RWTH RHEINISCH-WESTFÄLISCHE TECHNISCHE HOCHSCHULE AACHEN

LEHRSTUHL FÜR INFORMATIK 2
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Introduction to Model Checking
Winter term 2013/2014

– Series 5 –

Hand in on November 27th before the exercise class or in the box in front of the chair's secretary's office.

Exercise 1 **(2 points)**

Let $AP = \{a, b\}$ and let P be the LT property of all infinite words $\sigma = A_0 A_1 A_2 \cdots \in \left(2^{AP}\right)^\omega$ such that there exists $n \geq 0$ with $a \in A_i$ for $0 \leq i < n$, $\{a, b\} = A_n$ and $b \in A_j$ for infinitely many $j \geq 0$. Provide a decomposition $P = P_{safe} \cap P_{live}$ into a safety and a liveness property.

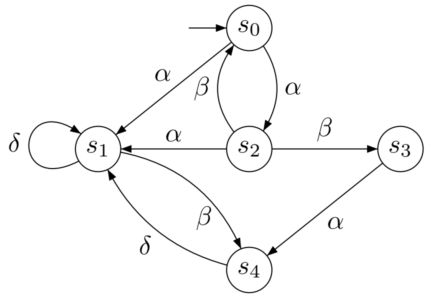
Exercise 2 **(3 points)**

Consider the transition system TS on the right (where atomic propositions are omitted). Decide which of the following fairness assumptions $\mathcal{F}_i$ are realizable for TS. Justify your answers!

a) $\mathcal{F}_1 = (\{\{\alpha\}\}, \{\{\delta\}\}, \{\{\alpha, \beta\}\})$

b) $\mathcal{F}_2 = (\{\{\alpha, \delta\}\}, \{\{\alpha, \beta\}\}, \{\{\delta\}\})$

c) $\mathcal{F}_3 = (\{\{\alpha, \delta\}, \{\beta\}\}, \{\{\alpha, \beta\}\}, \{\{\delta\}\})$



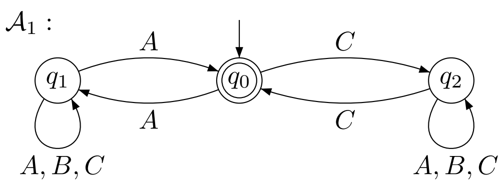
Exercise 3 **(2 points)**

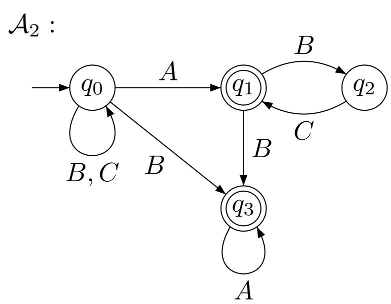
a) Find nondeterministic Büchi automata that accept the following ω-regular languages:

(a) $L_1 = \{\sigma \in \{A, B\}^\omega \mid \sigma$ contains ABA infinitely often, but AA only finitely often$\}$

(b) $L_2 = \mathcal{L}_\omega\left((AB + C)^*((AA + B)C)^\omega + (A^*C)^\omega\right)$

b) Consider the following NBA $\mathcal{A}_1$ and $\mathcal{A}_2$ over the alphabet $\Sigma = \{A, B, C\}$:

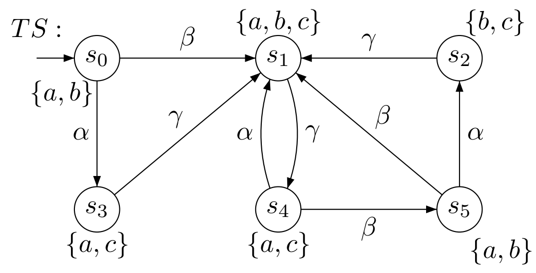




Find ω-regular expressions for the languages accepted by $\mathcal{A}_1$ and $\mathcal{A}_2$, respectively.

Exercise 4 **(3 points)**

Consider the following transition system TS



and the regular safety property

$$P_{safe} = \begin{array}{c}\text{“always if } a \text{ is valid and } b \wedge \neg c \text{ was valid somewhere before,} \\ \text{then neither } a \text{ nor } b \text{ holds thereafter at least until } c \text{ holds”}\end{array}$$

As an example, it holds:

$$\{b\}\emptyset\{a,b\}\{a,b,c\} \in pref(P_{safe})$$
$$\{a,b\}\{a,b\}\emptyset\{b,c\} \in pref(P_{safe})$$
$$\{b\}\{a,c\}\{a\}\{a,b,c\} \in BadPref(P_{safe})$$
$$\{b\}\{a,c\}\{a,c\}\{a\} \in BadPref(P_{safe})$$

Questions:

a) Define an NFA $\mathcal{A}$ such that $\mathcal{L}(\mathcal{A}) = MinBadPref(P_{safe})$.

b) Decide whether $TS \models P_{safe}$ using the $TS \otimes \mathcal{A}$ construction.
Provide a counterexample if $TS \not\models P_{safe}$.