

Modal μ -Calculus + Regular Expressions

Supplementary Exercises

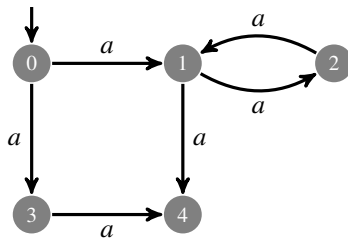
January 4, 2011

1 Hennessy-Milner Logic with Blocks of Equations

Exercise 1 (Exercise 6.8.3 of Aceto) Compute the least and greatest solutions of the system of equations

$$X = [a]Y \quad Y = \langle a \rangle X$$

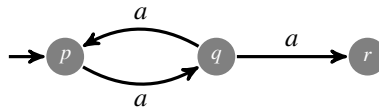
with respect to the following labeled transition system



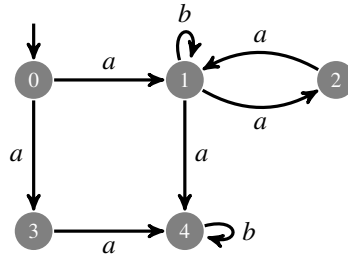
Exercise 2 (Exercise 6.9 of Aceto) Compute the solution of the system of equations

$$X \stackrel{\max}{=} [a]Y \quad Y \stackrel{\max}{=} \langle a \rangle X$$

with respect to the following labeled transition system



Exercise 3 Express the following property: “It is always possible to execute an a -transition such that subsequently b -actions can be executed forever”. Compute for which states of the following labeled transition system the property holds.



2 Regular alternation-free modal μ -calculus

Exercise 4 Translate the following properties into the modal μ -calculus without recursion, where the set of actions is $\{a, b, c\}$:

1. $[true]true$,
2. $\langle true^* \rangle [\bar{c}] false$,
3. $[true^* . a.\bar{b} + \bar{c}.a] false$.

Exercise 5 Express the property that as long as no *error* happens, a deadlock will not occur. First use the modal μ -calculus extended with regular expressions and then eliminate regular expressions.

Exercise 6 Express the property that after a *send* action a *receive* action is possible as long as it has not happened yet. First use the modal μ -calculus extended with regular expressions and then eliminate regular expressions.

Exercise 7 Express the property that whenever an *a* happens, a *b* can happen, except if it is canceled by a *c*. First use the modal μ -calculus extended with regular expressions and then eliminate regular expressions.

Exercise 8 Consider the following simplified railroad system. For the system the following events are modeled:

- *enter*: a train enters the crossing
- *leave*: a train leaves the crossing
- *down*: the gate is closed
- *up*: the gate is opened

Express the following properties by means of temporal logic formulas:

1. When the gate is up it can be closed. When the gate is down it can be opened.
2. The gate must remain closed until the train has left the crossing.
3. The closing and opening of the gate only occur alternatingly.
4. After entering the crossing, the train will eventually leave the crossing.
5. It must never be the case that the train is in the crossing when the gate is opened.