and/or*
- (ii) liveness properties.

Justify your answers.

Exercise 3

(3+3 Points)

(a) Let P and P' be liveness properties over AP . Prove or disprove the following claims:

- (i) $P \cup P'$ is a liveness property,
- (ii) $P \cap P'$ is a liveness property.

(b) Answer the same questions for P and P' being safety properties.

Hint: you can use the distributivity of union over closure for LT properties P, P' :

$$\text{closure}(P \cup P') = \text{closure}(P) \cup \text{closure}(P')$$

Exercise 4

(4 Points)

Let P be an LT property. Prove: $\text{pref}(\text{closure}(P)) = \text{pref}(P)$.