Software Validation and Verification – 13/01/2026

Recall: Write your name on every paper sheet **and** motivate all your answers

Exercise 1

[8 points]

A linear time property $E \subseteq (2^{AP})^\omega$ is a *guarantee property* if for each $\sigma \in E$, a finite prefix $\hat{\sigma}$ of σ exists such that for all $\sigma' \in (2^{AP})^\omega$ it holds that $\hat{\sigma}\sigma'$ is included in E ($\hat{\sigma}$ is a *good prefix* of σ). Discuss the following statements:

1. Every guarantee property is also a safety property
2. Every liveness property is also a guarantee property
3. The only guarantee property that is also a liveness property is $(2^{AP})^\omega$
4. The only guarantee property that is also a safety property is $\emptyset$

Exercise 2

[8 points]

For each of the following pairs of LTL formulas, discuss whether the first subsumes the second and vice-versa:

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

Exercise 3

[8 points]

Let $\phi = a \,\mathrm{U}(\neg b \,\mathrm{U}(a \wedge \neg\bigcirc a))$, with named subformulas $\phi' = \neg b \,\mathrm{U}\, \phi''$ and $\phi'' = a \wedge \neg\bigcirc a$.

1. Are the following sets *elementary*?

$$B_1 = \{a, b, \neg\phi'', \neg\phi', \phi\} \qquad B_2 = \{\neg a, \neg b, \neg\bigcirc a, \neg\phi'', \phi', \neg\phi\} \qquad B_3 = \{a, b, \neg\bigcirc a, \neg\phi'', \neg\phi', \phi\}$$

2. Are the following valid transitions of the GNBA $\mathcal{G}$ such that $\mathcal{L}_\omega(\mathcal{G}) = \mathit{Word}(\phi)$ returned by the algorithm from the lecture?

   (a) $\{a, \neg b, \bigcirc a, \neg\phi'', \phi', \phi\} \xrightarrow{\{a\}} \{a, \neg b, \neg\bigcirc a, \phi'', \phi', \phi\}$

   (b) $\{a, \neg b, \bigcirc a, \neg\phi'', \phi', \phi\} \xrightarrow{\{a\}} \{a, b, \bigcirc a, \neg\phi'', \neg\phi', \phi\}$

   (c) $\{\neg a, \neg b, \bigcirc a, \neg\phi'', \neg\phi', \neg\phi\} \xrightarrow{\emptyset} \{a, b, \neg\bigcirc a, \phi'', \phi', \phi\}$

Exercise 4

[4 points]

Does an LTL formula ϕ exist that is equivalent to the CTL formula $\Phi = \forall\bigcirc(\exists\bigcirc a \wedge \exists\bigcirc b)$.

Exercise 5

[4 points]

Consider the fairness assumption below:

$$\begin{aligned} \mathit{fair} = {} & \Box\Diamond(\exists\bigcirc b \wedge \exists\bigcirc c) \rightarrow \Box\Diamond b \\ & \wedge \Box\Diamond(a \wedge \exists\bigcirc\forall\Box\neg a) \end{aligned}$$

Determine which nodes of the transition system are labelled by the predicate a_{fair}.