Software Validation and Verification 10/12/2025 Exam

Notice: 32 points is the maximum (4 exercises are sufficient)
Recall: Write your name on every paper sheet

Exercise 1 **[8 points]**

Characterize each of the following properties as invariance, safety, liveness property, or none of these:

$E_1 := \mathit{Word}(\Diamond a \wedge \Box(a \to \bigcirc a))$
$E_2 := \mathit{Word}((a \,\mathrm{U}\, b) \wedge \Box(a \to \bigcirc \neg b))$
$E_3 := \{\sigma = A_0 A_1 A_2 A_3 \cdots \mid$ some $k > 0$ exists such that, for all $i \geq 0$, it holds that $A_{i \times k} = \{a\}\}$

Exercise 2 **[8 points]**

For each of the following pairs of LTL formulas ϕ — ψ discuss wether ϕ subsumes ψ and vice-versa:

1. $a \,\mathrm{U} \Diamond b$ — $\Diamond b$
2. $\Diamond a \,\mathrm{U}\, b$ — $b \vee (\Diamond a \wedge \Diamond b)$
3. $\Diamond a \,\mathrm{U}\, b$ — $b \vee \Diamond((a \wedge \bigcirc b) \vee (b \wedge \Diamond a))$

Exercise 3 **[8 points]**

Given a transition system $\mathcal{T}$ and a CTL fairness assumption *fair*, discuss the validity of the following statements:

1. If a_{fair} labels every node in $\mathcal{T}$, then, for every state s in $\mathcal{T}$ and CTL formula Φ, it holds that

$$s \models_{\mathit{fair}} \Phi \text{ if and only if } s \models \Phi.$$

2. If for every state s in $\mathcal{T}$ and CTL formula Φ, it holds that

$$s \models_{\mathit{fair}} \Phi \text{ if and only if } s \models \Phi,$$

then a_{fair} must label every node in $\mathcal{T}$.

Exercise 4 **[8 points]**

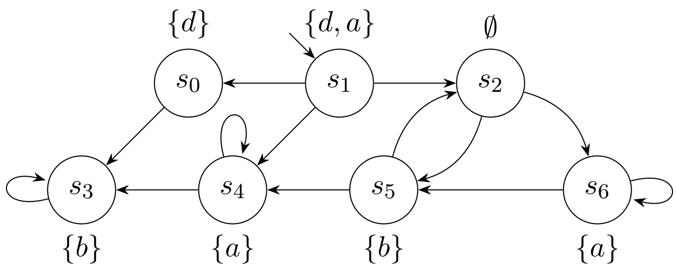
Let $\phi = (a \,\mathrm{U}\, b) \,\mathrm{U} (\neg \bigcirc a)$ be an LTL formula over $AP = \{a, b\}$.

1. Compute all elementary sets with respect to ϕ;
2. Construct the GNBA $\mathcal{G}$ such that $\mathcal{L}_\omega(\mathcal{G}) = \mathit{Word}(\phi)$ returned by the algorithm from the lecture.

Exercise 5 **[8 points]**

Consider the following transition system, the CTL formula Φ and the fairness assumption *fair*.

$$\Phi = \exists((\forall\Box\neg d) \,\mathrm{U} (\forall\Diamond\forall\Box\neg b))$$
$$\mathit{fair} = \Box\Diamond(a \wedge \exists\bigcirc b) \to \Box\Diamond b \wedge \Box\Diamond a$$



Compute $Sat_{\mathit{fair}}(\Phi)$ with the algorithm from the lecture.