LIACS — Leiden University

Examination Program Correctness — 21 August 2008, 10:00 - 13:00

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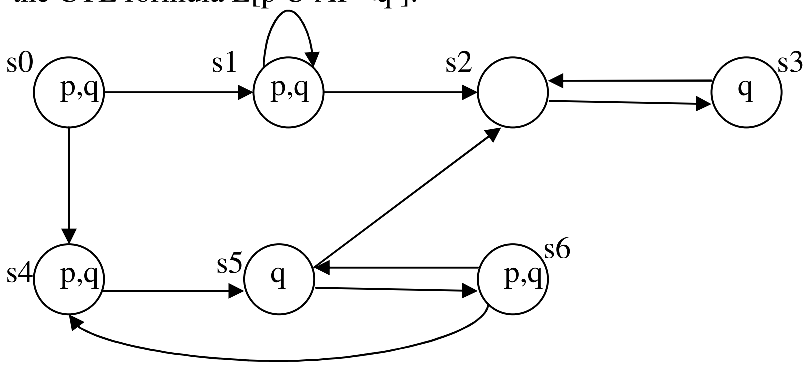
1. **[1,5 points]**
   a) The temporal connectives X and U form a *minimal set* of for LTL. Show how the other LTL temporal connectives G , F , and R can be defined in terms of the above minimal set.
   b) Draw a Kripke structure whose initial state satisfies $Fp \wedge Fq$ but not $F(p \wedge q)$.

2. **[1 point]** Let ϕ be a state formulas and let s_0, s_1 and s_2 be three states of a Kripke structure M. Suppose $M,s_0 \models EF\phi$. Also, s_1 is a state reachable from s_0 while s_2 is a state from which s_0 is reachable. No other information is known about M.
   a) Does $M,s_1 \models EF\phi$? Justify your answer.
   b) Does $M,s_2 \models EF\phi$? Justify your answer.

3. **[2,5 points]**
   a) Prove the CTL equivalence $AF(p \vee q) \equiv AFp \vee AFq$.
   b) Using the *labelling algorithm*, calculate the set of states of the following transition system that satisfy the CTL formula $E[p\ U\ AF\neg q\ ]$:



4. **[1 point]** Give a formal definition of *partial* and *total* correctness.

5. **[2 points]** Prove the total correctness of following Hoare triples:
   a) `{ true } if x<0 then x:=-x else x:=x fi {x≥0 }`
   b) `{ x=10 } while x >0 do x:=x-2od { x=0 }`

6. **[2 points]** Consider the following Hoare triple:

```
{ n ≥ 0 }
new := 0;
old := n;
while old ≠ 0 do
      new := new+1;
      old := old-1
od
{ new = n }
```

   a) Find an invariant and give a proof outline for *partial* correctness.
   b) Find a variant and give a proof outline for *total* correctness.

The final score is given by the sum of the points obtained.