# Model-Checking Exercises
# Sommersemester 2009 / Sheet 3

June 10, 2009

We are going to discuss the examples together at 18.6 and 25.6. For questions about the exercises or examples, please send me an email `campetel@in.tum.de`.

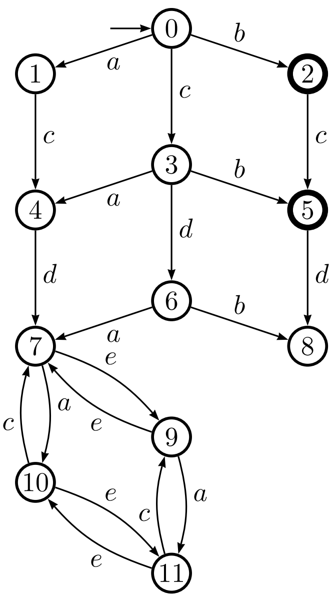
## Example 3.1: Translation of LTL to Büchi automata

Enter the following **LTL** formulas as possible small Büchi automata (and do not use the construction from the lecture):

1. $(\mathbf{G}p) \rightarrow (p\mathbf{U}q)$
2. $\mathbf{G}(p \rightarrow \mathbf{X}(\neg p\mathbf{U}q))$
3. $p\mathbf{R}q$

## Example 3.2: Ample Sets

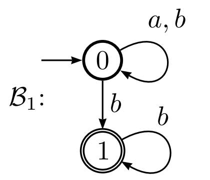
Alongside you see the Kripke structure $K$ with the states $S = \{0, \ldots, 11\}$, the actions $A = \{a, b, c, d, e\}$, the atomic propositions $\mathbf{AP} = \{p\}$ with $\nu(2) = \nu(5) = \{p\}$ and $\nu(s) = \emptyset$ for all $s \in S \setminus \{2, 5\}$ (the proposition $p$ holds therefore only in thick rimmed states)

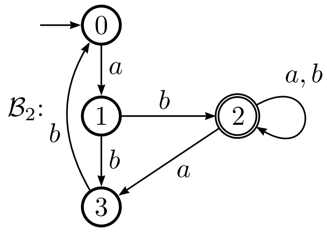



1. Provide a maximal independence relation $I \subseteq A \times A$ and determine the set of invisible actions.
2. Declare a reduced Kripke structure $\mathcal{K}_R$ that is stuttering equivalent to $\mathcal{K}$. Declare besides for all states $s \in S$ a suitable set $\mathsf{red}(s)$ which satisfies the conditions $C0$ to $C3$.

## Example 3.3: Intersection automata and emptiness

Construct an automaton $\mathcal{B}$ as the intersection of the two below automata $\mathcal{B}_1$ and $\mathcal{B}_2$, so with $\mathcal{L}(\mathcal{B}) = \mathcal{L}(\mathcal{B}_1) \cap \mathcal{L}(\mathcal{B}_2)$, and check whether the language accepted by $\mathcal{B}$, $\mathcal{L}(\mathcal{B})$ is empty.




## Example 3.4: C1 is difficult to prove

Show, that the verification, whether a set $\mathsf{red}(s)$ satisfies the condition C1, is at least so difficult, such as the verification whether a state $r$ is reachable in the corrisponding complete Kripke structure, starting from an initial state $s$.

Show how an algorithm that verifies C1, may help to decide if holds $s \rightarrow^* r$, by declare a kripke structure $\mathcal{K}'$ and an ample set $\mathsf{red}(s)$ for $s$, that satisfies then the condition C1 precisely, whether $s \rightarrow^* r$ holds in $\mathcal{K}$.