Formal Methods
Tutorial 4 - Timed Automata

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1. Consider a two button mouse having a *left* button and a *right* button. The user actions are as follows:
   - `left_button`: The user presses the left button
   - `right_button`: The user presses the right button

   The timing of the user actions are important towards interpreting the user's intent. The following events are generated by various interpretations:
   - `left_double_click`: This event is generated when the mouse is in the idle state and two `left_button` actions are performed within 3 units of time.
   - `right_double_click`: This event is generated when the mouse is in the idle state and two `right_button` actions are performed within 3 units of time.

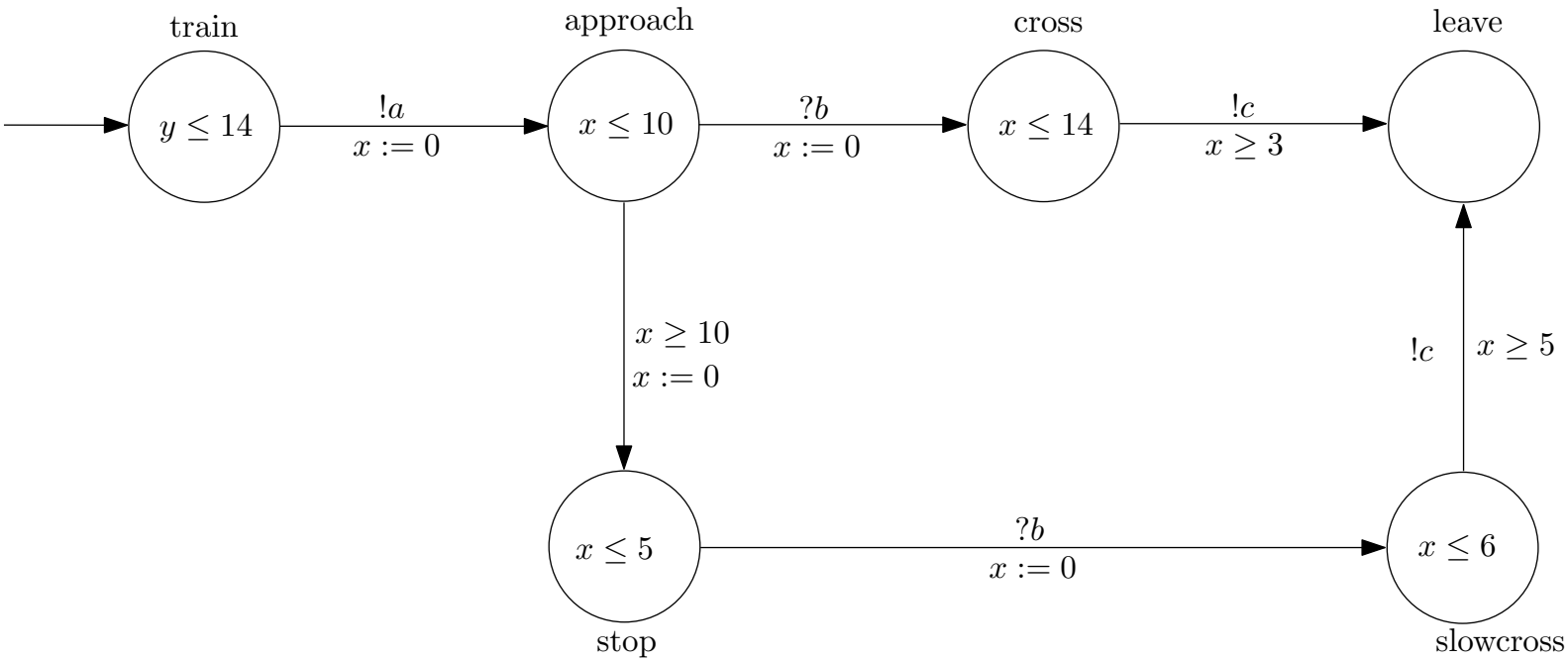
- `middle_click`: This event is generated when the mouse is in the idle state and one `right_button` action and one `left_button` action is performed within 3 units of time in any order.
- `left_click`: This event is generated when the mouse is in the idle state and one `left_button` action is not succeeded by any other action within 3 units of time.
- `right_click`: This event is generated when the mouse is in the idle state and one `right_button` action is not succeeded by any other action within 3 units of time

The mouse returns to the idle state after generating the appropriate type of event.

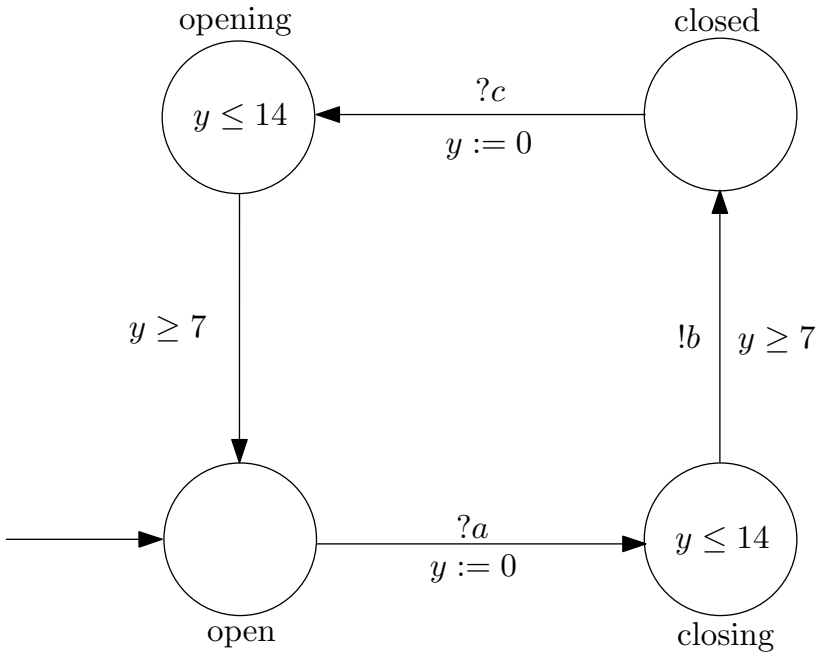
1.1 Draw a timed automaton for the mouse.

1.2 Write the timed sequence of events generated by the following timed sequence of actions:
{(left_button,2.5),(left_button,5.8),(right_button,7.7),
(right_button,8.9),(left_button,12.2),(left_button,15.1)}

2. RAILWAY CONTROLLER



Timed Automaton for the Train Sensor



Timed Automaton for the Gate Controller

2.1 Draw the product timed automaton representing the interaction of the two controllers.

3. When the door of a refrigerator is opened, the light inside the refrigerator turns ON. If the door is kept open for more than one minute, then a beeper is activated. The beeper, when activated produces a beep, and then repeats the beep at least once in every 30 seconds. When the door is closed, the light goes OFF and the beeper(if active) is deactivated.
    - 3.1 Draw a timed automaton for the door controller which controls the light and the beeper.
    - 3.2 Give the formal definition of a timed trace. Give an example of a timed trace in your timed automaton.
    - 3.3 Give the formal definition of a time convergent path. Does your timed automaton have such a path?
    - 3.4 What is a zeno behaviour? Does your timed automaton have zeno behaviours? If so, describe a timed trace exhibiting zeno behaviour and then modify the timed automaton to eliminate zeno behaviours?

4. Automobiles today have the features listed below. Implement each feature as a timed automaton.

   4.1 The dome light is turned on as soon as any door is opened. It stays on for 30 seconds after all the doors are shut. What sensors are needed?

   4.2 Once the engine is started, a beeper is sounded and a red warning light is indicated if there are passengers that have not buckled their seat belt. The beeper stops sounding after 30 seconds, or as soon as the seat belts are buckled, whichever is sooner. The warning light is on all the time the seat belt is unbuckled.

   Assume that the sensors provide a warn event when the ignition is turned on and there is a seat with passenger not buckled in, or if the ignition is already on and a passenger sits in a seat without buckling the seatbelt. Assume further that the sensors provide a `noWarn` *event when a passenger departs from a seat, or when the buckle is buckled, or when the ignition is turned off.*

5. For the Timed-Automaton given below check whether it is:
    5.1 Non-Zeno.
    5.2 Timelock-Free.