Master of Science in Computer Science - University of Camerino
Systems Verification Lab A. Y. 2018/2019
Written Test of 28th June 2019 (Appello IV)
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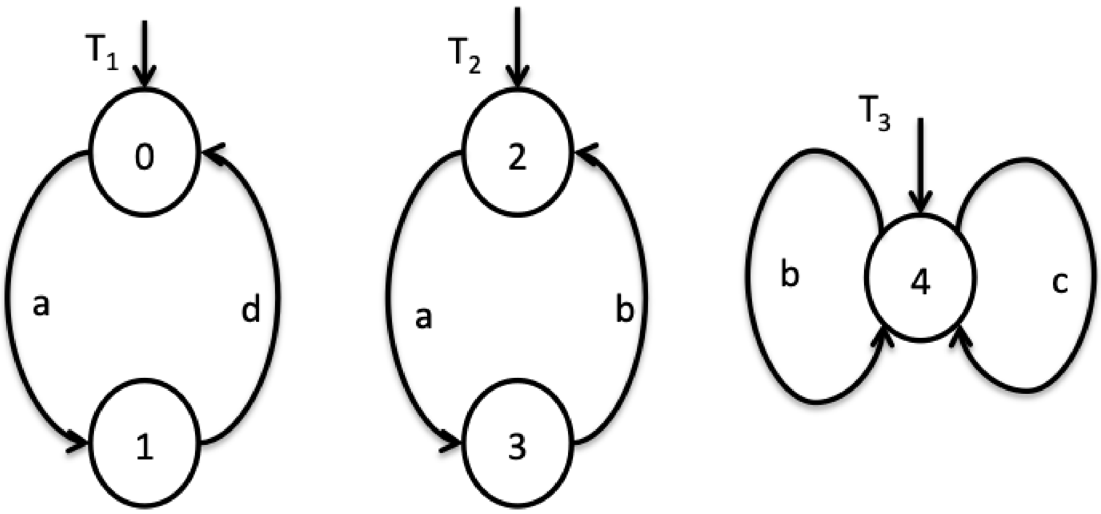
EXERCISE 1 (4 points)

Consider the three following transition systems T_1, T_2 and T_3.



Draw the transition system resulting from their product using handshaking with the handshake action set $H = \{a, b\}$, i.e., $T_1 \|_{\{a,b\}} T_2 \|_{\{a,b\}} T_3$.

EXERCISE 2 (10 points)

Consider the alphabet $AP = \{A, B, C\}$ and the following linear time properties:

(a) A holds at least twice

(b) B holds infinitely many times and whenever B holds then also C holds

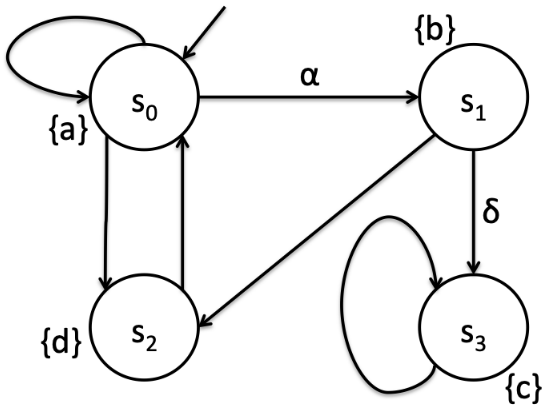
(c) Whenever A holds then B does not hold in the next step and whenever B holds then A does not hold in the next step

For each property:

1. formalise it using set expressions and first order logic;
2. formalise it in LTL (you can use the operators next, until, box and diamond, together with all boolean connectives);
3. tell if it is a safety, liveness or mixed property. In case it is a pure safety property provide an NFA for the language of the **minimal bad prefixes**.

EXERCISE 3 (10 points)

Consider the following transition system TS on $AP = \{a, b, c, d\}$.



Decide whether or not the following LTL formulas:

$$\varphi_0 = \Box\Diamond(a \vee c) \qquad \varphi_1 = (a \vee d)\,\mathcal{U}\,b$$
$$\varphi_2 = \Box(a \to \bigcirc(b \vee d)) \qquad \varphi_3 = \Diamond c$$

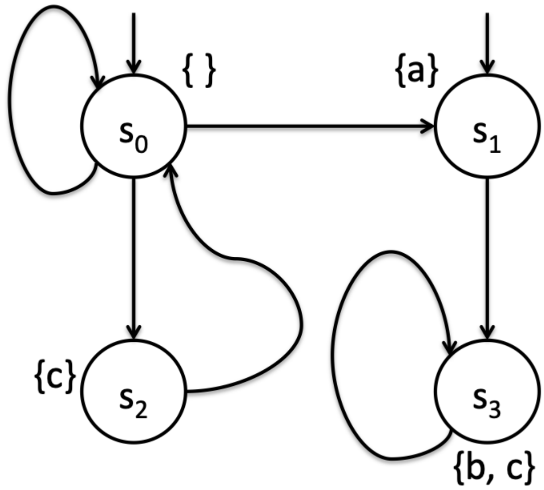
are satisfied by TS under the following fairness conditions (to be considered separately):

$$\psi_0^{\text{fair}} = (\{\}, \{\}, \{\}) \qquad \psi_1^{\text{fair}} = (\{\}, \{\{\alpha\}, \{\delta\}\}, \{\})$$
$$\psi_2^{\text{fair}} = (\{\}, \{\}, \{\{\alpha\}, \{\delta\}\}) \qquad \psi_3^{\text{fair}} = (\{\}, \{\{\alpha, \delta\}\}, \{\})$$

Justify your answers! In case the answer is no, provide a counterexample.

EXERCISE 4 (8 points)

Consider the following transition system TS on $AP = \{a, b, c\}$.



Decide whether or not the following CTL formulas:

$$\phi_0 = \forall\Diamond c \qquad \phi_1 = \exists\Box(\exists\bigcirc a)$$
$$\phi_2 = \forall\Box(c \to \exists\Diamond b) \qquad \phi_3 = \forall\Box(c \to \forall\Diamond b)$$

are satisfied by TS. Justify your answers! When possible, provide a counterexample or a witness.