Model Checking WS 2012: Assignment 1

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Exercise 1

a) Graphically describe an automaton which accepts the numbers 20 to 28 written in Roman style, i.e., the language is \{ XX, XXI, XXII, XXIII, XXIV, XXV, XXVI, XXVII, XXVIII \}.

b) Given the infinite sets of words \( abc, abcabc, abcabcabc, \ldots, a, a, a, a, a, a, a, a, \ldots \) Graphically specify the automaton which accepts exactly the words described above. Define the automaton as 5-tupel. Is it deterministic? Is it complete?

Exercise 2

Let \( Q := (S_Q, I_Q, \Sigma_Q, T_Q, F_Q) \) be a finite automaton where \( S_Q := \{ A, B, C \} \), \( I_Q := \{ A \} \), \( \Sigma_Q := \{ a, b \} \), \( T_Q := \{ (A, b, B), (B, a, B), (B, a, C), (C, b, C), (C, b, A) \} \) and \( F_Q := \{ A \} \).

Let \( R := (S_R, I_R, \Sigma_R, T_R, F_R) \) be a finite automaton where \( S_R := \{ 1, 2, 3 \} \), \( I_R := \{ 1 \} \), \( \Sigma_R := \{ a, b \} \), \( T_R := \{ (1, b, 2), (1, b, 3), (2, b, 2), (3, a, 3), (3, a, 2), (1, a, 3), (2, a, 2) \} \) and \( F_R := \{ 1 \} \).

Draw the product automaton \( P := Q \times R \) for automata \( Q \) and \( R \) as defined above.

Exercise 3

For finite automaton \( A \) as defined below, check if \( A \) is deterministic, complete and if \( L(K(A)) = L(A) \) holds. Justify your answers. Show the power automata.

a) Let \( A := (S, I, \Sigma, T, F) \) be a finite automaton where \( S := \{ A, B \} \), \( I := \{ A \} \), \( \Sigma := \{ a, b \} \), \( T := \{ (A, a, B), (A, b, B), (B, a, B), (B, b, B), (B, a, A), (B, a, B) \} \) and \( F := \{ A \} \).

b) Let \( A := (S, I, \Sigma, T, F) \) be a finite automaton where \( S := \{ A, B \} \), \( I := \{ A, B \} \), \( \Sigma := \{ a, b \} \), \( T := \{ (A, b, B), (B, b, B), (B, a, A) \} \) and \( F := \{ A \} \).

Exercise 4

Let \( A \) and \( B \) be two finite automata and \( P := A \times B \) the product automaton of \( A \) and \( B \). Do the following two statements hold? If so then give a proof sketch for the claim. Otherwise, provide a concrete counterexample, i.e., concrete \( A, B \) and \( P \) refuting the claim.

a) If both \( A \) and \( B \) are deterministic then \( P \) is deterministic.
b) If $P$ is deterministic then both $A$ and $B$ are deterministic.

**Exercise 5**

a) Given two FA $A_I$ and $A_S$ describing an implementation $I$ and specification $S$, respectively. Explain in detail how to check whether $I$ conforms to $S$, given $A_I$ and $A_S$. Illustrate your explanations using set diagrams.

Check conformance of implementation $I$ and specification $S$ given as FA on the right.

**Exercise 6**

Check conformance of implementation $I$ and specification $S$ given as FA on the right.

**Bonus Exercise**

Read sections I and III “Software Model Checking” in the survey on software verification\(^1\) and describe the approach of counterexample-guided abstraction refinement (CEGAR).

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\(^1\)V. D’Silva, D. Kroening, G. Weissenbacher: A Survey of Automated Techniques for Formal Software Verification. IEEE TCAD 27(7), 2008. The article can be found in KUSSS.