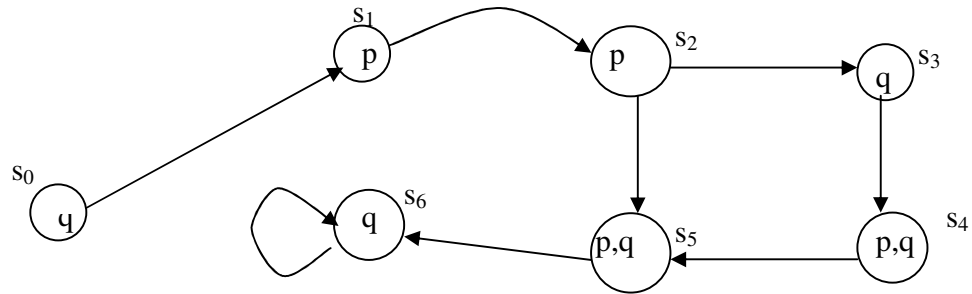


1. [2 points] Using the labelling algorithm, calculate the set of states of the following transition system satisfying the CTL formula $E [p U AX q]$.



2. [1 point] Show that any CTL formula is semantically equivalent to a formula which uses only the following connectives: \perp , \wedge , \neg , AF, EU, and AX.
3. [1 point] Give the definition of validity of partial correctness and of total correctness of a Hoare triple $\{ \phi \} c \{ \psi \}$.
4. [2 points] Exhibit a proof tree for the partial correctness of the following Hoare triple:
- $$\{ \text{true} \} \text{ if } x > 5 \text{ then } x := 5 \text{ else if } x < 0 \text{ then } x := 0 \text{ fi fi } \{ 0 \leq x \leq 5 \}$$
5. Compute the weakest precondition of the assertion $x > 0$ with respect to the following commands:
- a) [1 point] $x := x + 1; y := y - x$
- b) [1 point] $\text{if } x = 3 \text{ then } y := 5 \text{ else } y := x \text{ fi}$
6. [2 points] Give a proof outline for the total correctness of the following Hoare triple:

$$\begin{array}{l}
 \{ x \geq 0 \} \\
 y := 0; \\
 z := x; \\
 \text{while } z \neq 0 \text{ do} \\
 \quad y := y + 1; \\
 \quad z := z - 1 \\
 \text{od} \\
 \{ y = x \}
 \end{array}$$

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