

# 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  $\sigma$  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  $\sigma$ ). 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.  $(a \mathbf{U} b) \wedge (b \mathbf{U} a) — (a \wedge (a \mathbf{U} b)) \vee (b \wedge (b \mathbf{U} a))$
2.  $\square(a \mathbf{U} b) — \square\lozenge b \wedge \square a$
3.  $\square\lozenge(a \mathbf{W} b) — \square\lozenge b \vee \lozenge\square a$

## Exercise 3

[8 points]

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

1. Are the following sets *elementary*?

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

2. Are the following valid transitions of the GNBA  $\mathcal{G}$  such that  $\mathcal{L}_\omega(\mathcal{G}) = \text{Word}(\phi)$  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)  $\{\neg a, \neg b, \bigcirc a, \neg\phi'', \neg\phi', \neg\phi\} \xrightarrow{\emptyset} \{a, b, \neg \bigcirc a, \phi'', \phi', \phi\}$

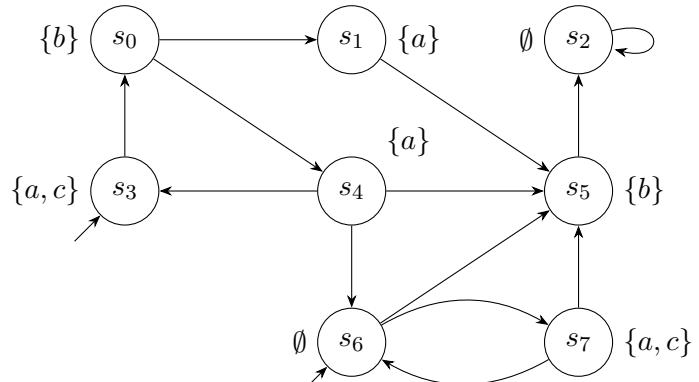
## Exercise 4

[4 points]

Does an LTL formula  $\phi$  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:

$$\begin{aligned} \text{fair} = & \square\lozenge(\exists \bigcirc b \wedge \exists \bigcirc c) \rightarrow \square\lozenge b \\ & \wedge \square\lozenge(a \wedge \exists \bigcirc \forall \square \neg a) \end{aligned}$$

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