ALBERT-LUDWIGS-
UNIVERSITÄT FREIBURG

A. Podelski
S. Bogomolov

Tutorials for Cyber-Physical Systems - Hybrid Models
Exercise sheet 2

Consider the following state transition system over the set of atomic propostions $\{\, a, b, c \,\}$:
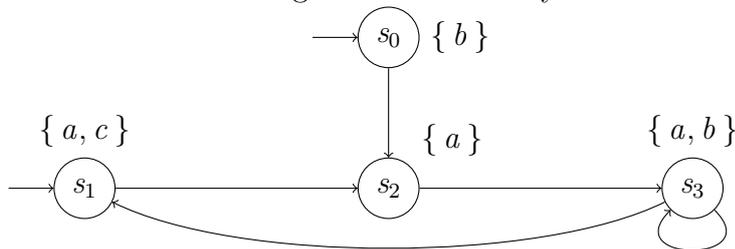
Exercise 1: States satisfying LTL-formulae

Give for each of the following LTL-formulae the set of states for which the formula is satisfied. Note that state s satisfies a LTL formula if every path starting in s satisfies this formula.

(a) $a \wedge \mathsf{X} b$ (b) $\mathsf{X}\, c$ (c) $\mathsf{X}\,\mathsf{X} c$

(d) $a \,\mathsf{U}\, b$ (e) $b \,\mathsf{U}\, a$ (f) $b \,\mathsf{U}\, \mathsf{G} a$

(g) $a \,\mathsf{U}\, \mathsf{G} b$ (h) $\neg(a \,\mathsf{U}\, \mathsf{G} b)$ (i) $(\mathsf{F} c) \,\mathsf{U}\, (\mathsf{G} a)$

(j) $\mathsf{F}\,\mathsf{G} a$ (k) $\mathsf{G}\,\mathsf{F} b$ (l) $\mathsf{G}\,\mathsf{F} c$

Exercise 2: States satisfying CTL-formulae

Give for each of the following CTL-formulae the set of states for which the formula is satisfied.

(a) $a \wedge \mathsf{E}\,\mathsf{X}\, b$ (b) $\mathsf{E}\,\mathsf{X} c$ (c) $\mathsf{A}\,\mathsf{X}\,\mathsf{E}\,\mathsf{X} c$

(d) $\mathsf{A}\,(a \,\mathsf{U}\, b)$ (e) $\mathsf{A}\,(b \,\mathsf{U}\, a)$ (f) $\mathsf{A}\,(b \,\mathsf{U}\, \mathsf{A}\,\mathsf{G}\, a)$

(g) $\mathsf{A}\,(a \,\mathsf{U}\, \mathsf{E}\,\mathsf{G}\, b)$ (h) $\neg\,\mathsf{E}\,(a \,\mathsf{U}\, \mathsf{E}\,\mathsf{G}\, b)$ (i) $\mathsf{A}\,((\mathsf{E}\,\mathsf{F}\, c) \,\mathsf{U}\, (\mathsf{A}\,\mathsf{G}\, a))$

(j) $\mathsf{A}\,\mathsf{F}\,\mathsf{A}\,\mathsf{G} a$ (k) $\mathsf{A}\,\mathsf{G}\,\mathsf{A}\,\mathsf{F} b$ (l) $\mathsf{A}\,\mathsf{G}\,\mathsf{E}\,\mathsf{F} c$

Exercise 3: Stating properties in LTL

Consider a lift system that services N floors numbered 0 through $N - 1$. Assume atomic propostion $door(i)$ indicates that the doors on the i-th floor are open, $lift(i)$ indicates

that the lift is at floor i, and $req(i)$ indicates that the request button at floor i was pressed and is lit. In the lift cabin there are N buttons for the floors and $send(i)$ indicates that the i-th send button is lit.

State the following properties in LTL.

(a) A floor door is never open if the cabin is not present at that floor.

(b) A requested floor will be served sometime.

(c) The lift returns to floor 0 infinitely often.

(d) The lift does not move unless there is some request.