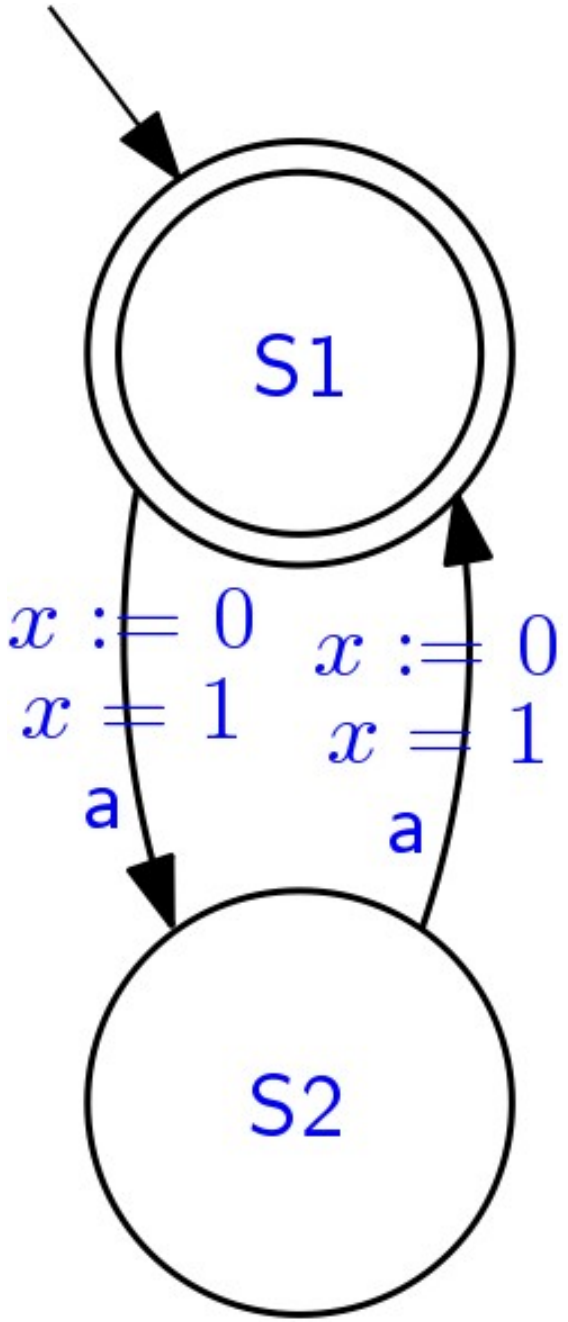
Software Verification
Exercise class:
Real Time Systems

Carlo A. Furia

Exercises:

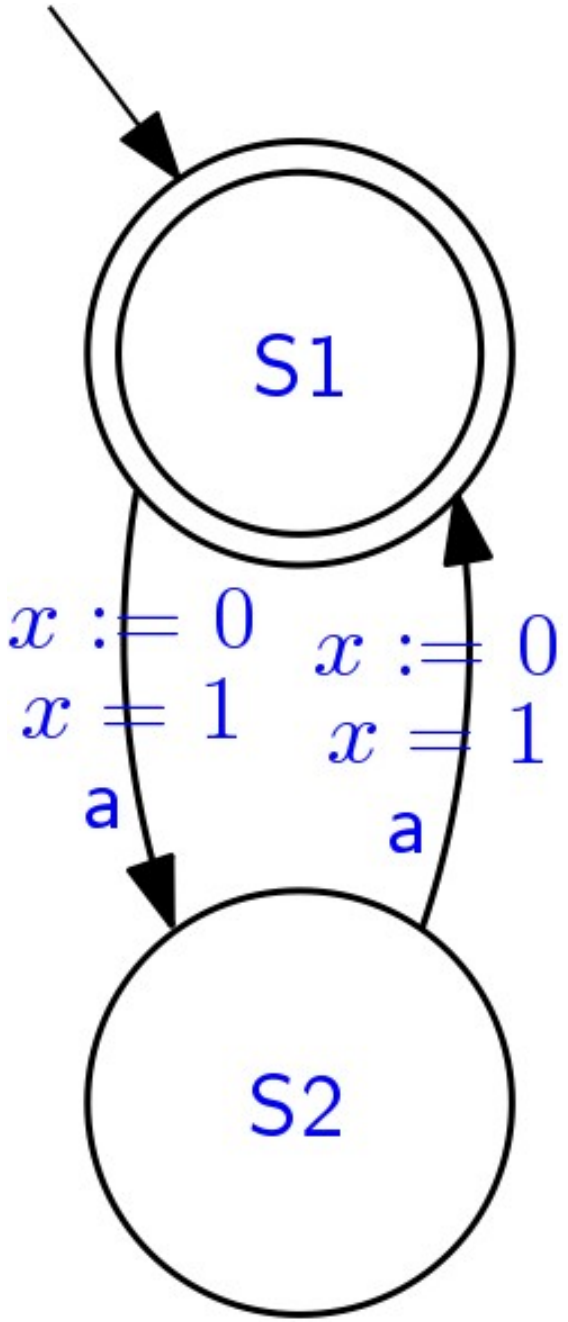
Does the property hold?

Does the property hold?



$\Box$ a

Does the property hold?

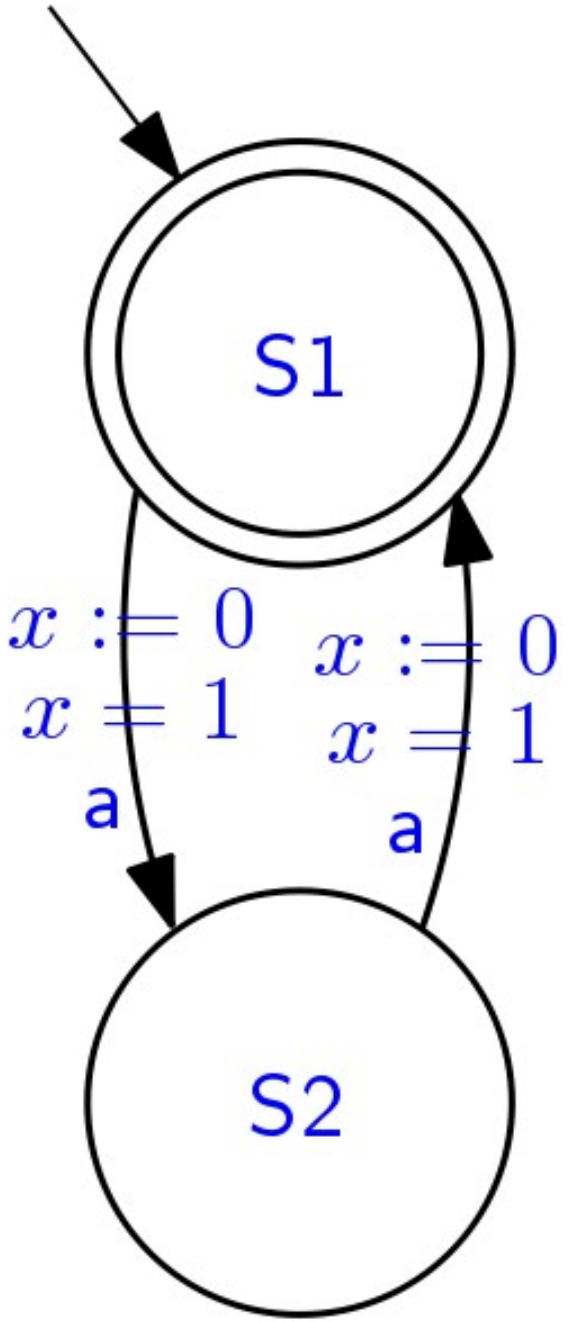


$\Box$ a

Yes:

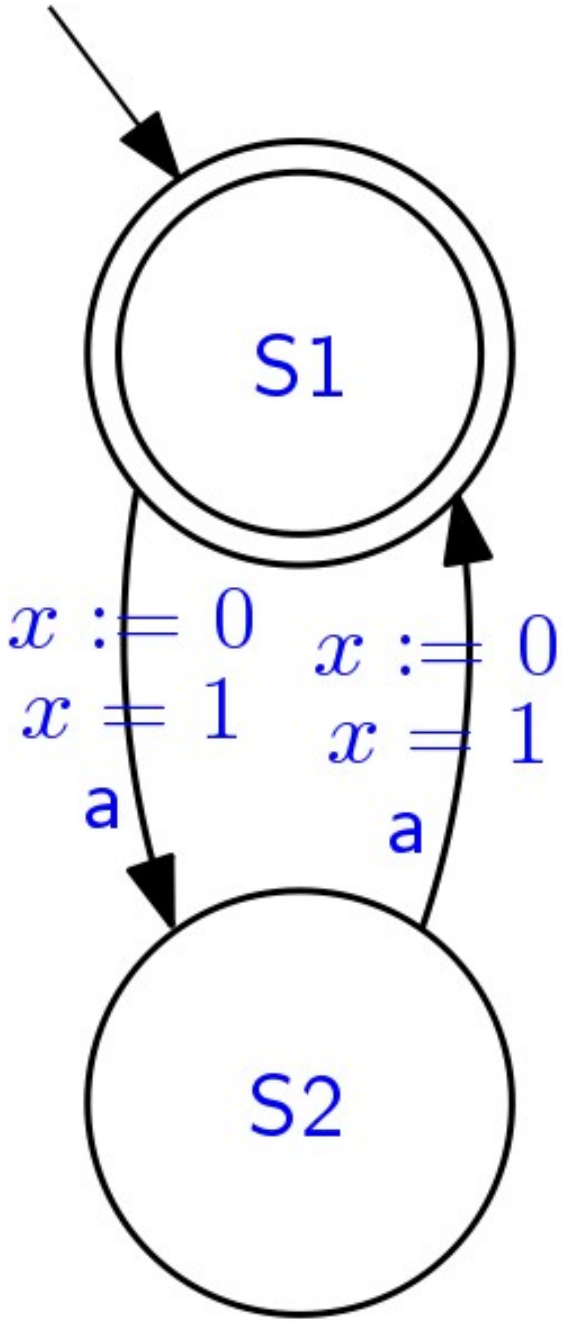
- it simply means that a holds at every position in the word (if any)

Does the property hold?



$\Box (\Diamond{=}1\ a)$

Does the property hold?

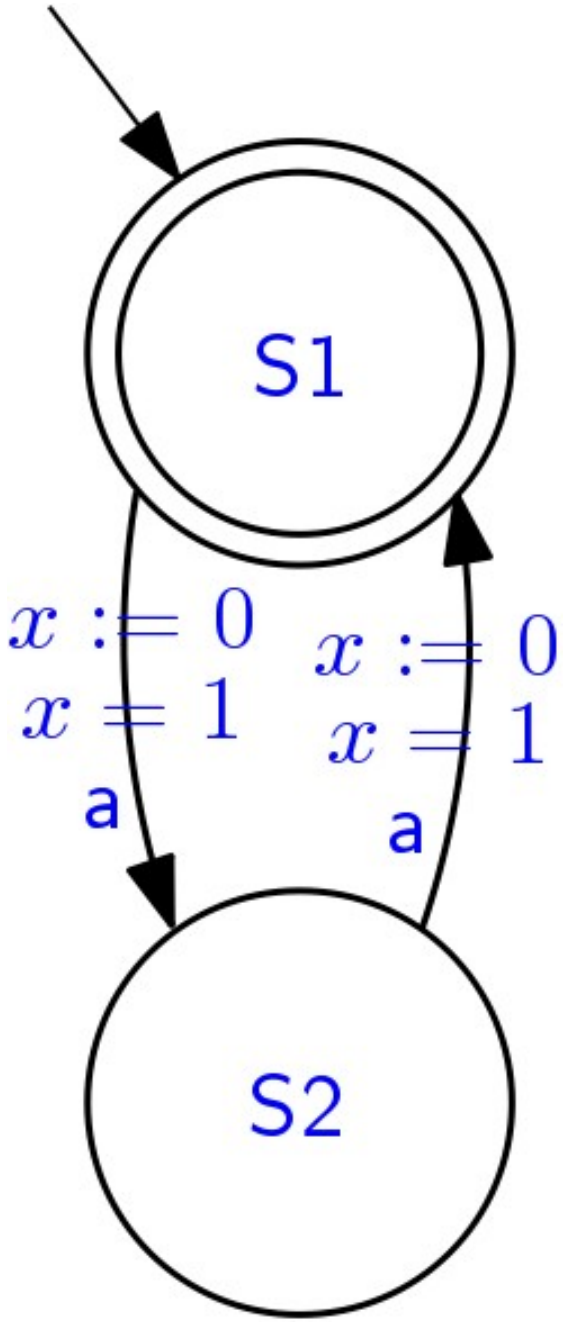


$\Box (\Diamond_{=1} a)$

No:

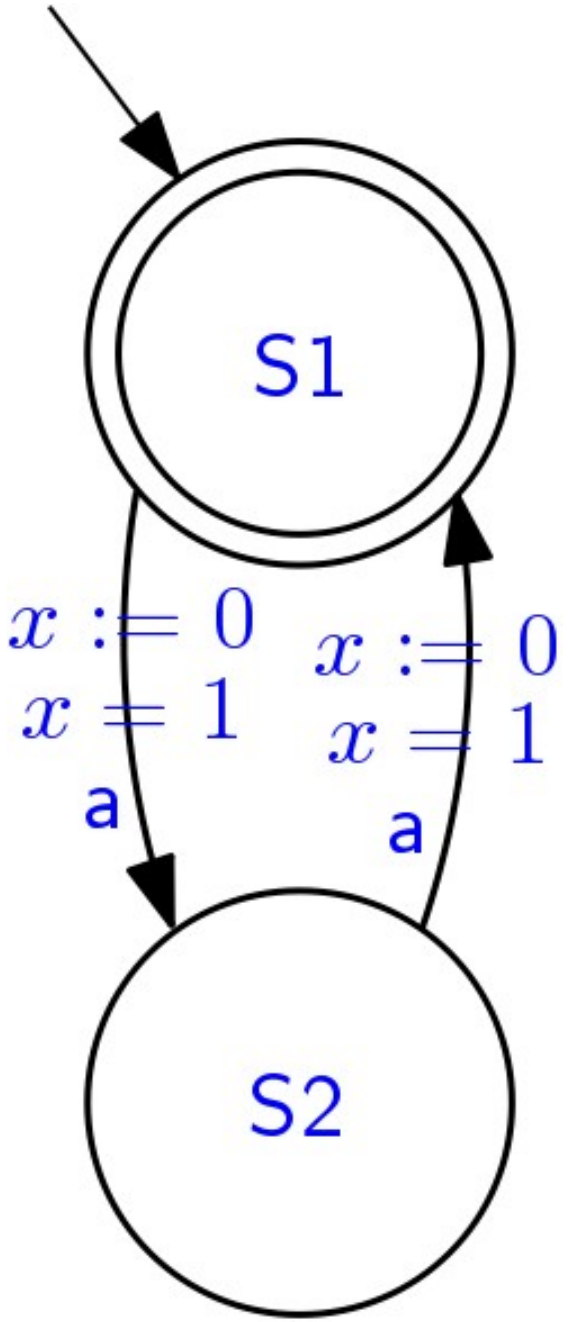
- this requires that there is always a future position, 1 time unit in the future, where a holds
- but this is not the case in the last position of any (non-empty) timed word

Does the property hold?



$\Box (\Box^{=1} a)$

Does the property hold?



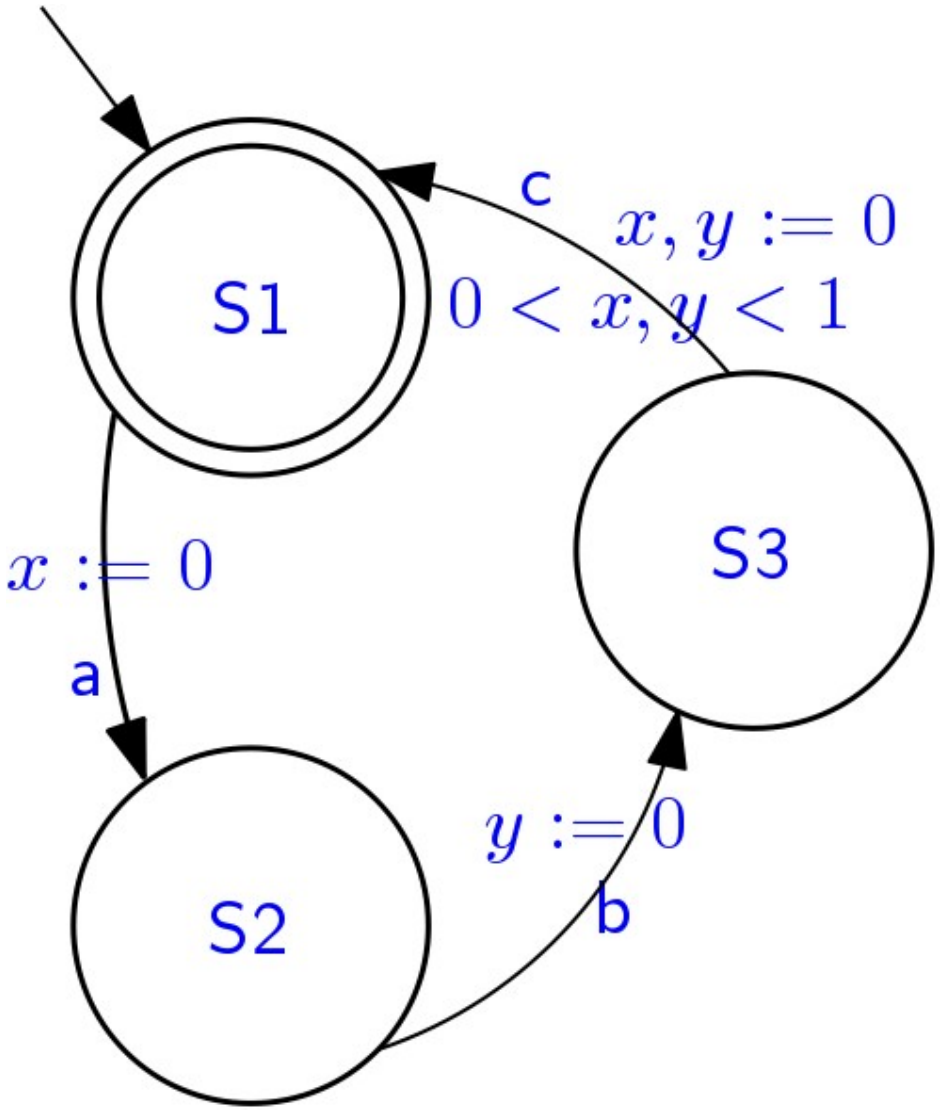
$$\Box\,(\,\Box^{=1}\,a\,)$$

Yes:

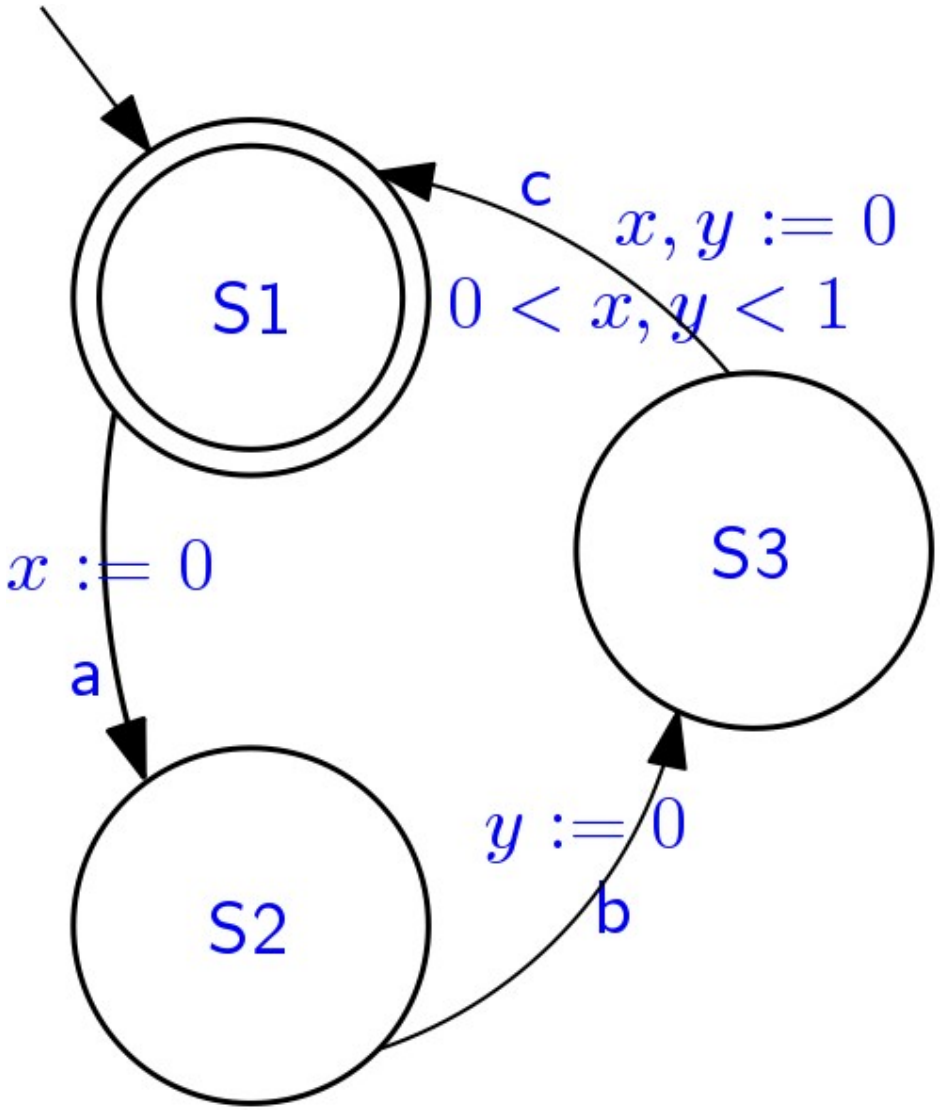
- the formula just requires that there if there is a future position 1 time unit in the future, then a holds there
- the automaton accepts only a's every time unit, hence the property is satisfied by any word accepted by the automaton

Does the property hold?

$\Box$ (a $\Rightarrow$ $\Diamond_{(0,1)}$ c)



Does the property hold?



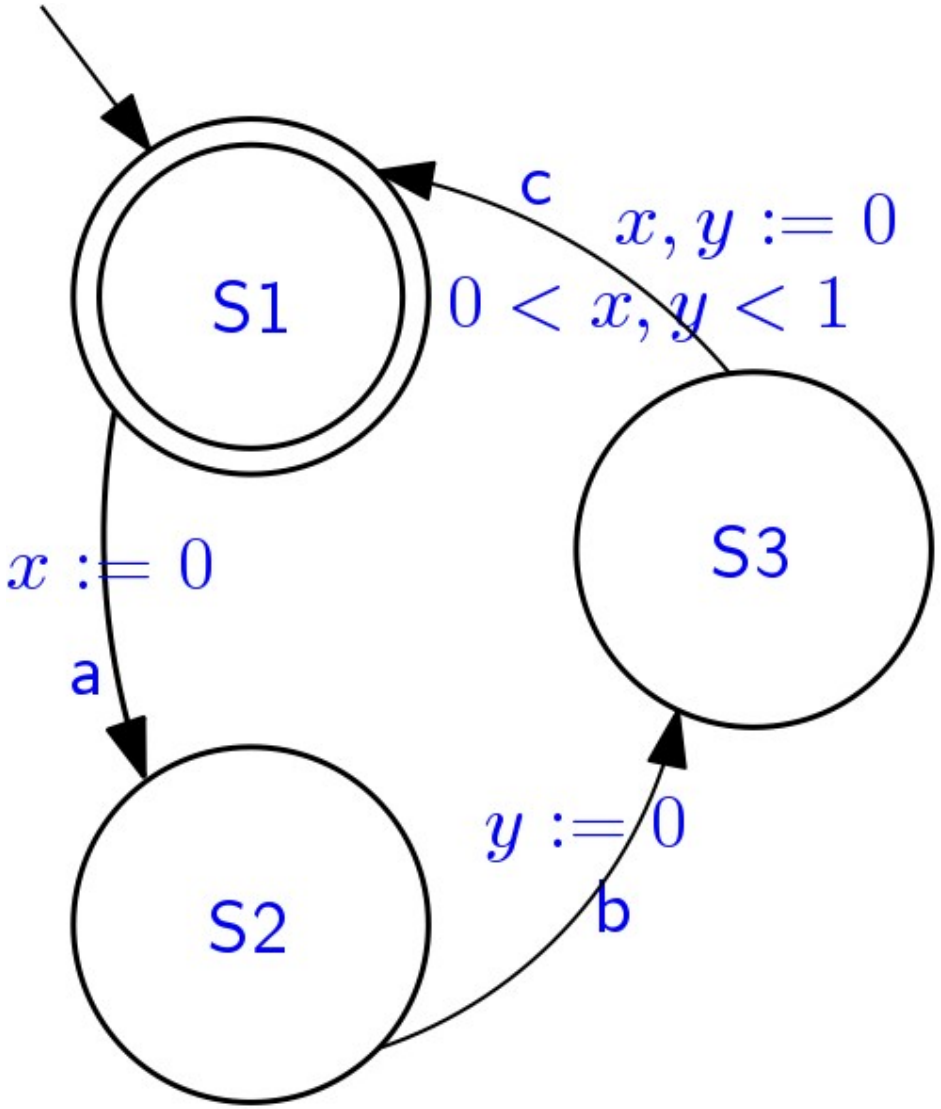
$$\Box\,(\,a \Rightarrow \Diamond(0,1)\ c)$$

Yes:

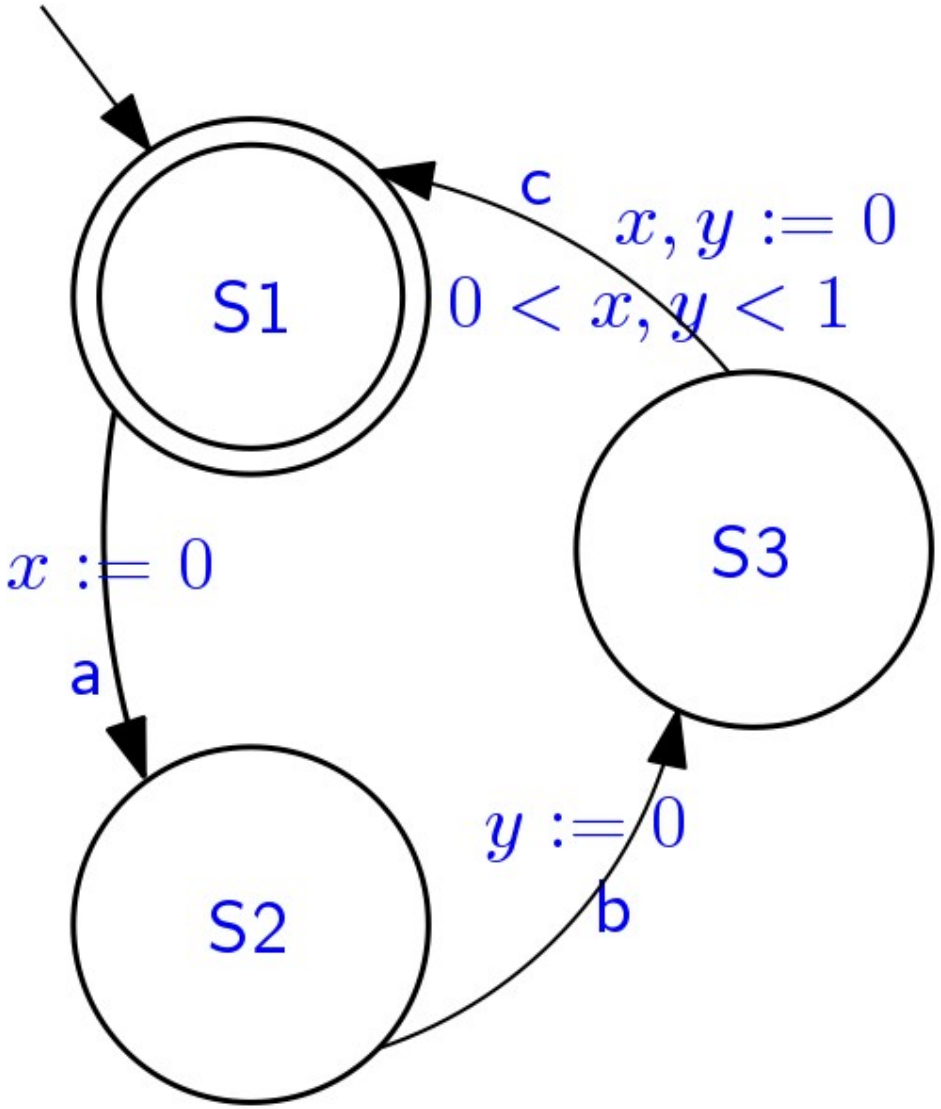
- clock x is reset upon reading a
- after that, it is checked upon reading c
- the constraint requires that x is in the range (0,1)

Does the property hold?

$\Box$ (a $\Rightarrow$ $\Diamond_{(0,1)}$ b)



Does the property hold?



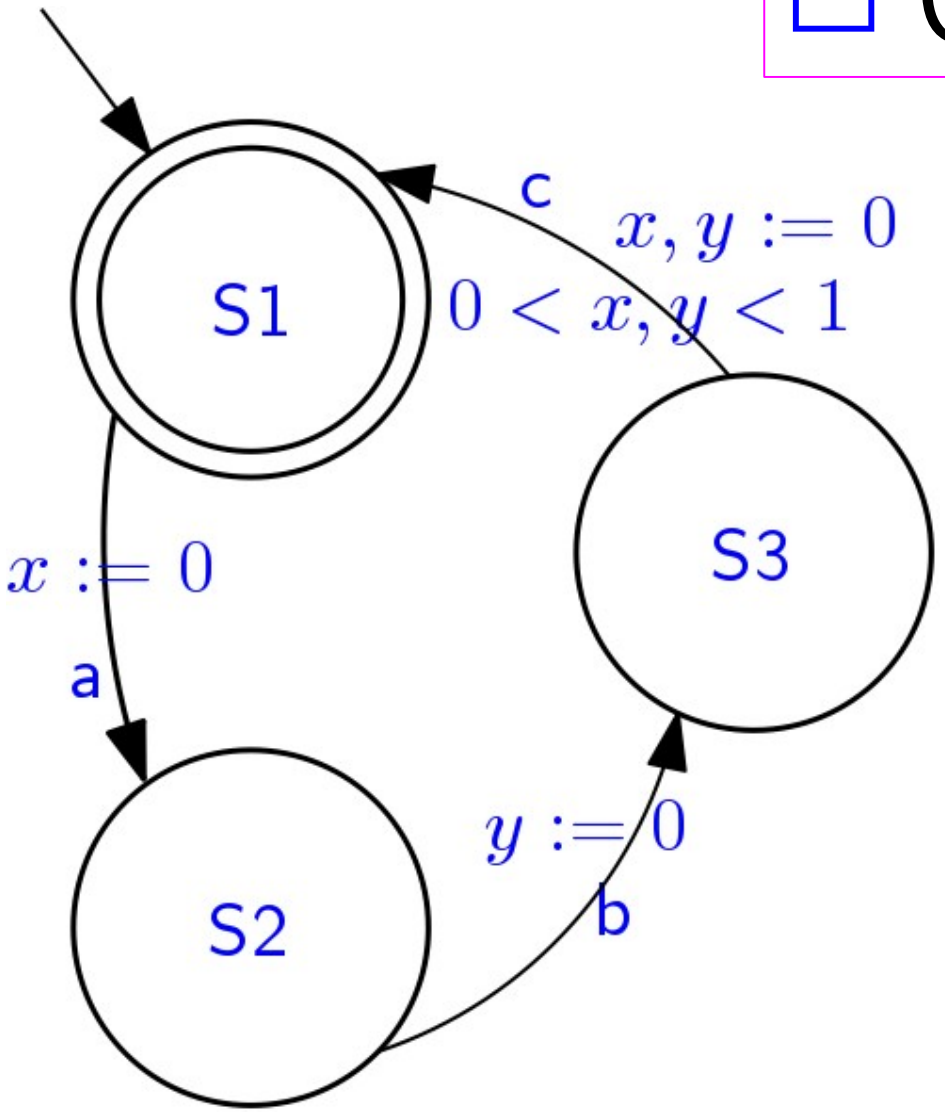
$$\Box\,(\,a \Rightarrow \Diamond_{(0,1)}\, b)$$

Yes:

- clock x is reset upon reading a; after that, it is checked upon reading c, which is always preceded by a reading of b
- if b occurs later than or exactly after 1 time unit since the reading of b, the same occurs for the reading of c
- in this case the constraint on x would be violated

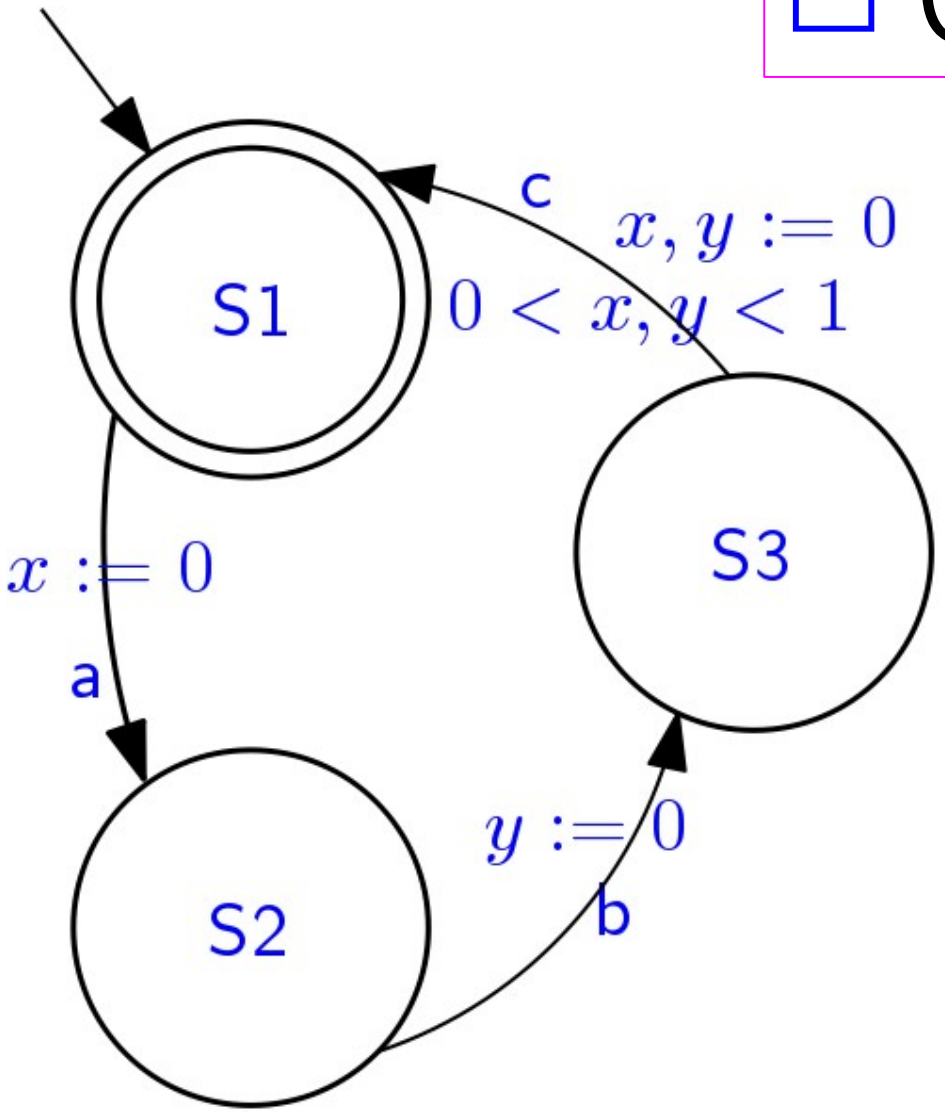
Does the property hold?

$$\Box\,(\,a \Rightarrow (a \vee b)\; U(0,1)\; c)$$



Does the property hold?

$$\Box\,(\,a \Rightarrow (a \vee b)\; U(0,1)\; c)$$

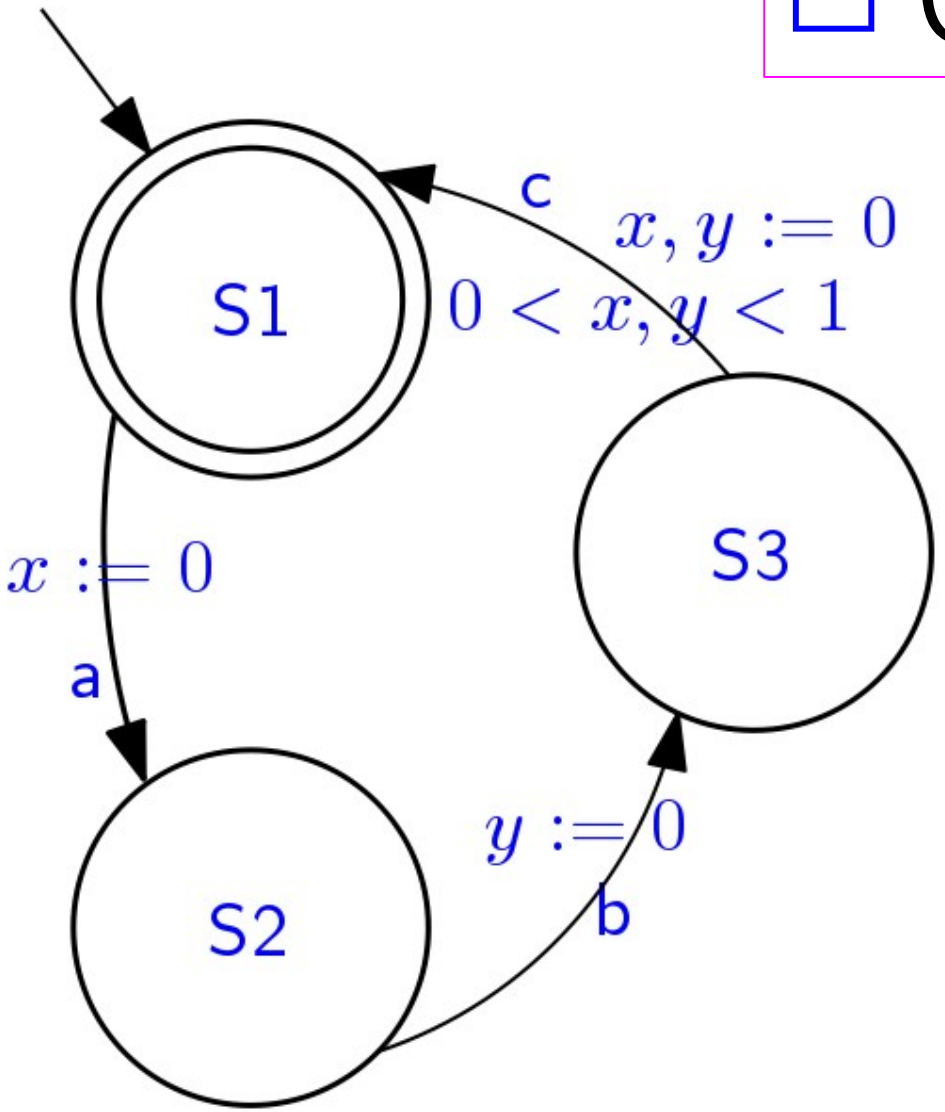


Yes:

- clock x is reset upon reading a
- after that there is one reading of b followed by a reading of c, which satisfies the sequence of events required by the until formula
- as far as timing is concerned, c must occur within interval of time (0,1) since a occurred because of the clock constraint 0 < x,y < 1

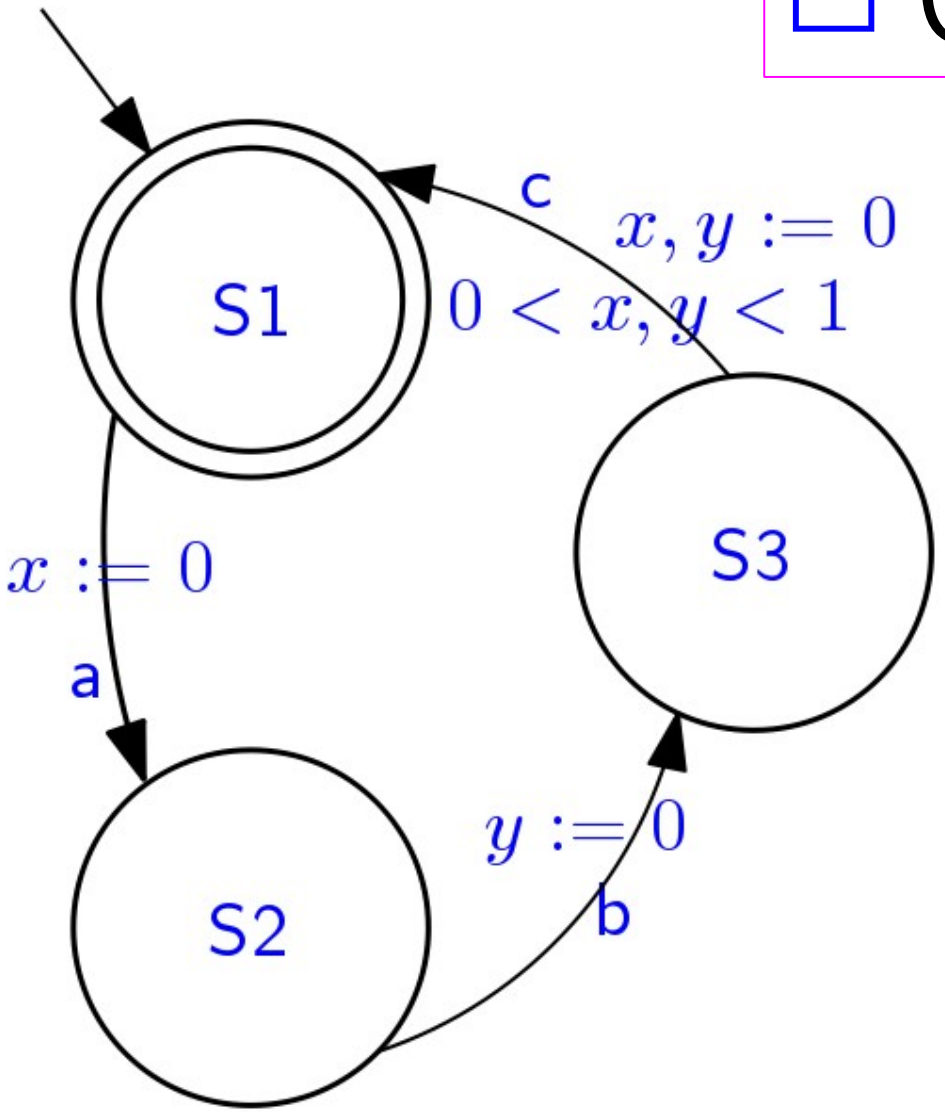
Does the property hold?

$$\Box\,(\,a \Rightarrow (a \vee b)\; U(1,2)\; c)$$



Does the property hold?

$$\Box\,(\,a \Rightarrow (a \vee b)\; U(1,2)\; c)$$

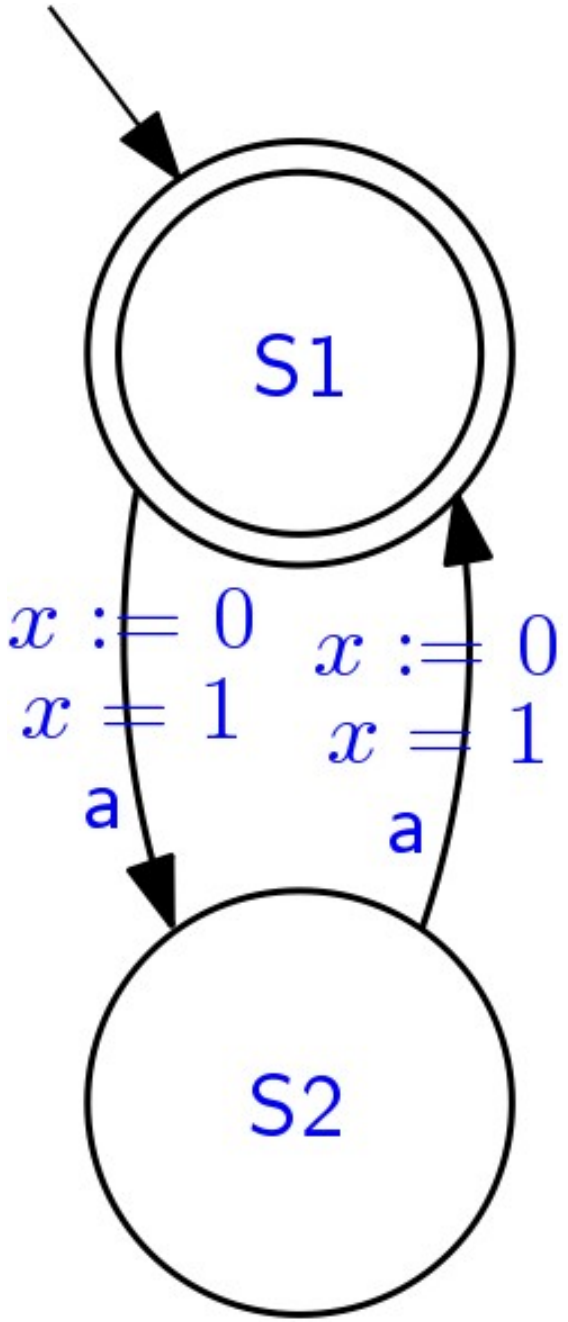


No:

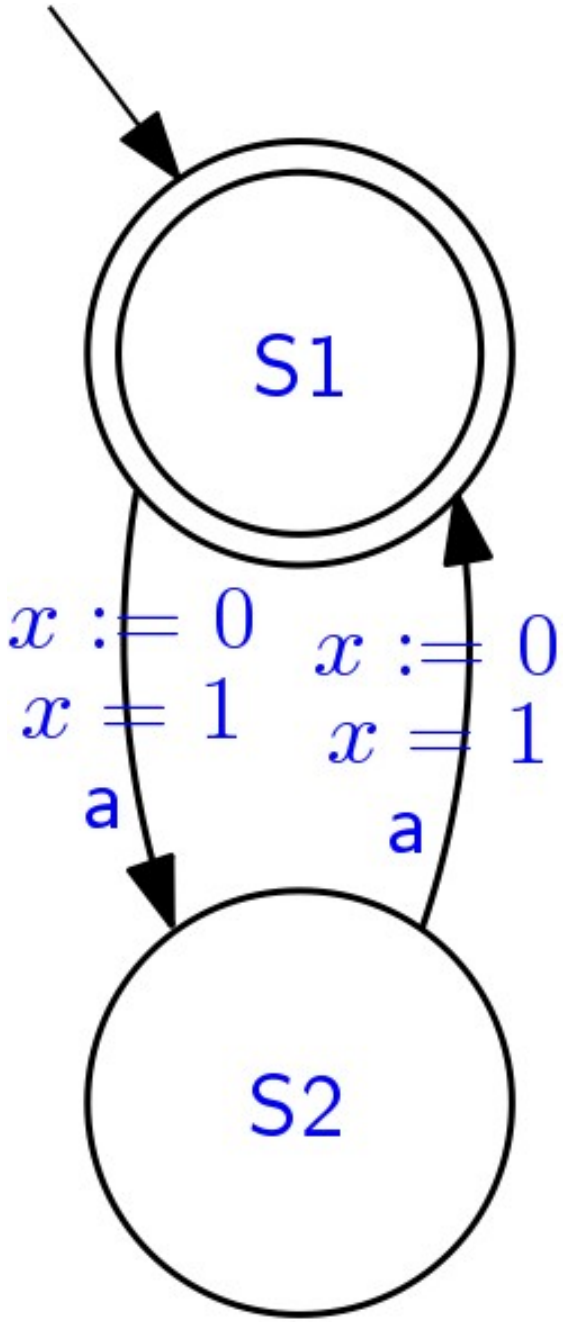
- if the "next" c is considered w.r.t when a occurs, it cannot happen in interval (1,2)
- if a successive occurrence of c is considered, it is preceded by at least another occurrence of c, which is not admitted by avb

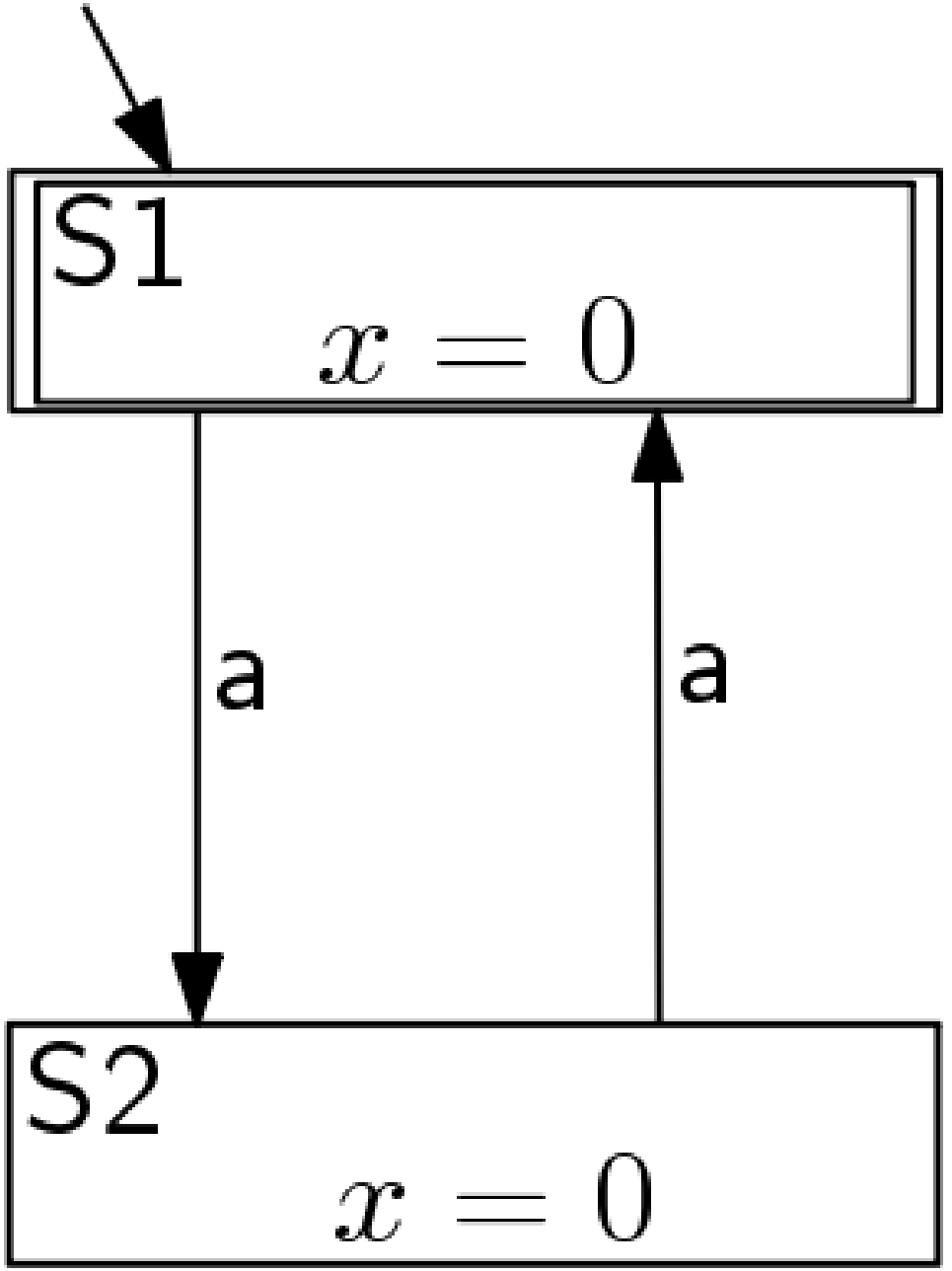
Exercises:
Region automaton construction

Build the region automaton for:

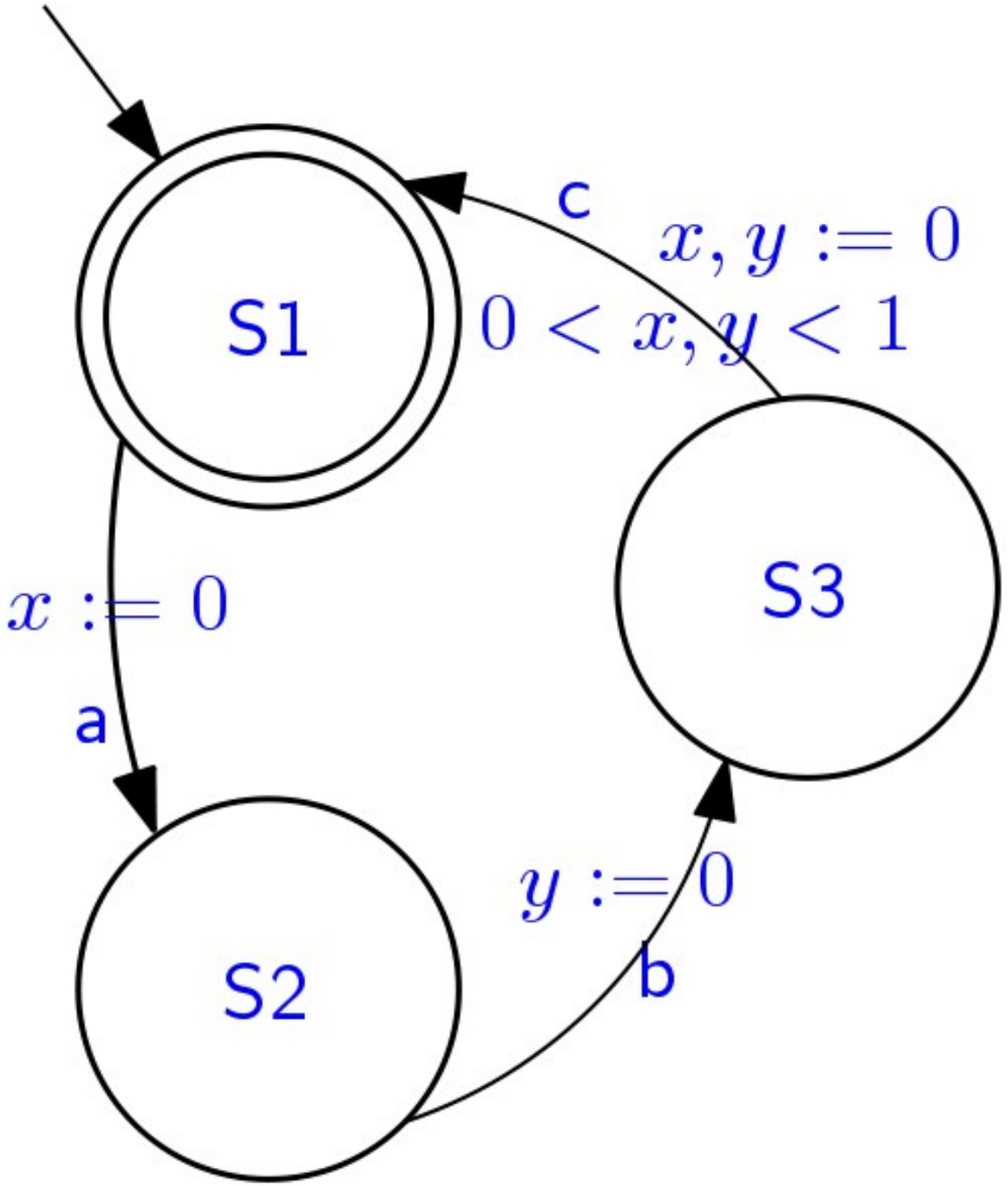


Build the region automaton for:

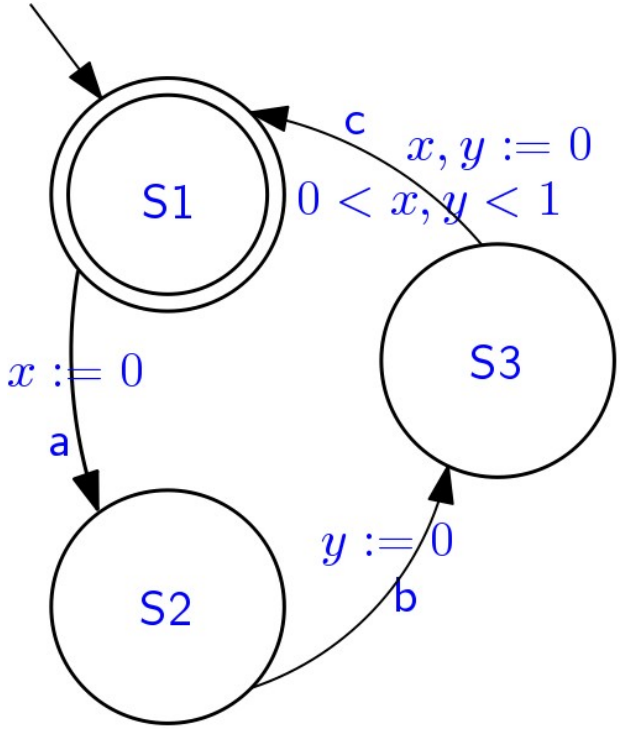


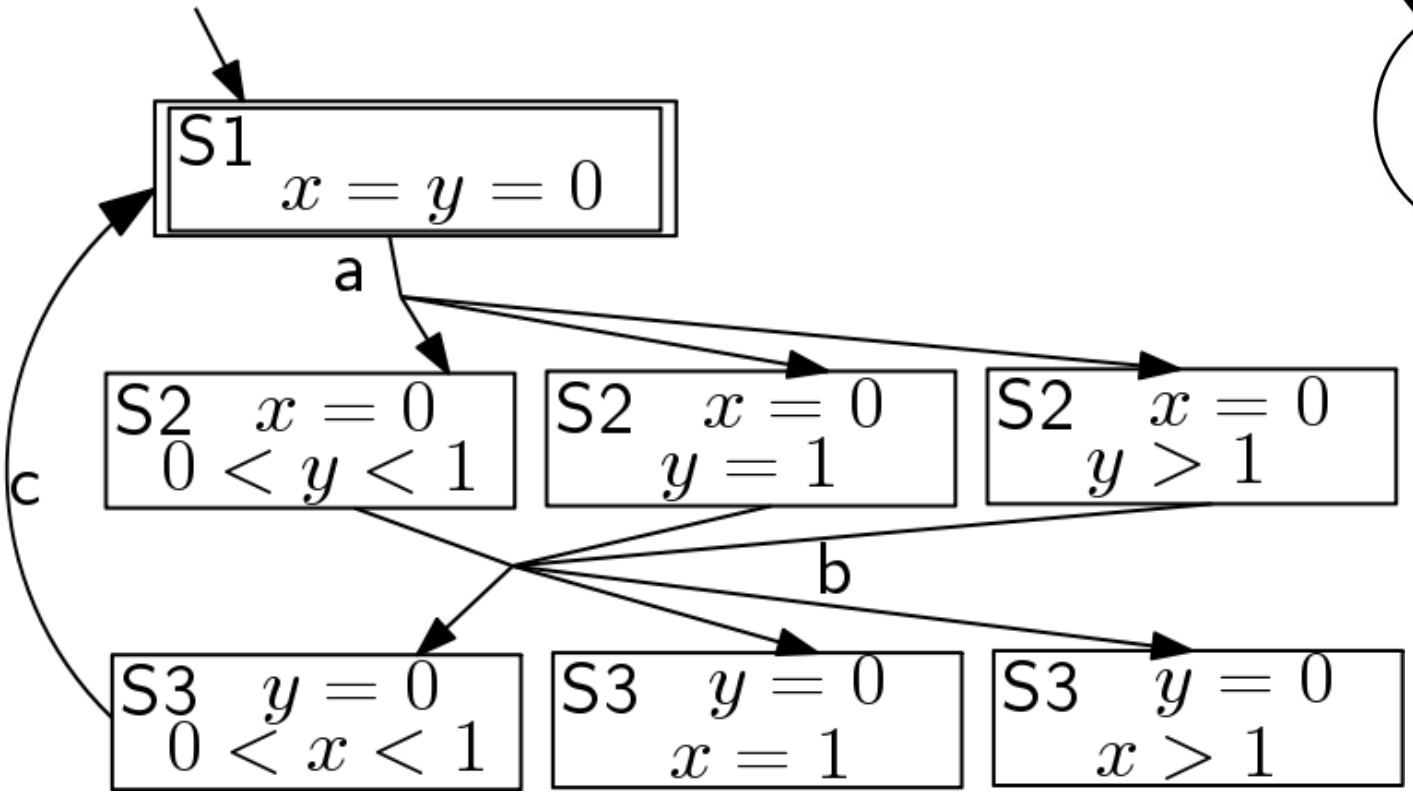


Build the region automaton for:



Build the region automaton for:





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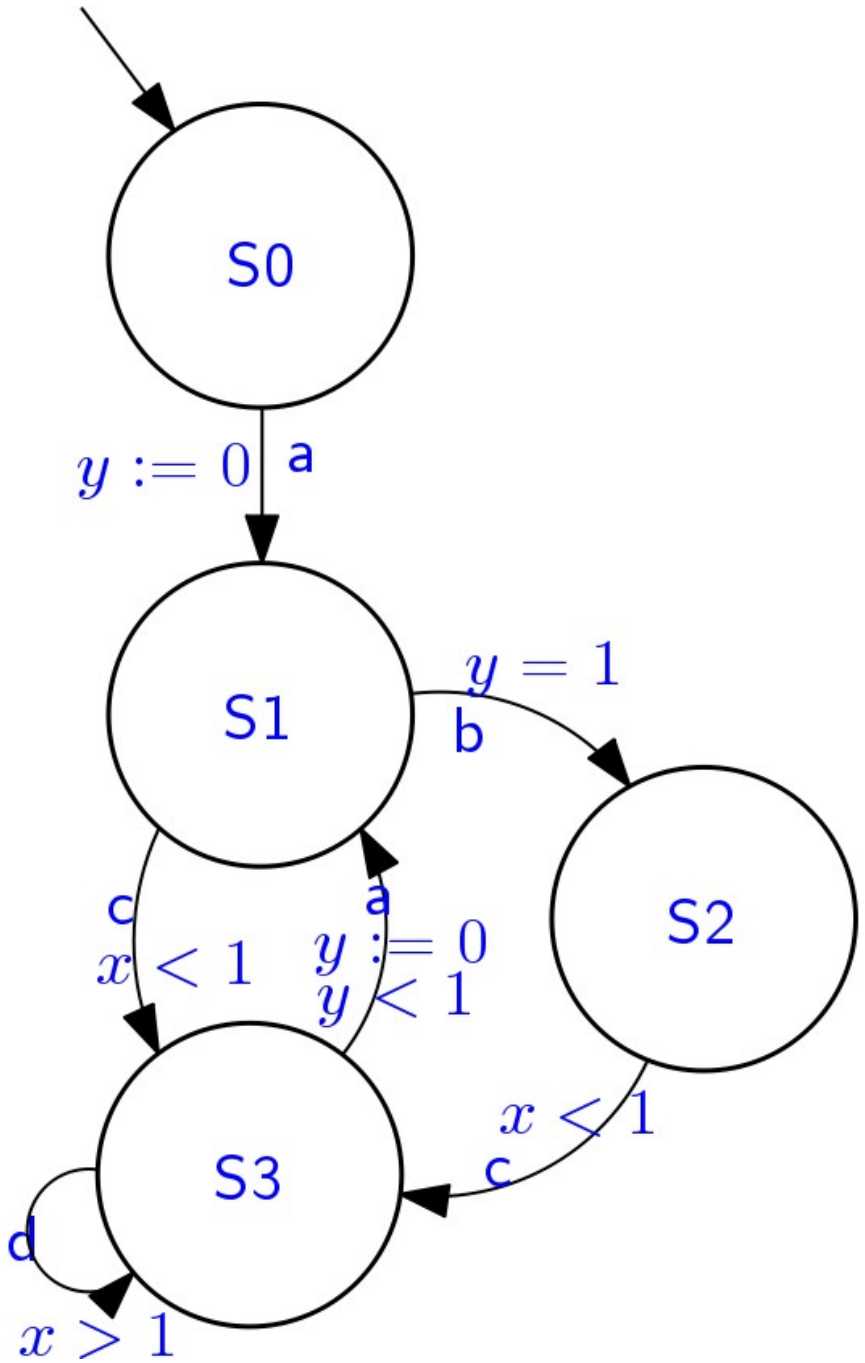
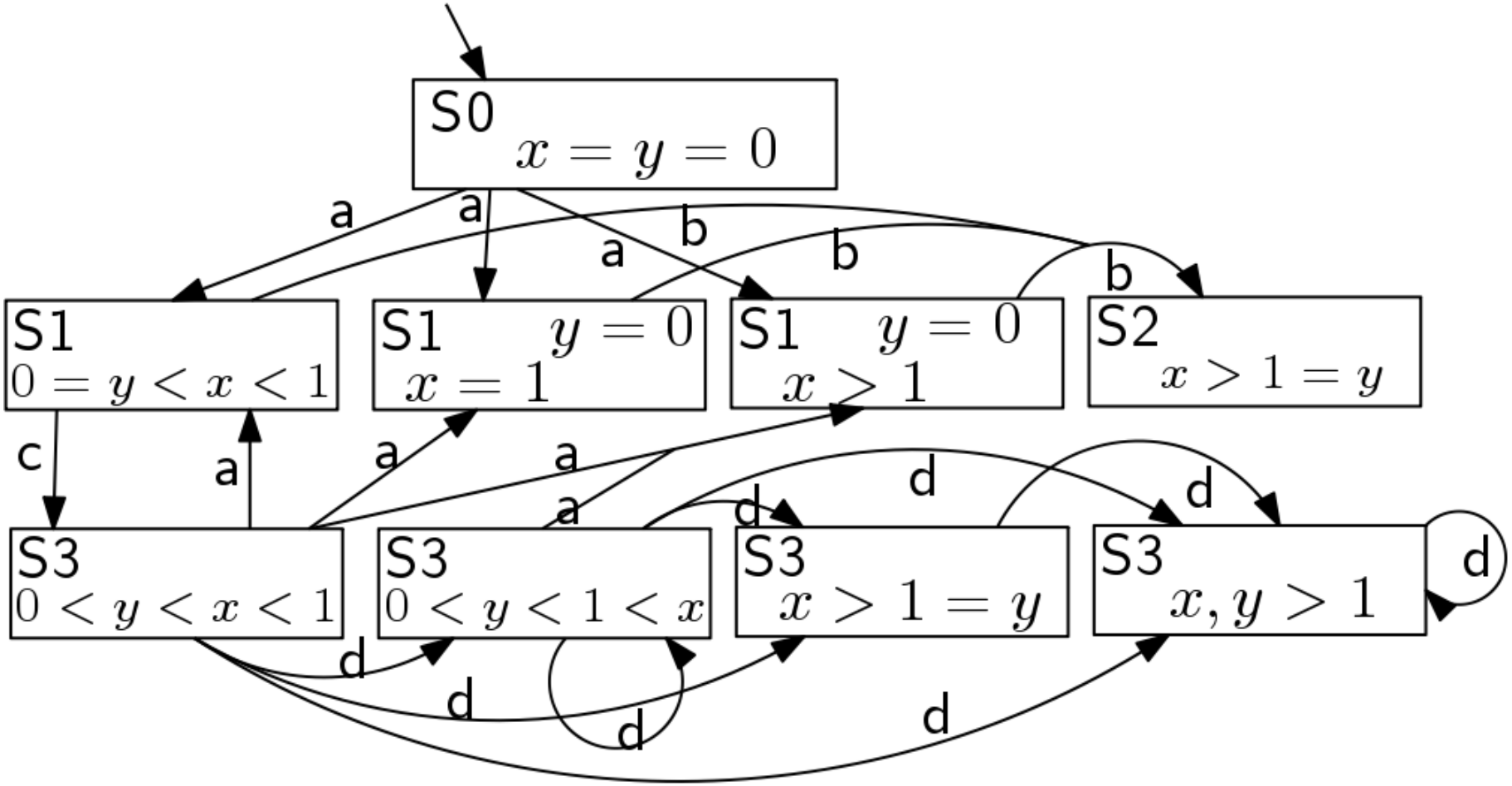
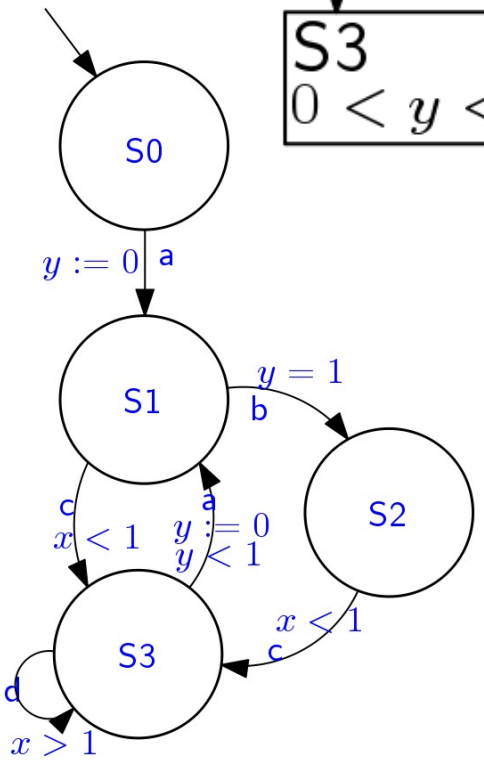


Example from: Alur & Dill, 1994

Build the region automaton for:





Example from: Alur & Dill, 1994