ALBERT-LUDWIGS-
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Discussion: Jan 7– Jan 11
Different rooms

Tutorials for Verification
Exercise sheet 8

Exercise 1: NBA might be smaller than DBA
Prove: there exists an alphabet such that for all $n \geq 1$ there is an n-state NBA A so that there is a DBA recognizing $L_\omega(A)$ and so that any DBA recognizing $L_\omega(A)$ has $\Omega(2^n)$ states.

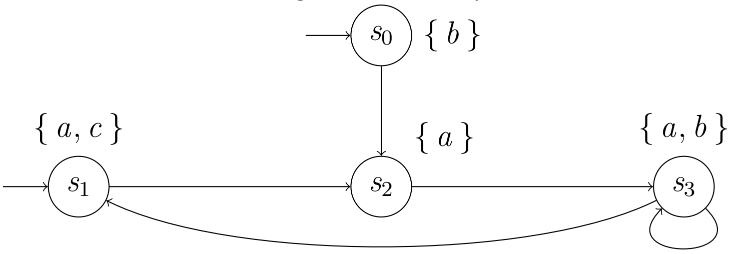
Exercise 2: Checking ω-regular properties
Let $AP = \{ \mathit{req}_1, \mathit{crit}_1 \}$. Consider the non-starvation property, which can be expressed in LTL as $P_{starve} = \mathit{Words}(\Box(\mathit{req}_1 \Rightarrow \Diamond\, \mathit{crit}_1))$.

(a) Construct a Büchi-Automaton $\mathcal{A}$ that recognizes the complement of P_{starve}.

(b) Build the reachable part of the cross product $TS_{pet} \otimes \mathcal{A}$ where TS_{pet} is the transition system of Petersen's mutual exclusion. Check if there is a reachable cycle containing a final state. Does $TS_{pet} \models P_{starve}$?

(c) Do the same for TS_{sem} the transition system for the semaphore based mutual exclusion.

Exercise 3: States satisfying LTL-formulae
Consider the following transition system over the set of atomic propostions $\{ a, b, c \}$:



Give for each of the following LTL-formulae the set of states for which the formula is satisfied.

(a) $a \wedge \bigcirc\, b$	(b) $\bigcirc\, c$	(c) $\bigcirc \bigcirc\, c$
(d) $a \mathsf{U} b$	(e) $b \mathsf{U} a$	(f) $b \mathsf{U} \Box\, a$
(g) $a \mathsf{U} \Box\, b$	(h) $\neg(a \mathsf{U} \Box\, b)$	(i) $(\Diamond\, c) \mathsf{U} (\Box\, a)$
(j) $\Diamond \Box\, a$	(k) $\Box \Diamond\, b$	(l) $\Box \Diamond\, c$

Exercise 4*: Complements need exponential space in worst case

Prove or refute:

(a) There is an alphabet such that for infinitely many n, there is an n-state NFA (nondeterministic finite automaton) A such that any NFA accepting $\Sigma^* \setminus L(A)$ has $\Omega(2^n)$ states.

(b) There is an alphabet such that for infinitely many n, there is an n-state NBA (nondeterministic Büchi automaton) A such that any NBA accepting $\Sigma^\omega \setminus L_\omega(A)$ has $\Omega(2^n)$ states.

In positive cases, can you prove a larger lower bound than 2^n?