Software Validation and Verification – 17/07/2026

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

Exercise 1 [6 points]

Assume that the set of propositions AP coincides with the natural numbers $\mathbb{N}$.

Let E_1 and E_2 be the linear time properties defined as follows:

$$E_1 = \left\{\sigma = A_0, A_1, \dots \;\middle|\; \bigcup_i A_i = \mathbb{N}\right\} \qquad E_2 = \left\{\sigma = A_0, A_1, \dots \;\middle|\; \sum_i \sum_{n \in A_i} n = 110\right\}$$

Informally, each word of E_1 contains all natural numbers, whereas each word of E_2 adds up to 110.

Express each of E_1 and E_2 as the intersection of a safety and of a liveness properties.

Exercise 2 [6 points]

Discuss whether the following linear time property is ω-regular:

$$E = \{\sigma = A_0, A_1, \cdots \mid \forall i, j. \text{ if } a \in A_i \text{ and } a \in A_j \text{ then } \#\{\ k \mid i < k < j \text{ and } b \in A_k\} \text{ is even } \}$$

Informally, a word is in E if the occurrences of the proposition a are separated by an even number of states where b holds.

Notation: given a set X, we write $\#X$ for the *cardinality* of X, i.e. the number of its elements.

Exercise 3 [9 points]

Consider the set of LTL formulas $\Xi = \{\phi, \psi, \xi\}$, where:

$$\phi = \Box(a \Rightarrow (a \,\mathrm{U} \bigcirc a)) \qquad \psi = \Box(\neg a \Rightarrow \bigcirc a) \qquad \xi = \neg\Box\Diamond\neg a$$

For each pair $(x, y) \in \Xi \times \Xi$, discuss whether $\mathit{Word}(x) \subseteq \mathit{Word}(y)$.

Exercise 4 [5 points]

Discuss the validity of the following statement:

For any LTL formula ϕ, for any non-atomic proposition ψ subformula of ϕ,
if $B' \xrightarrow{A} B$ and $B'' \xrightarrow{A} B$ are valid transitions of $\mathcal{G}_\phi$, then $\psi \in B'$ implies $\psi \in B''$

Notation: given an LTL formula ϕ, we write $\mathcal{G}_\phi$ for the GNBA such that $\mathcal{L}_\omega(\mathcal{G}_\phi) = \mathit{Word}(\phi)$ returned by the algorithm from the lecture.

Exercise 5 [6 points]

Consider the following transition system and CTL formula.

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

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