University of Innsbruck | Institute of Computer Science
2nd exam | March 16, 2010

Introduction to Model Checking (VO) | WS 2009/2010 | LVA 703503

First name: ______________________________

Last name: ______________________________

Matriculation number: ______________________________

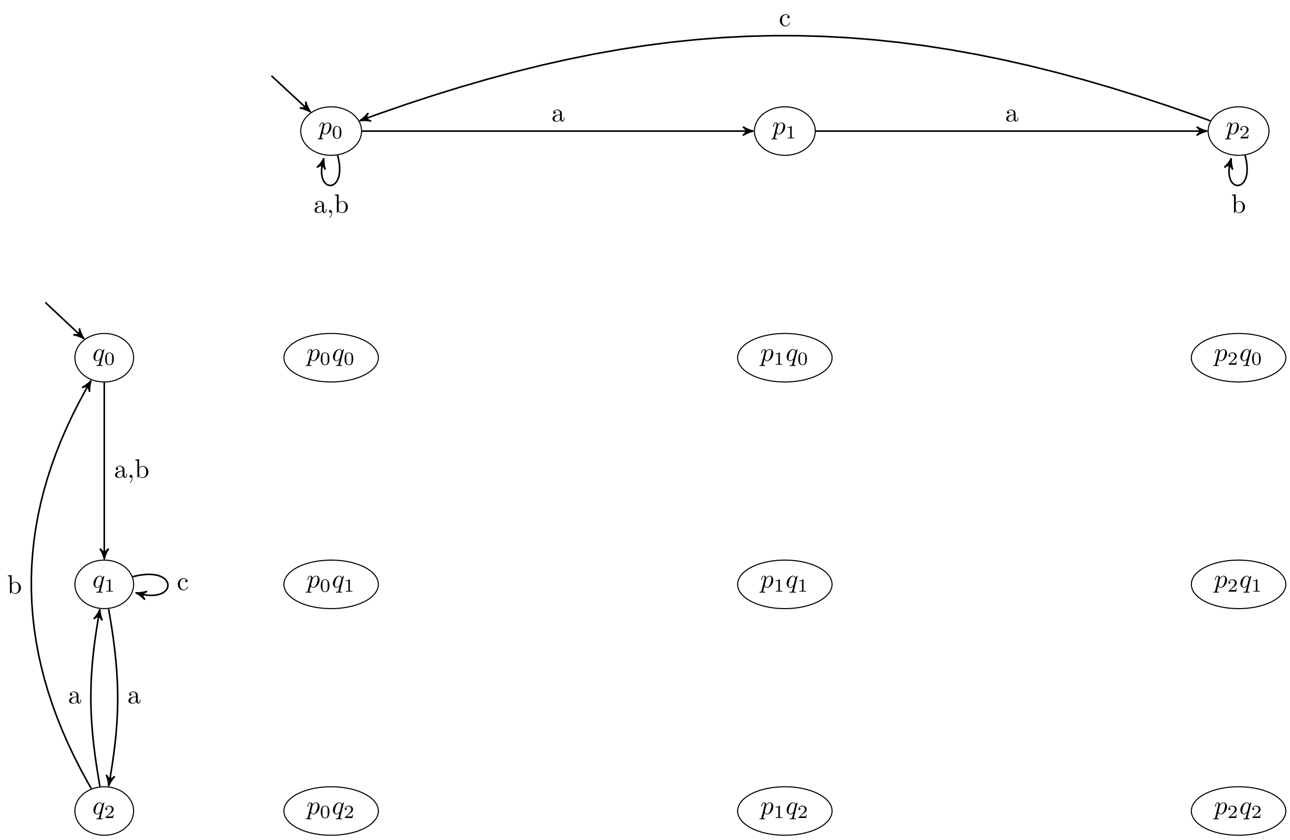
- Please answer all exercises in a readable and precise way.
- Please cross out solution attempts which are replaced by another solution.
- Please do not remove the staples of the exam.
- Cheating is not allowed. Everyone who is caught will fail the exam.

Exercise	**Maximal points**	**Points**
1	**20**	
2	**20**	
3	**21**	
4	**9**	
Σ	**70**	
Grade		

Exercise 1 (14 + 3 + 3 points)

Consider the GNBAs $\mathcal{A}_1 = (\{p_0, p_1, p_2\}, \Sigma, p_0, \delta_1, \{p_0, p_2\}, \{p_1\})$ and $\mathcal{A}_2 = (\{q_0, q_1, q_2\}, \Sigma, q_0, \delta_2, \{q_2\})$.

(i) Construct the GNBA $\mathcal{A}$ for the intersection of $\mathcal{A}_1$ and $\mathcal{A}_2$.

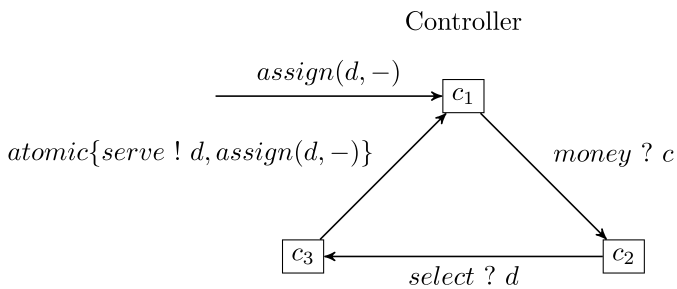


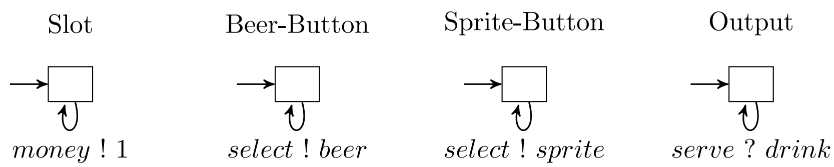
(ii) Write down the final states set(s) of $\mathcal{A}$ explicitly.

(iii) Is $\mathcal{L}(\mathcal{A}) = \varnothing$? If not, provide a word which is contained in $\mathcal{L}(\mathcal{A})$.

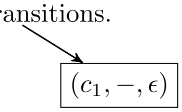
Exercise 2 (20 points)

Consider the following channel system [Slot | Beer-Button | Sprite-Button | Controller | Output] which models a distributed beverage vending machine. Here, communication is done via three channels where the capacity of the *money*-channel is 1, and the capacity of the *select*- and *serve*-channel is 0.





Complete the following transition system where a state (c_i, x, c) represents the current location in the controller c_i, the value x of the variable d of the controller, and the value c of the *money*-channel. You do not have to label transitions.



Exercise 3 (6 + 15 points)

Consider the following formula:

$$\varphi = \neg(\text{true}\,\mathsf{U}\,(\mathsf{red} \wedge \neg(\neg\mathsf{green} \wedge \mathsf{X}\,(\neg\mathsf{green}\,\mathsf{U}\,\neg\mathsf{red}))))$$

The following exercises can be done independently!

(i) Construct a simplified formula ψ with $\varphi \equiv \psi$ by introducing operators like F, G, $\vee$, $\Rightarrow$, ... Then try to formulate the meaning of ψ in words (German or English).

(ii) Construct the automaton for φ using the improved translation.
$\mathcal{A}_\varphi = (\{q_0\} \uplus 2^5, 2^2, q_0, \delta, F_1, F_2)$ where

- The reduced Fischer Ladner closure is

  $cl'(\varphi) = \mathsf{red}, \mathsf{green},$

- $(c_1, \ldots, c_5)^T \in \delta(q_0, (d_1, d_2)^T)$ iff

- $(c_1, \ldots, c_5)^T \in \delta((b_1, \ldots, b_5)^T, (d_1, d_2)^T)$ iff

- $F_1 = \{(b_1, \ldots, b_5)^T \mid$

  $F_2 = \{(b_1, \ldots, b_5)^T \mid$

Compute the number of direct preceding states of state $(1, 0, 0, 1, 1)^T$.

Exercise 4 (9 points)

Give an algorithm which decides for two LTL formulas φ and ψ whether $\mathcal{L}(\varphi) = \mathcal{L}(\psi)$. Prove the correctness.