University of Innsbruck | Institute of Computer Science
2. Exam | 25 February 2008

Introduction to Model Checking (VO) | WS 2007/2008 | LVA 703503

First name: ______________________

Last name: ______________________

Matriculation number: ______________________

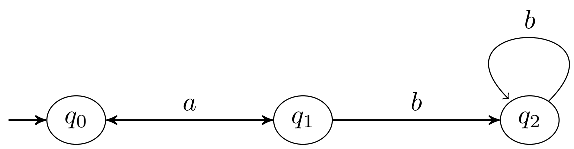
- Write your name and matriculation number on every page.
- Please answer all exercises in a readable and precise way. Do *not* write with a pencil or a red pen. Please cross out solution attempts which are replaced by another solution.
- Cheating is not allowed. Everyone who is caught will fail the exam.
- Please do not remove the staples of the exam.

Exercise	**Maximal points**	**Points**
1	**17**	
2	**14**	
3	**17**	
4	**12**	
Σ	**60**	
Grade		

First name	Last name	Matriculation number

Exercise 1 (15 + 2 points)

Consider the GNBA $\mathcal{A} = (\{q_0, q_1, q_2\}, \{a, b\}, q_0, \delta, F_1, F_2, F_3)$ where $F_1 = \{q_0, q_1\}$, $F_2 = \{q_1, q_2\}$, and $F_3 = \{q_0, q_2\}$, and where δ is represented graphically.



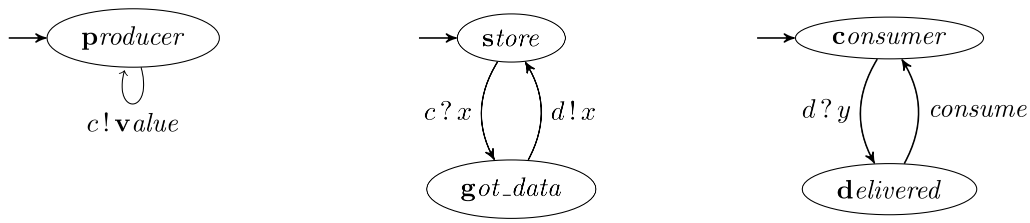
- Construct the corresponding equivalent NBA.

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

First name	Last name	Matriculation number

Exercise 2 (14 points)

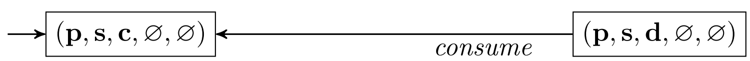
Consider the following channel system which transmits values from a producer via a store to a consumer.



We assume that the capacity of channel c is 1 and the capacity of channel d is 0. To construct the transition system for this channel system we will encounter states of the form

$$(\ell_1, \ell_2, \ell_3, \mathit{Eval}(c), \mathit{Eval}(d))$$

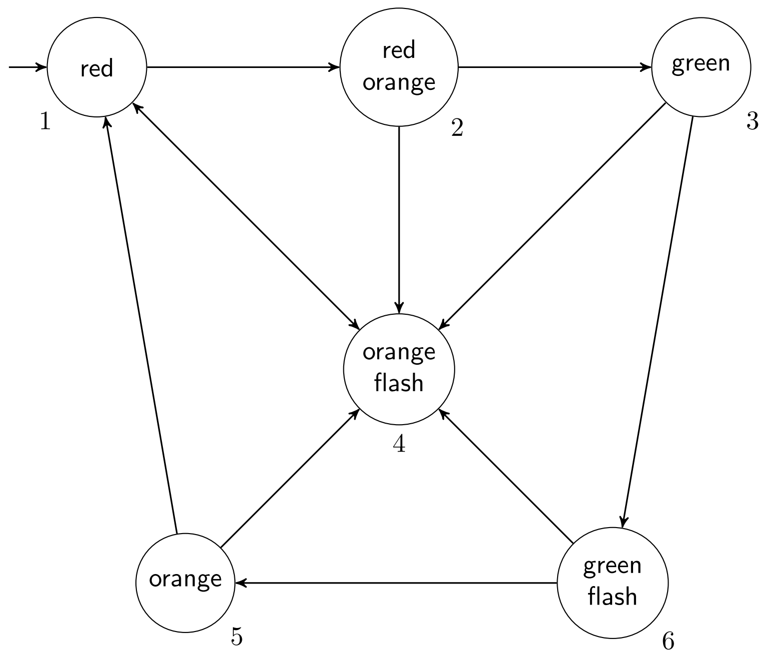
where we ignore the evaluation of variables since there is only one possible value. Here, ℓ_1, ℓ_2, and ℓ_3 are (the first letters of) the locations, i.e., $\ell_1 \in \{\mathbf{p}\}$, $\ell_2 \in \{\mathbf{s}, \mathbf{g}\}$, and $\ell_3 \in \{\mathbf{c}, \mathbf{d}\}$. Of course, **v***alue* can be abbreviated by **v**. Some initial part of the transition system is already depicted below. Draw the remaining parts.



First name	Last name	Matriculation number

Exercise 3 (2 + 15 points)

Consider the following transition system TS of an Austrian traffic light using the atomic propositions $\{\mathsf{red}, \mathsf{orange}, \mathsf{green}, \mathsf{flash}\}$.



Consider the following CTL*-formula Φ.

$$\Phi = \mathsf{A}\,\mathsf{G}\,(\neg\mathsf{red} \vee \mathsf{E}\,(\mathsf{orange}\,\mathsf{U}\,\mathsf{X}\,\mathsf{red}))$$

Perform CTL*-model checking to decide whether the transition systems satisfies Φ.

(i) Compute a formula Φ' which is equivalent to Φ and does not contain E.

(ii) Compute $Sat(\Psi)$ for every state-subformula Ψ of Φ'. Note that the subformula $\neg\mathsf{red} \vee \ldots$ of Φ' should be seen as a state-formula.

When computing a set $Sat(\mathsf{A}\,\varphi)$ write down the corresponding LTL-formula φ' that is checked. However, it is not necessary to perform the LTL-model checking explicitly.

First name	Last name	Matriculation number

First name	Last name	Matriculation number

Exercise 4 (6 + 6 points)

Consider the LTL formula

$$\varphi = a \,\mathsf{U}\, (\mathsf{X}\,(b \wedge (c \,\mathsf{U}\, \mathsf{X}\, b)) \,\mathsf{U}\, c)$$

The GNBA $\mathcal{A}_\varphi$ is of the form $(\mathcal{Q}, 2^3, q_0, \delta, F_1, F_2, F_3)$.

(i) The set of states $\mathcal{Q}$ is $2^m \cup \{q_0\}$. Determine m by specifying which subformula corresponds to which bit d_i in the state $(d_1, \ldots, d_m)^T$.

(ii) Suppose F_1 corresponds to the left U of φ, F_2 to the middle U of φ, and F_3 corresponds to the right U of φ. Complete the definitions of F_1, F_2, and F_3.

$$F_1 = \{(d_1, \ldots, d_m)^T \mid \qquad\qquad\qquad\qquad \}$$

$$F_2 = \{(d_1, \ldots, d_m)^T \mid \qquad\qquad\qquad\qquad \}$$

$$F_3 = \{(d_1, \ldots, d_m)^T \mid \qquad\qquad\qquad\qquad \}$$