# Homework 2

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Propose a NuSmv model for a traffic light controller managing the intersection of two heavily trafficked bike-roads: a north-south road and an east-west road.
Each road has a single direction. The system has two sensors (captured with two boolean variables `north_sensor` and `east_sensor`) that sense the arrival of bikes (respectively from the north and biking south or from the east and biking west). It has also two red lights modeled as two boolean variables `north_light` and `east_light`, each capturing if the corresponding light is green or red. The `north_sensor` and `east_sensor` variables are updated with non-deterministic values in the main module (to capture random arrival of bikes). Additional boolean variable `north_req` (resp. `east_req`) is used by the north-south controller (resp. east-west controller) to remember that some bikes were sensed on the north-south (resp. east-west) road but did not get the green light yet. For this, the main module ensures that each time a `sensor` (`north_sensor` or `east_sensor`) senses a bike, the corresponding `req` variable (`north_req` or `east_req`) is changed to `true`. You should decide which module should ensure that each time a `light` (`north_light` or `east_light`) is made true by a controller, the corresponding `req` variable (`north_req` or `east_req`) is changed to `false`.
Your solution should consist of two modules. A main module and a controller module. The controller module will be instantiated twice: once for the north-south controller and another for the east-west controller. The north-south and east-west instantiations communicate via boolean variables `north_lock` and `east_lock`. You can also add a boolean `turn` variable to help ensure starvation freedom.
The main module initializes the lock and light variables, instantiates the two controllers and updates (non-deterministically) the arrival of the bikes (via the sensor variables). It also updates the request variables.
The north-south controller (the east-west controller is similar) has a number of states (e.g., idle, wait, critical, more?). It updates its state and the values of the `north_light` and `north_lock` variables based on their current values and on the values of other variables such as `east_lock`, `north_req` and/or `turn` values.

- Express in CTL that lights never get simultaneously green (mutual exclusion).
- Express in CTL that each time a bike is sensed on the north-south road (respectively, east-west road), the corresponding light gets eventually green (starvation freedom).
- Explain the CTL formula:

$$\mathbf{AG}\,((\mathbf{AG}\,!\,\texttt{north\_sensor}) \implies (\mathbf{AF}(\mathbf{AG}\,!\,\texttt{north\_light})))$$

Propose a "reasonable" solution that satisfies (as in model-check with NuSMV) the above properties. You will need suitable fairness conditions for the last two pairs of properties. Your solution should consist of a readable and well documented NuSMV file. Your are welcome to add more variables or states. This source might be relevant `https://www.cs.cmu.edu/~mtschant/15414-f07/lectures/traffic.pdf`. State any other sources that might have inspired you.