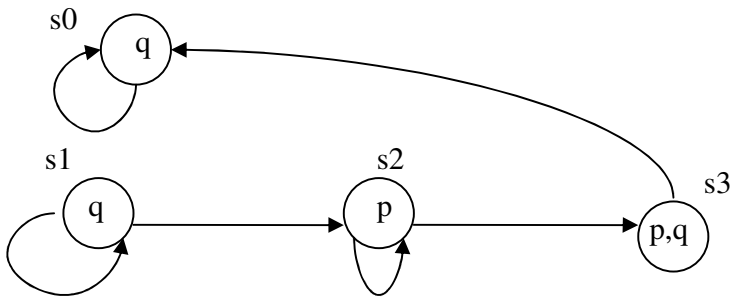
LIACS
Leiden University

Examination Program Correctness
17 August 2006, 14:00 - 17:00

1. **[2 points]** Using the *fixed point method*, give the set of states of the following transition system satisfying the CTL formula E[q U EGAFp].



2. **[1 point]** Give a definition in LTL of the F, G, R, and W operators using only the U operator and the Boolean connectives.

3. **[1 point]** Write a CTL formula for each of the following sentences:
   a) it is possible to return to a state where property p holds;
   b) it is always possible to return to a state where property p holds.

4. **[2 points]** The command <u>repeat</u> { c } <u>until</u> b is intended to execute the command c repeatedly until the condition b is false. Give the rules for defining its formal operational semantics.

5. **[1 point]** Give the formal definitions of validity for partial and total correctness of an Hoare triple { ϕ } c { ψ }.

6. **[1 point]** For each of the following cases, give a command c that satisfies the following Hoare triples for total correctness:
   a) { false } c {false}
   b) { true } c { false }
   c) { true } c { true}.

7. **[2 points]** Give a proof outline for the total correctness of the following Hoare triple

```
{ 0 ≤ y }
z := 1 ;
a := 0 ;
while a ≠ y do
        z := z * x ;
        a := a + 1
od
{ z = x^y }
```

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