

Software Validation and Verification

Fourth Exercise Sheet

Exercise 1

Let ϕ, ψ be arbitrary LTL formulae. Consider the following new operators:

- "At next" $\phi N \psi$: at the next time where ψ holds (if it exists), ϕ also holds.
- "While" $\phi Y \psi$: ϕ holds at least as long as ψ does.
- "Before" $\phi B \psi$: if ψ holds at some point, then it is (either immediately or not immediately) preceded by ϕ .

Make the definitions of these informally explained operators precise by providing LTL formulae that formalize their intuitive meanings.

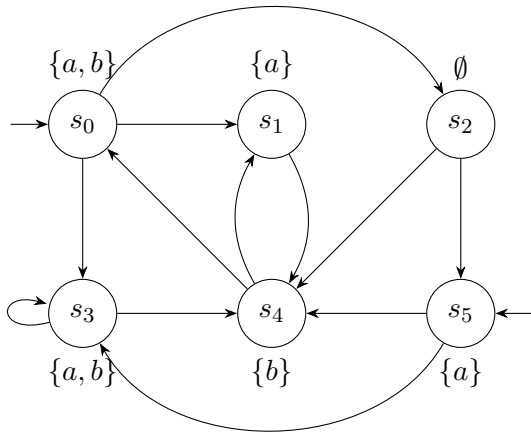
Exercise 2

Let ϕ, ψ, ξ be arbitrary LTL formulae. For each of the following pairs of LTL formulae, determine whether they are equivalent, one of them subsumes the other or they are incomparable.

1. $\Diamond \Box \phi$ and $\Box \Diamond \phi$
2. $\Diamond \Box \phi \wedge \Diamond \Box \psi$ and $\Diamond(\Box \phi \wedge \Box \psi)$
3. $\phi \wedge \Box(\phi \rightarrow \bigcirc \Diamond \phi)$ and $\Box \Diamond \phi$
4. $\phi U(\psi U \xi)$ and $(\phi U \psi) U \xi$

Exercise 3

Consider the following transition system \mathcal{T} , for each of the following ϕ_i determine if $\mathcal{T} \models \phi_i$.



- $\phi_1 = \Box \Diamond a$
 $\phi_2 = \Diamond \Box a$
 $\phi_3 = a \rightarrow \bigcirc \bigcirc a$
 $\phi_4 = b R a$ where $\phi R \psi$ is defined as $\neg(\neg\phi U \psi)$

Exercise 4

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

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