Universität Duisburg-Essen
Faculty of Engineering
Department of Computer Science and Applied Cognitive Science
Theoretical Computer Science Group
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Exercise sheet 4

Automaten und Formale Sprachen

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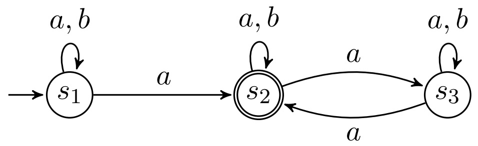
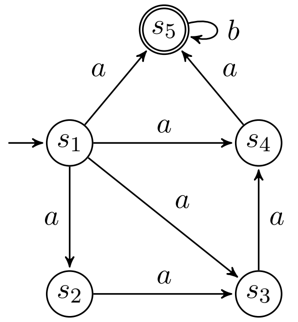
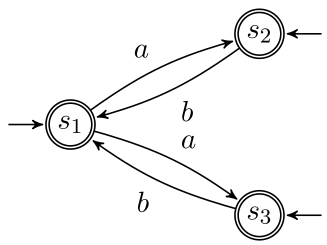
Submission[1]: Monday, May 13, 2019, 10:00 Uhr

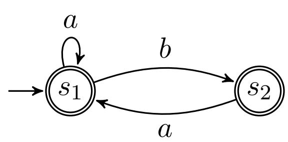
Exercise 11: Languages of NFA (4 points)

Let $\Sigma = \{a, b\}$. In the following there are four non-deterministic finite automata (NFA) M_i. For every M_i, give the language accepted by the automaton.

(a) M_1:  (1 p)

(b) M_2:  (1 p)

(c) M_3:  (1 p)

(d) M_4:  (1 p)

[1] *Options to submit your solutions:* Letterbox next to LF 259 (Campus Duisburg) or via Moodle `https://moodle.uni-due.de/course/view.php?id=15777`

Exercise 12: NFAs for regular languages (6 points)

Give a (non-deterministic) finite automaton for each of the following languages over the alphabet $\Sigma = \{a, b, c\}$, which accepts *exactly* the given language.

Note: Do *not* use ε-edges in your NFAs.

(a) The set of all words which end with ccb. (1.5 p)

(b) The set of all words, where the words length is divisible by two or three (or both). (1.5 p)

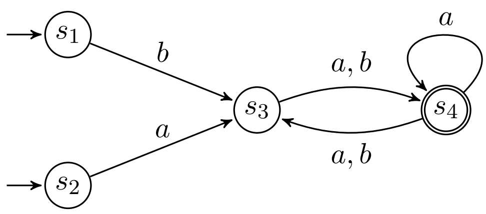
(c) The set of all words of the form $(aa)^n$ or $(bbb)^n$. (1.5 p)

(d) The set of all words which can be constructed by an arbitrary concatenation of words of the set $\{aa, ab, cba\}$. This also includes concatenating one of the words zero times, i.e. the empty word is also in the language. (1.5 p)
Note: This language can also be written as $L((aa \mid ab \mid cba)^*)$.

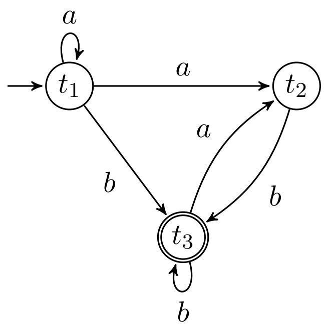
Exercise 13: Getting rid of NFAs (5 points)

Let the following non-deterministic automata N_1 and N_2 with input alphabet $\Sigma = \{a, b\}$ be given:

N_1:



N_2:



Convert N_1 and N_2 to deterministic automata M_1 and M_2 by means of the power set construction.
Note: You only have to specify reachable states.

Exercise 14: Conversion to NFAs (5 points)

Let the following regular grammars $G_1 = (\{S, X\}, \Sigma, P_1, S)$ and $G_2 = (\{S, A, B, C\}, \Sigma, P_2, S)$ over the alphabet $\Sigma = \{a, b, c\}$ be given, where P_1 is defined as

$$S \to aX \mid bX \mid cX \qquad\qquad X \to aS \mid a$$

and P_2 is defined as:

$$S \to cS \mid aA \mid bB \mid a \mid b \mid c \qquad\qquad A \to cA \mid bC \mid b \mid c$$
$$C \to cC \mid c \qquad\qquad B \to cB \mid aC \mid a \mid c$$

(a) Describe, in words or in set notation, the languages L_1 and L_2, which are generated by the grammars G_1 and G_2. (2 p)

(b) Construct a nondeterministic finite automata for each language L_1 and L_2, by means of the procedure presented in the lecture. (3 p)

Note: First converting the grammars to automata can help you to understand their languages.

(In total, there are **20** points in this exercise sheet.)