Exam in *Model Checking* for Master of Science and diploma students

February 27, 2009

Family name: ____________________

First name: ____________________

Student number: ____________________

Field of study: ☐ **Informatik (Übungsschein)**
☐ **Software Systems Engineering**
☐ **Others:** ____________________

Please note the following hints:

- Keep your student id card and a passport ready.
- The only allowed materials are
  - a copy of the lecture notes,
  - a copy of the lecture slides.
  - a dictionary.

  No other materials (i.a. exercises, solutions, handwritten notes) are admitted.
- This test should have six pages (including this cover sheet).
- Write your name and student number on every sheet.
- Also use the back side of the pages if needed.
- Write with blue or black ink; do not use a pencil.
- Any attempt at deception leads to failure for this exam, even if it is detected only later.
- The editing time is **90 minutes**.

Question	Possible	Received
1	10	
2	10	
3	10	
4	10	
5	10	
Total	50	
Grade		

Question 1

(10 points)

Let P and P' be safety properties. Prove that $\mathit{BadPref}(P) \cap \mathit{BadPref}(P') = \mathit{BadPref}(P \cup P')$.

Question 2 (10 points)

Consider the linear-time property P over $AP = \{a, b\}$:

"$(\neg a \wedge \neg b)$ holds infinitely often and $(a \wedge b)$ never holds and
between any two occurrences of $(\neg a \wedge \neg b)$, the number of states where b holds is even."

(a) Provide an NBA $\mathcal{A}$ over 2^{AP} such that $\mathcal{L}_\omega(\mathcal{A}) = P$.
Hint: Parts (b) and (c) can be solved without a solution for part (a).

(b) Formally prove or disprove the following statements:

- P is a safety property.
- P is a liveness property.

(c) Let $\mathcal{A}'$ be an NBA over 2^{AP}. Then $P' = \mathcal{L}_\omega(\mathcal{A}')$ is the linear-time property defined by $\mathcal{A}'$.
Is it always the case that there exists an LTL-formula φ such that $P' = \mathit{Words}(\varphi)$?
Justify your answer!

Question 3 (10 points)

Let $\varphi = (a \wedge \bigcirc a) \mathsf{U} (a \wedge \neg \bigcirc a)$ be an LTL–formula over $AP = \{a\}$.

(a) Compute all elementary sets with respect to φ.

(b) Construct the GNBA $\mathcal{G}_\varphi$ according to the algorithm from the lecture such that $\mathcal{L}_\omega(\mathcal{G}_\varphi) = \mathit{Words}(\varphi)$.

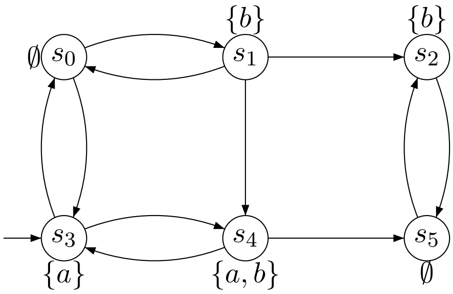
(c) Give an ω-regular expression E such that $\mathcal{L}_\omega(\mathcal{G}_\varphi) = \mathcal{L}_\omega(E)$.

Question 4 (10 points)

Compute $Sat_{sfair}(\Phi)$ for the CTL-formula Φ and the strong fairness assumption *sfair*:

$$\Phi = \exists \Box a$$
$$sfair = \Box\Diamond a \rightarrow \Box\Diamond\exists (\neg a) \mathsf{U} (\forall \bigcirc b)$$

where TS over $AP = \{a, b\}$ is given by:



Proceed in the following steps:

(a) Determine $Sat\,(\exists (\neg a) \mathsf{U} (\forall \bigcirc b))$ (without fairness).

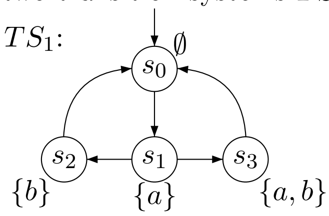
(b) Determine $Sat_{sfair}(\exists\Box\, \mathsf{true})$.

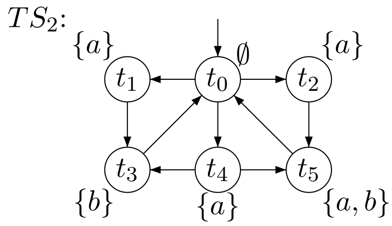
(c) Determine $Sat_{sfair}(\Phi)$.

Question 5

(10 points)

Consider the two transition systems TS_1 and TS_2:





(a) Prove or disprove $TS_1 \sim TS_2$.

(b) Prove or disprove $TS_1 \simeq TS_2$.