LTL + CTL Model checking Assignment

Franco Raimondi

Academic Year 2015/16

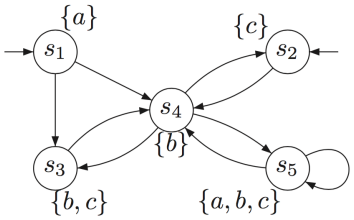
Instructions

Reply to all questions justifying your answers as clearly as possible. Send an electronic (also handwritten and scanned, but readable) version to

f.raimondi <at> mdx.ac.uk
by **Friday 10th June 2016 23.59**

Exercise 1

a) Consider the following transition system:



Find the *set of states* in which the following formulae hold and motivate your answer:

- GFc
- $\neg a \rightarrow Xc$
- $aU(G(b \vee c))$

b) Provide a NBA for each of the following LTL formulae:

- $G(a \vee \neg Xb)$
- $Fa \vee Fb$
- $GF(a \vee Fb)$

Exercise 2

Consider the CTL model $M = (S, R_t, L)$, where:

- $S = (s_0, s_1, s_2, s_3)$
- $R_t = \{(s_0, s_0), (s_0, s_1), (s_0, s_3), (s_1, s_3), (s_2, s_2), (s_2, s_1), (s_2, s_0), (s_3, s_1), (s_3, s_2)\}$
- $L(s_0) = \{p, q\}$; $L(s_1) = \{q\}$; $L(s_2) = \{q\}$; $L(s_3) = \{p\}$

Provide a graphical representation of the model, establish whether or not the following formulae hold and motivate your answer:

1. $M, s_1 \models EX(q) \wedge EX(p)$
2. $M, s_0 \models EG(p)$
3. $M, s_0 \models AX(q)$
4. $M, s_1 \models EG(p \vee q)$
5. $M, s_2 \models EG(p)$
6. $M, s_3 \models EX(AX(q))$

Exercise 3

a) Encode the following English requirements using CTL

1. "From every state, it is possible to reach a state in which p holds in at most 2 steps"
2. "For all states, if p is true in that state, then q will **not** be true in the next state, but q will eventually be true in the future"

b) Establish whether or not the following equivalences hold. If they hold, provide a short proof. If they do not hold, draw a simple model where the equivalence does not hold in at least one state.

1. $AX(p) \wedge (\neg EF(\neg p)) \equiv AG(p)$.
2. $AF(p) \equiv \neg AF(\neg p)$.

Exercise 4

Consider the Boolean expression $a \rightarrow (b \vee \neg c)$.
a) Given the variable ordering $\{a, b, c\}$, draw the corresponding Ordered Binary Decision Diagram (you should include all the reduction steps).
b) Given the variable ordering $\{b, c, a\}$, draw the corresponding Ordered Binary Decision Diagram (you should include all the reduction steps).