Formal Models SS 2017: Assignment 9

Institute for Formal Models and Verification, JKU Linz

Due 08.06.2017

To indicate that you solved an exercise and that you can present it in the exercise group, tick it off in our MOODLE course until **11am on the day of the exercise**.

Exercise 33 Draw a computation tree for each of the following CTL formulae (see also lecture slides 63-65 and lecture video "Lecture 12.June 2014" (min 29:00-32:30)).

1. $\mathbf{EF}\, p$	2. $\mathbf{EX}\, p$	3. $\mathbf{EG}\, p$
4. $\mathbf{AX}\, p$	5. $\mathbf{A}[p\, \mathbf{U}\, q]$	6. $\mathbf{E}[p\, \mathbf{U}\, q]$

Exercise 34

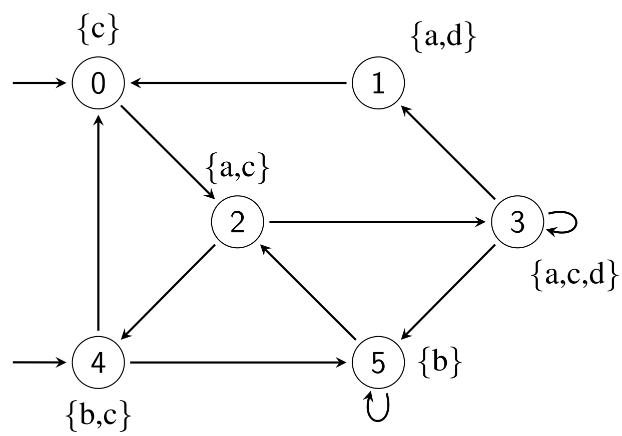
Given Kripke structure K as shown below. Which of the following CTL formulas hold in K?

a) $\mathbf{AG}\,(\neg a \rightarrow c)$

b) $\mathbf{E}\,((c \vee d)\,\mathbf{U}\,b)$

c) $\mathbf{AG}\,((c \wedge d) \rightarrow \mathbf{EX}\,a)$

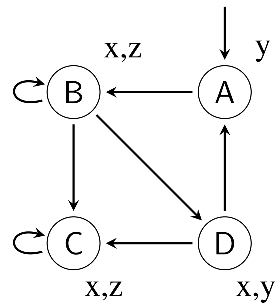
d) $\mathbf{EF}\,((a \wedge \neg c) \rightarrow \mathbf{EX}\,c)$



Exercise 35

Given trace π in Kripke structure on the right and LTL formula f. Decide if f holds in π, i.e., $\pi \models f$.

Trace π	Formula f	yes	no
$(A,B,D)^\omega$	$\mathbf{GF}(\mathsf{x})$	☐	☐
$A,B,(C)^\omega$	$\mathbf{GF}(\mathsf{y})$	☐	☐
$A,(B)^\omega$	$\mathbf{FG}(\mathsf{x})$	☐	☐
$(A,B,D)^\omega$	$(\mathsf{x}\,\mathbf{U}\,\mathsf{y})$	☐	☐
$(A,B,D)^\omega$	$\mathbf{G}(\mathsf{y} \vee \mathbf{X}\mathsf{x})$	☐	☐



Exercise 36

Given two Kripke structures K_1, K_2.

We call a temporal logic L *compositional* if $K_1 \models f$ and $K_2 \models g$ implies that $K_1 \times K_2 \models f \wedge g$ where $f, g \in L$ and $K_1 \times K_2$ is the product of K_1 and K_2.

We assume that the two Kripke structures are defined over the same set of atomic propositions. The definition of the product of Kripke structures is similar as for automata plus $L((s_1, s_2)) = L_1(s_1) \cup L_2(s_2)$. Note that the union of the labels of two states can result in a contradiction, e.g, a and $\neg a$ hold. In such a case, the state is not included in the product.

Is CTL compositional? If yes, prove that it is compositional, if no, give an example showing that CTL is not compositional.