

HW #5: Due June 21st 23:59

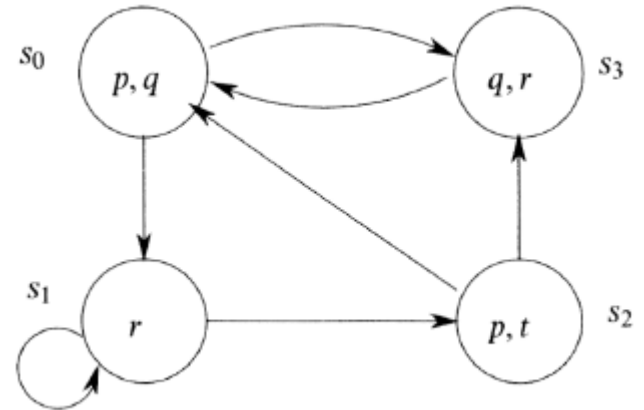
1. Prove that $\phi \text{ U } \psi \equiv \psi \text{ R } (\phi \vee \psi) \wedge \text{ F } \psi$
2. Prove that for all paths π of all models, $\pi \models \phi \text{ W } \psi \wedge \text{ F } \psi$ implies $\pi \models \phi \text{ U } \psi$

3. (a) Beginning from state s_0 , unwind this system into an infinite tree, and draw all computation paths up to length 4 (= the first four layers of that tree).

(b) Make the following checks $\mathcal{M}, s_0 \models \phi$, where ϕ is listed below. For that you need to explain why the check holds, or what reasons there are for its failure:

- * (i) $\neg p \rightarrow r$
- (ii) $\text{AF } t$
- * (iii) $\neg \text{EG } r$
- (iv) $\text{E}(t \text{ U } q)$
- (v) $\text{AF } q$
- (vi) $\text{EF } q$
- (vii) $\text{EG } r$
- (viii) $\text{AG}(r \vee q)$.

(c) Make the same checks as in (b) but now for state s_2 .



4. Express the following properties in CTL and LTL whenever possible. If neither is possible, try to express the property in CTL*
- Whenever **p** is followed by **q** (after finitely many steps), then the system enters an ‘interval’ in which no **r** occurs until **t**
 - Event **p** precedes **s** and **t** on all computation paths. (you may find it easier to code the negation of that specification first)
 - After **p**, **q** is never true (Where this constraint is meant to apply on all computation paths)
 - Between the events **q** and **r**, event **p** is never true.
 - Transitions to states satisfying **p** occur at most twice.
 - Property **p** is true for every second state along a path
5. Find a transition system which distinguishes the following pairs of CTL* formulas (i.e. show that they are *not* equivalent):
- $AF G p$ and $AF AG p$
 - * $AG F p$ and $AG EF p$
 - $A[(p U r) \vee (q U r)]$ and $A[(p \vee q) U r]$
 - * $A[X p \vee XX p]$ and $AX p \vee AX AX p$
 - $E[GF p]$ and $EG EF p$.