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Summer Semester 2016
16.06.2016

Model Checking – Exercise sheet 8

Exercise 8.1

Given two CTL formulas ϕ_1 and ϕ_2, we write $\phi_1 \Rightarrow \phi_2$ iff for every Kripke structure $\mathcal{K}$ we have $(\mathcal{K} \models \phi_1) \Rightarrow (\mathcal{K} \models \phi_2)$. Furthermore, we define an implication graph as a directed graph in which nodes are CTL formulas and there is an edge from ϕ_1 to ϕ_2 iff $\phi_1 \Rightarrow \phi_2$.

Let $AP = \{p\}$.

(a) Draw an implication graph with the nodes: $\mathbf{EF}\,\mathbf{EF}\,p$, $\mathbf{EG}\,\mathbf{EG}\,p$, $\mathbf{AF}\,\mathbf{AF}\,p$, $\mathbf{AG}\,\mathbf{AG}\,p$.

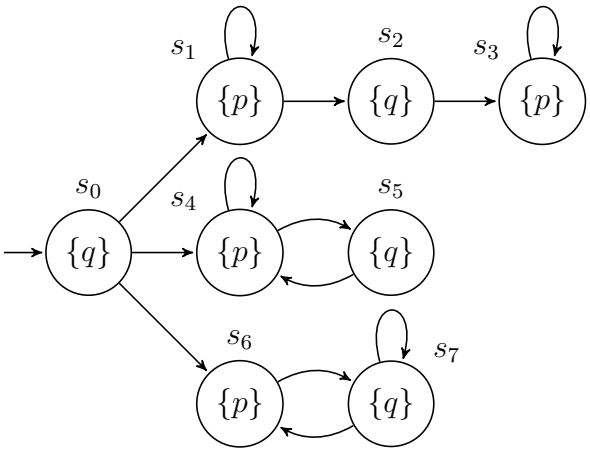
(b) Add to the graph in (a) the following CTL formulas: $\mathbf{AF}\,\mathbf{EF}\,p$, $\mathbf{EF}\,\mathbf{AF}\,p$, $\mathbf{AG}\,\mathbf{EG}\,p$, $\mathbf{EG}\,\mathbf{AG}\,p$.

(c) For each implication $\phi_1 \Rightarrow \phi_2$ in (b), give a Kripke structure $\mathcal{K}$ that only satisfies ϕ_2 but not ϕ_1, i.e. give a $\mathcal{K}$ such that $\mathcal{K} \models \phi_2$ but $\mathcal{K} \not\models \phi_1$.

(d) Complete the graph in (b) with the nodes: $\mathbf{AG}\,\mathbf{AF}\,p$, $\mathbf{AF}\,\mathbf{AG}\,p$, $\mathbf{AG}\,\mathbf{EF}\,p$, $\mathbf{EG}\,\mathbf{AF}\,p$, $\mathbf{AF}\,\mathbf{EG}\,p$, $\mathbf{EF}\,\mathbf{AG}\,p$, $\mathbf{EF}\,\mathbf{EG}\,p$, $\mathbf{EG}\,\mathbf{EF}\,p$.

Exercise 8.2

Consider the following Kripke structure over $AP = \{p, q\}$:



a) Compute $[\![\mathbf{EG}\,q]\!]$ and $[\![\mathbf{EF}\,q]\!]$.

b) Compute $[\![\mathbf{AG}\,\mathbf{AF}\,p]\!]$ and $[\![\mathbf{AF}\,\mathbf{AG}\,p]\!]$.