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Hand in until November 6th, 2019
15:59 via the post boxes
Discussion: November 11th, 2019

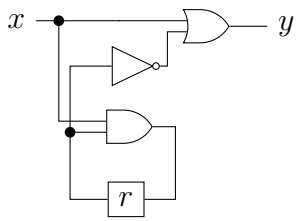
Tutorial for Cyber-Physical Systems - Discrete Models
Exercise Sheet 3

The goal of this exercise sheet is to understand transition systems, and how they can be used to model cyber-physical systems. The exercises are meant to train you in translating between different formalisms, both graphical and mathematical.

Exercise 1: Hardware Circuit and Transition System — 4 Points

The goal of this exercise is to go from a pictorial representation of a hardware system to a formal model.

Consider the following sequential hardware circuit.



Draw the transition system of the hardware circuit. That is, the states are the valuations of the input x and the register r. The transitions represent the stepwise behavior where the value of the input bit x may or may not change in each step.
You may assume that initially the register r has the value `false`.

For your reference:  = AND gate, = OR gate,  = NOT gate

Exercise 2: Transition Systems — 6 Points

The goal of this exercise is to understand the connection between mathematical notation and graphical representation of transition systems.

(a) Let $\mathcal{T} = (S, Act, \to, S_0, AP, L)$ be a transition system with

- the set of states $S = \{\texttt{locked}, \texttt{checking}, \texttt{opened}\}$,
- the set of action $Act = \{\texttt{insert\_ticket}, \texttt{unlock}, \texttt{enter}, \texttt{error}\}$,
- the transition relation

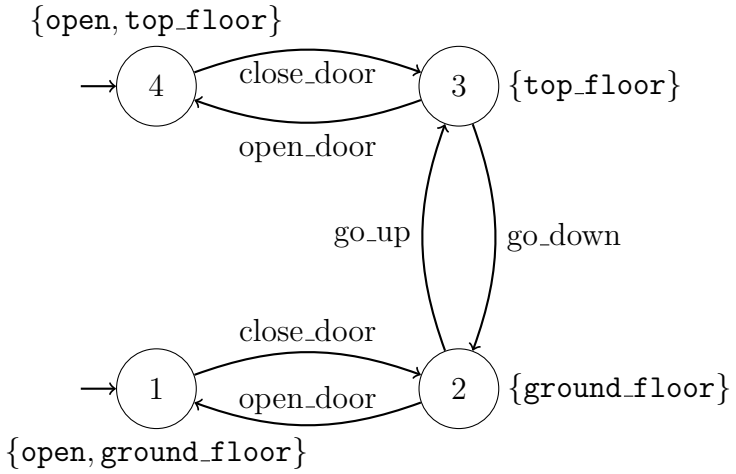
$$\to = \{(\texttt{locked}, \texttt{insert\_ticket}, \texttt{checking}), (\texttt{checking}, \texttt{unlock}, \texttt{opened}), (\texttt{opened}, \texttt{enter}, \texttt{locked}), (\texttt{checking}, \texttt{error}, \texttt{locked})\},$$

- the initial states $S_0 = \{\texttt{locked}\}$,

- the set of atomic propositions $AP = \{\texttt{light\_red}, \texttt{light\_green}\}$,
- and the labeling function L with $L(\texttt{locked}) = \{\texttt{light\_red}\}$, $L(\texttt{checking}) = \emptyset$ and $L(\texttt{opened}) = \{\texttt{light\_green}\}$.

Draw this transition system. Can you see what cyber-physical system it models?

(b) The transition system shown below models an elevator. Give the corresponding mathematical definition, i.e., define the tuple $\mathcal{T} = (S, Act, \rightarrow, S_0, AP, L)$ that is described by the picture, in the style of (a).



In which states is the elevator door closed?