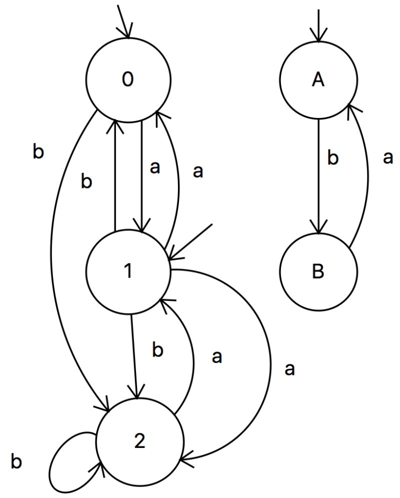
Master of Science in Computer Science - University of Camerino
Reactive Systems Verification A. Y. 2016/2017
Written Test of 12th July 2017 (Appello II)
Teacher: Luca Tesei

EXERCISE 1 (6 points)

Consider the two following transition systems.



1. Draw the transition system resulting from their product using handshaking with the handshake action set $H = \{a, b\}$.

EXERCISE 2 (9 points)

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

(a) Whenever A holds then B does not hold for two steps

(b) B and C hold together only finitely many times

(c) If C holds infinitely many times then D holds only finitely many times

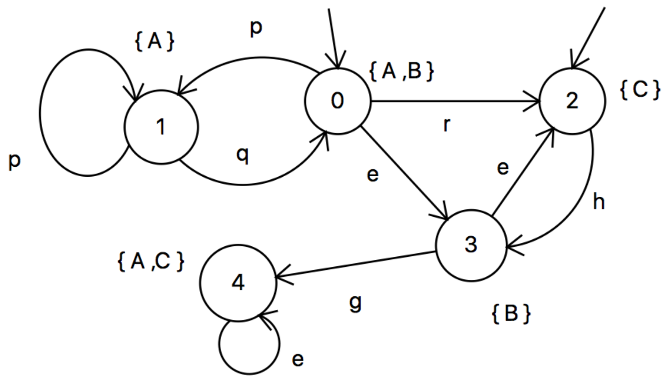
(d) C holds at least once and whenever D holds also A must hold

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 safety property provide an NFA for the language of the **minimal** bad prefixes.

EXERCISE 3

Consider the following transition system TS on $AP = \{A, B, C\}$.



1. **(3 points)** Decide, for each LTL formula φ_i below, whether or not $TS \models \varphi_i$. Justify your answers! If $TS \not\models \varphi_i$ provide a path $\pi \in Paths(TS)$ such that $\pi \not\models \varphi_i$.

$$\varphi_1 = \bigcirc \bigcirc A$$
$$\varphi_2 = \Box(A \Rightarrow \Diamond C)$$
$$\varphi_3 = \Diamond\Box(A \vee C)$$

2. Consider the following fairness assumptions:

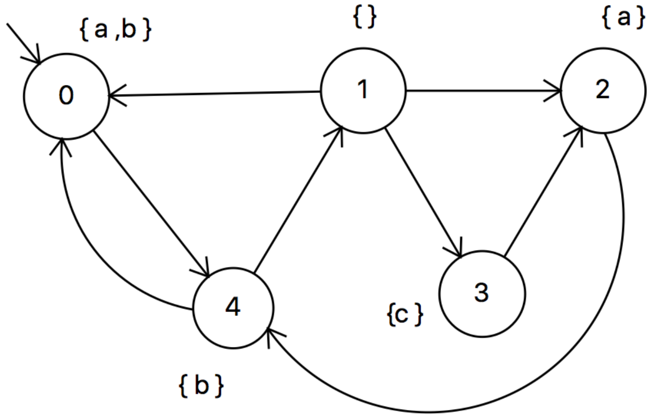
$$\psi_1^{\text{fair}} = \{\{\}, \{q\}, \{r\}\} \qquad \psi_2^{\text{fair}} = \{\{\}, \{r\}, \{q\}\}$$
$$\psi_3^{\text{fair}} = \{\{\}, \{g\}, \{e\}\} \qquad \psi_4^{\text{fair}} = \{\{\}, \{\}, \{g, e\}\}$$

   (a) **(3 points)** Decide whether or not $TS \models_{\text{fair}} \varphi_2$ under the four different fairness conditions ψ_{fair}^i, $i \in \{1, 2, 3, 4\}$, **separately**. Whenever $TS \not\models_{\text{fair}} \varphi_2$ provide a path $\pi \in Paths(TS)$ such that $\pi \not\models \varphi_1$ and arguing that π is fair with respect to ψ_{fair}^i.

   (b) **(3 points)** Decide whether or not $TS \models_{\text{fair}} \varphi_3$ under the four different fairness conditions ψ_{fair}^i, $i \in \{1, 2, 3, 4\}$, **separately**. Whenever $TS \not\models_{\text{fair}} \varphi_3$ provide a path $\pi \in Paths(TS)$ such that $\pi \not\models \varphi_6$ and arguing that π is fair with respect to ψ_{fair}^i.

EXERCISE 4 (8 points)

Consider the following transition system



1. Calculate $\text{Sat}(a \wedge (b \leftrightarrow c))$, $\text{Sat}(\exists(c \vee b)\mathcal{U}a)$ and $\text{Sat}(\exists\Box(b \vee c))$. Justify your answers by showing the steps of the algorithm used for the CTL formulas.