Software Validation and Verification
Third Exercise Sheet

Exercise 1

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

- "At next" $\phi \,\mathrm{N}\, \psi$: at the next time where ψ holds, ϕ also holds.
- "While" $\phi \,\mathrm{Y}\, \psi$: ϕ holds as least as long as ψ does.
- "Before" $\phi \,\mathrm{B}\, \psi$: if ψ holds sometime, ϕ does so before.

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

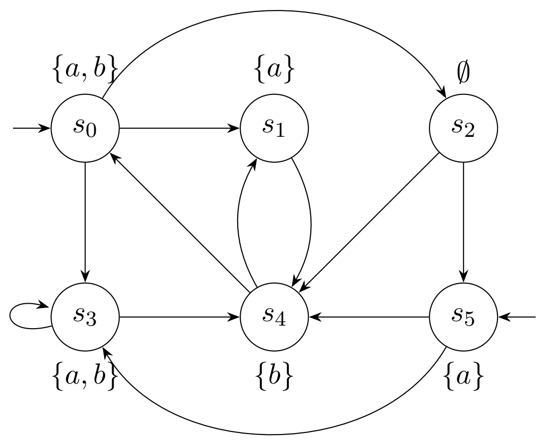
Exercise 2

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. $\phi \,\mathrm{U}(\psi \,\mathrm{U}\, \xi)$ and $(\phi \,\mathrm{U}\, \psi) \,\mathrm{U}\, \xi$

Exercise 3

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



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

Exercise 4

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

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