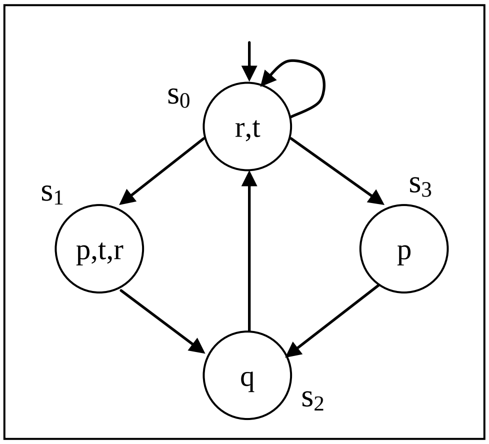
Formal methods Exercises 1

1) Given a transition system M = (S, S_0, L, R) (in the figure),
   a) complete the specification of M by substituting "..." with right symbols from figure;
   b) draw the computation tree of M up to 4 levels starting from s_0.



S = {s0, … , s3}
S_0= {s0}
L : l(s0) = {r},
l(s1) = {p, t, r}
l(s2) = {...}
l(s3) = {...}
R = {..., <s2, s0> ,.....}

2) Specify the transition relation R of model M (in figure) in symbolic form.
   Example
   Transition <s2, s0> symbolically $R_{2,0} \equiv \neg p \wedge q \wedge \neg r \wedge \neg t \wedge \neg p' \wedge \neg q' \wedge r' \wedge t'$

3) a) Check the satisfiability of following CTL formulas for the transition system M (see figure)
   b) transform the formulas to base form (using EX, EG, EU and negation).

   a) M, s_0 |= EF(q)

   b) M, s_0 |= EG(r)

   c) M, s_2 |= AG(r)

   d) M, s_2 |= ¬EX(r)

   e) M, s_0 |= A((t ∨ p) U q)

   f) M, s_0 |= E(r --> (t ∧¬ q))

   Where --> denotes "leads to" operator not implication!

3. Given a symbolic state: $\varphi \equiv \neg x_1 \wedge \neg x_2$
   and transition relation $R \equiv x_0 \wedge (x_1 \Rightarrow x_2) \wedge \neg x_0' \wedge \neg x_1' \wedge \neg x_2'$,
   find symbolic pre-image $EX(\varphi) \equiv \exists V' (R \wedge \varphi [V' / V])$ by showing separately $[V' / V]$ - substitution and ∃-quantifier elimination.