Embedded Systems

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Homework 8

Chapter 13 - Invariants and Temporal Logic

June 1, 2024

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Question 2

Consider the following state machine:

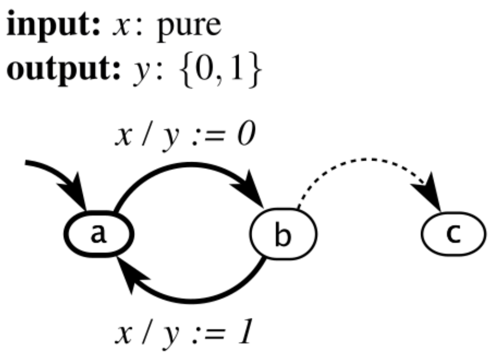

Figure 1: State machine of Q2

(Recall that the dashed line represents a default transition.) For each of the fol lowing LTL formulas, determine whether it is true or false, and if it is false, give a counterexample:

(a) $x \implies \mathbf{F}\mathbf{b}$

(b) $\mathbf{G}(x \implies \mathbf{F}(y = 1))$

(c) $(\mathbf{G}x) \implies \mathbf{F}(y = 1)$

(d) $(\mathbf{G}x) \implies \mathbf{GF}(y = 1)$

(e) $\mathbf{G}((b \wedge \neg x) \implies \mathbf{FG}c)$

(f) $\mathbf{G}((b \wedge \neg x) \implies \mathbf{G}c)$

(g) $(\mathbf{GF}\neg x) \implies \mathbf{FG}c$

Soloution

(Recall that the dashed line represents a default transition.) For each of the following LTL formulas, determine whether it is true or false, and if it is false, give a counterexample:

(a)	$x \implies \mathbf{Fb}$	T
(b)	$\mathbf{G}(x \implies \mathbf{F}(y=1))$	F
(c)	$(\mathbf{G}x) \implies \mathbf{F}(y=1)$	F
(d)	$(\mathbf{G}x) \implies \mathbf{GF}(y=1)$	F
(e)	$\mathbf{G}((b \wedge \neg x) \implies \mathbf{FG}c)$	T
(f)	$\mathbf{G}((b \wedge \neg x) \implies \mathbf{G}c)$	F
(g)	$(\mathbf{GF}\neg x) \implies \mathbf{FG}c$	F

(a)

$$\begin{array}{ccccc} & x/1 & & \text{True} & \\ a & \implies & b & \implies & c \end{array}$$

(b)

$$\begin{array}{ccccc} & x/1 & & \text{True} & \\ a & \implies & b & \implies & c \end{array}$$

(c)

$$\begin{array}{ccccc} & x/1 & & \text{True} & \\ a & \implies & b & \implies & c \end{array}$$

(d)

$$\begin{array}{ccccc} & x/1 & & \text{True} & \\ a & \implies & b & \implies & c \end{array}$$

(e)

$$\begin{array}{ccc} & b \wedge \neg x/ & \\ b & \implies & b \ldots \end{array}$$

(f)

$$\begin{array}{ccc} & \neg x/ & \\ a & \implies & a \ldots \end{array}$$

Question 4

This problem is concerned with specifying in linear temporal logic tasks to be per formed by a robot. Suppose the robot must visit a set of n locations $l_1, l_2, ..., l_n$. Let p_i be an atomic formula that is $t$rue if and only if the robot visits location l_i.

Give LTL formulas specifying the following tasks:

(a) The robot must eventually visit at least one of the n locations.

(b) The robot must eventually visit all n locations, but in any order.

(c) The robot must eventually visit all n locations, in the order $l_1, l_2, ..., l_n$.

Soloution

(a) $\mathbf{F}p_1 \vee \mathbf{F}p_2 \vee \mathbf{F}p_3 \vee \ldots \vee \mathbf{F}p_n$

1. $\mathbf{F}p_1 \wedge \mathbf{F}p_2 \wedge \mathbf{F}p_3 \wedge \ldots \wedge \mathbf{F}p_n$

2. $\mathbf{F}(p_n \wedge \ldots \mathbf{F}(p_3 \wedge \mathbf{F}(p_2 \wedge \mathbf{F}p_1)))$

End of Homework 8