Introduction to Model Checking (VO) — WS 2008/2009 — LVA 703503

First name: ____________________

Last name: ____________________

Matriculation number: ____________________

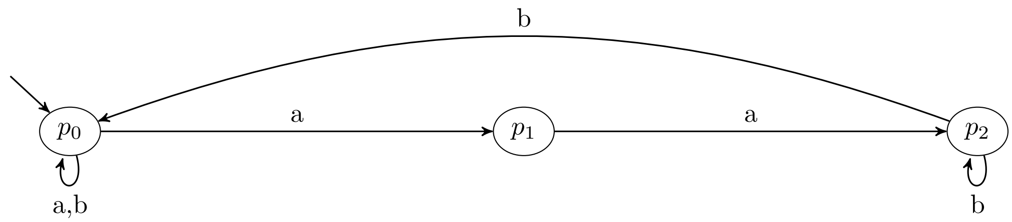
- Please answer all exercises in a readable and precise way.
- Please cross out solution attempts which are replaced by another solution.
- Please do not remove the staples of the exam.
- Cheating is not allowed. Everyone who is caught will fail the exam.

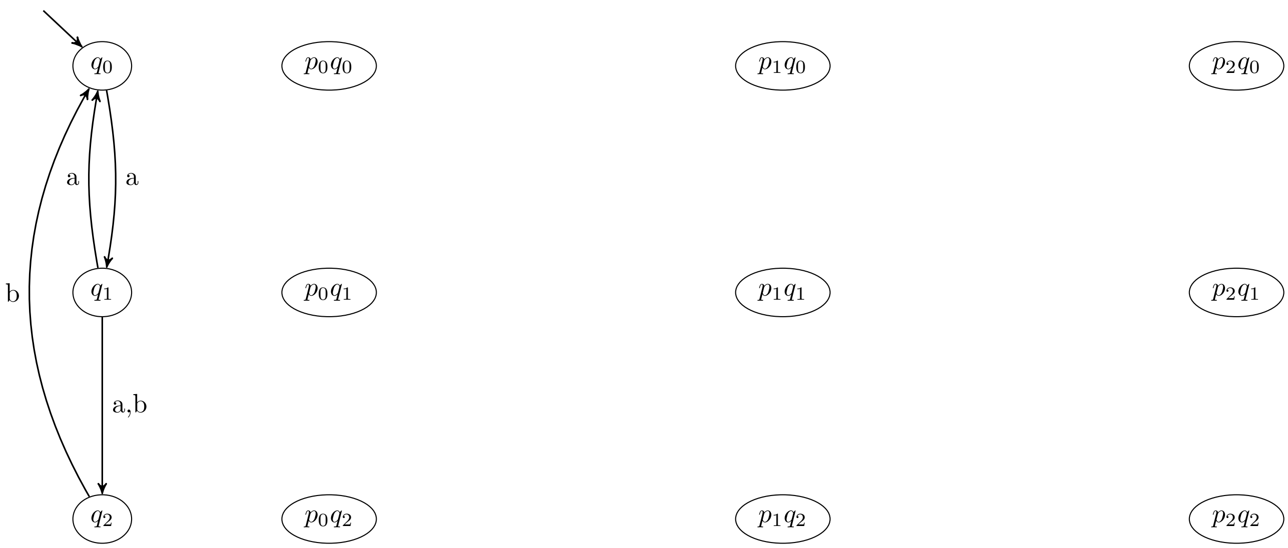
Exercise	Maximal points	Points
1	21	
2	20	
3	20	
4	9	
Σ	70	
Grade		

Exercise 1 (14+5+2 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 $\mathcal{A}_2 = (\{q_0, q_1, q_2\}, \Sigma, q_0, \delta_2, \{q_0, q_1\})$.

(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)

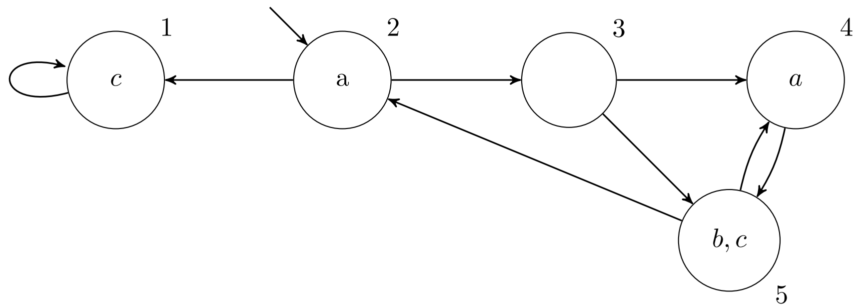
Consider the following nanoPromela statement.

```
do
  :: a  => if :: d => e ! f fi ; g ! h
  :: b  => i ! j ; if :: k => l ! m fi
  :: c  => skip
od
```

Formally derive all transitions that are possible from this initial statement. You may use abbreviations like "`do` ... `od`" and "`if` ... `fi`".

Exercise 3 (20 points)

Consider the following transition system *TS*.



Perform CTL*-model checking for the formula

$$\Phi = (\mathsf{A}\,((\mathsf{E}\,\mathsf{X}\,a) \Rightarrow \mathsf{X}\,a)) \wedge (\mathsf{E}\,(\neg a \wedge \neg b)\,\mathsf{U}\,c)$$

Here, the sets $Sat(\Psi)$ should be indicated for every non-atomic state-subformula Ψ of Φ. Note that the subformula $\neg a \wedge \neg b$ of Φ should be seen as a state-formula. It is not necessary to perform the LTL-model checking explicitly, but write down each LTL-formula that is checked.

Exercise 4 (9 points)

Each correct answer is worth 3 points. A wrong answer results in zero points (for that question, not for the whole exercise). Giving no answer is worth 1 point.

	Yes	No
$\mathsf{F}\,(a\,\mathsf{U}\,b) \equiv \neg\mathsf{E}\,\mathsf{G}\,\neg b$.		
The LTL formula $\mathsf{F}\,(a\,\mathsf{U}\,\mathsf{X}\,(b\,\mathsf{U}\,\mathsf{X}\,a))$ describes the following property: Every path contains two a's with a b in between.		
The number of states of the GNBA $\mathcal{A}_\varphi$ for some LTL-formula φ using the improved translation is $1 + 2^n$ where n is the number of temporal operators in φ.		