Technische Universität München (I7) **Winter Semester 2021-22**
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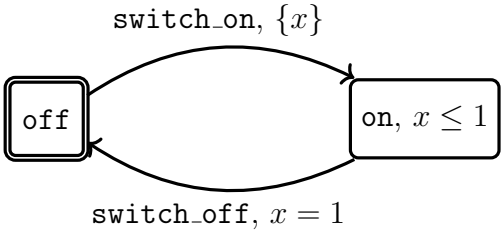
Quantitative Verification – Exercise sheet 4

Exercise 4.1

Consider the timed automaton shown in figure 1. Model check the TCTL properties "$\mathbf{E}\Diamond^{\leq 1}\texttt{on}$" and "$\mathbf{A}\Diamond^{\leq 1}\texttt{on}$". To this end, draw the region transition system, augmented with a new clock z.



Exercise 4.2

Model Fischer's mutual exclusion protocol (shown in algorithm 1) in UPPAAL. For a system of 10 processes following this protocol, verify the listed properties.

1. Mutual exclusion.
2. Deadlock free.
3. Whenever P_3 request access to the critical section it will eventually enter the wait state.

Algorithm 1: Fischer's mutual exclusion protocol

```
Input: id: Global, atomic variable, initialized to 0. delay: waiting time parameter
while true do
    while id ≠ −1 do
        continue
    end
    id ← i
    pause(delay)
    if id = i then
        // critical section
        id ← −1
    end
end
```

Solution 4.1

Recall that the clock z, i.e. the y-axis, represents total elapsed time. As we can reach, e.g., the state (`on`, 1) in the Region Transition System, $\mathbf{E}\Diamond^{\leq 1}\texttt{on}$ holds. For $\mathbf{A}\Diamond^{\leq 1}\texttt{on}$, observe that we have the trace (`off`, 1), (`off`, 2), (`off`, 3), (`off`, 16), which violates the property.

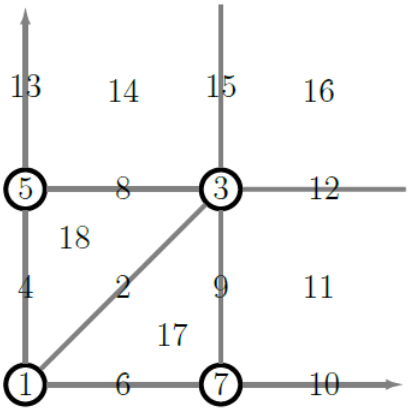


Figure 1: Regions

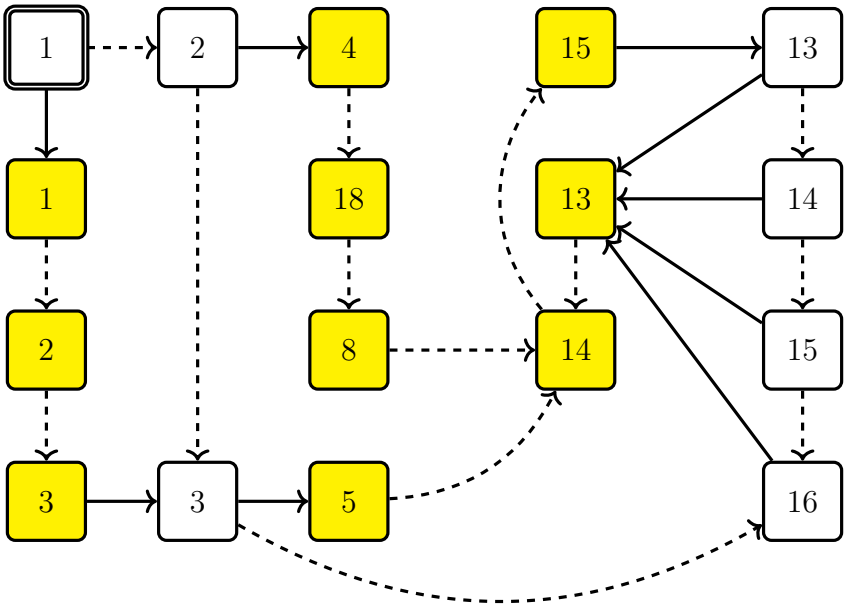


Figure 2: Region transition system: `on` states are yellow and `off` states are white

Solution 4.2
Look at the file `fischer.xml`. The properties to verify are:

1. $A\Box\ \neg(P_1.CS \wedge P_2.CS)$.
2. $A\Box\ \neg(deadlock)$.
3. $P_3.req \rightarrow P_3.wait$.