Prof. Dr. Ir. J.-P. Katoen
Dr. T. Han and A. Mereacre

Introduction to Model Checking
Summer term 2010

– Series 9 –

Hand in on July 7 before the exercise class.

Exercise 1 (4 points)

Express the following properties as CTL formulas over $AP = \{a, b, c\}$ and provide a justification. For more complicated formulas, also comment on their subformulas!

a) There exists a path on which for every state s it holds: there exists a path which starts in s and on which eventually a holds and in the next state, $\neg a$ holds.

b) There exists a state s for which it holds: a is true and on all paths starting from s, c holds as long as b does not hold.

c) On every path it holds for every state: a is valid iff (b is valid and in the previous state, c is valid). *Hint*: Note that this excludes the case where a is valid at the beginning.

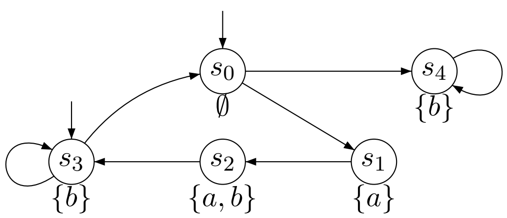
Exercise 2 (2 points)

Provide two finite transition systems TS_1 and TS_2 (without terminal states, and over the same set of atomic propositions) and a CTL formula Φ such that $Traces(TS_1) = Traces(TS_2)$ and $TS_1 \models \Phi$, but $TS_2 \not\models \Phi$.

Exercise 3 (4 points)

Consider the following CTL formulas and the transition system TS outlined on the right:

$$\Phi_1 = \forall(a \mathsf{U} b) \vee \exists\bigcirc(\forall\Box b)$$
$$\Phi_2 = \forall\Box\forall(a \mathsf{U} b)$$
$$\Phi_3 = (a \wedge b) \rightarrow \exists\Box\exists\bigcirc\forall(b \mathsf{W} a)$$
$$\Phi_4 = (\forall\Box\exists\Diamond\Phi_3)$$



Give the satisfaction sets $Sat(\Phi_i)$ and decide whether $TS \models \Phi_i$ holds ($1 \leq i \leq 4$).

Exercise 4 (2 + 2 points)

Prove or disprove the following implications:

a) Let $\Phi_1 = \forall\Diamond a \vee \forall\Diamond b$ and $\Phi_2 = \forall\Diamond(a \vee b)$.
Prove or disprove the following implications: $\Phi_1 \Longrightarrow \Phi_2$ and $\Phi_2 \Longrightarrow \Phi_1$.

b) Now consider $\Psi_1 = \exists(a \mathsf{U} \exists(b \mathsf{U} c))$ and $\Psi_2 = \exists(\exists(a \mathsf{U} b) \mathsf{U} c)$.
Again, prove or disprove $\Psi_1 \Longrightarrow \Psi_2$ and $\Psi_2 \Longrightarrow \Psi_1$.