Homework Assignment

Title: **Traffic Lights**

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The modeling task

Construct the model of the following problem using the extended timed automaton formalism of the UPPAAL tool!

Our company has signed a contract for designing a traffic light control system for a crossroads with a priority and a secondary road. According to the design, the system will consist of three modules: a **central controller** and two *identical* **traffic light controllers** (for controlling the priority and secondary roads).

The **traffic light controller** changes the state of the controlled traffic light in accordance with an incoming *toggle* signal. Initially, the traffic light displays a red light. After receiving a toggle signal, the traffic light displays a green light, and after receiving another toggle signal, it displays a yellow light. After the next incoming toggle signal, the traffic light displays a red light again (this is the main cycle for normal operation). Furthermore, the traffic light controller is capable of handling incoming *interrupts*. In an arbitrary state, when the controller receives an interrupt signal, it puts the traffic light into a blinking state. In this state, the traffic light displays a yellow light for 1 time unit and then turns off all its lights for 1 time unit (none of the lights are displayed), and repeats this behavior. The traffic light controller returns to its normal operation state when receiving another interrupt signal; the traffic light must return to the same state it was in before the reception of the interrupt (the same lights must be displayed).

The **central controller** (immediately after the initialization of the system) sends a *toggle* signal to the priority controller. Then, it waits for 2 time units and sends another toggle signal to the priority controller. After that, the central controller follows a cyclic behavior. It waits for 1 time unit and then sends a toggle signal to each traffic light controller (both the priority and the secondary controllers) *in an arbitrary order*. Then, it waits for 2 time units and sends a toggle signal to the secondary controller. After that, it waits for 1 time unit and sends a toggle signal to each traffic light controller in an arbitrary order. Finally, it waits for 2 time units and sends a toggle signal to the priority controller. With this final action, the central controller finishes a cycle and starts a new one according to the behavior mentioned above. Note that when the central controller sends a signal to the traffic light controllers, it does not examine whether the signal can be adequately received; the signal is sent anyway. Apart from the toggle signal, the central controller can send *interrupt* signals to the traffic light controllers in an arbitrary state. Similarly to the toggle signals, the central controller does not examine whether the interrupt signals can be adequately received.

The verification task

Using temporal logic expressions and model checking, verify the fulfillment of the following requirements! If a requirement is not met, explain the reason of the violation based on a counterexample! The fulfillment of the first four requirements is necessary. If the original design has to be changed to achieve this, then fix the design, and based on that, the system model!

1. There is no deadlock in the system.
2. The priority and secondary traffic lights never display a green light at the same time. (If one of them displays a green light, the other one does not.)

3. The system does not have a state where one of the traffic lights is in blinking and the other one is in normal operation state.
4. The secondary traffic light can reach that phase of the blinking state where none of the lights is displayed, given that the interrupt signal came in the green state (where the green light was displayed).
5. If the secondary traffic light displays a yellow light (during normal operation), then it shall eventually reach a state where it displays a red light.

Hints

The notifications and commands between the modules are worth modeling by using synchronization channels. Consider broadcast channels too!

Note that it is allowed to submit the homework without the successful verification of all requirements, but this is not a solution of full value (i.e., the grade of the homework will be less than 5).