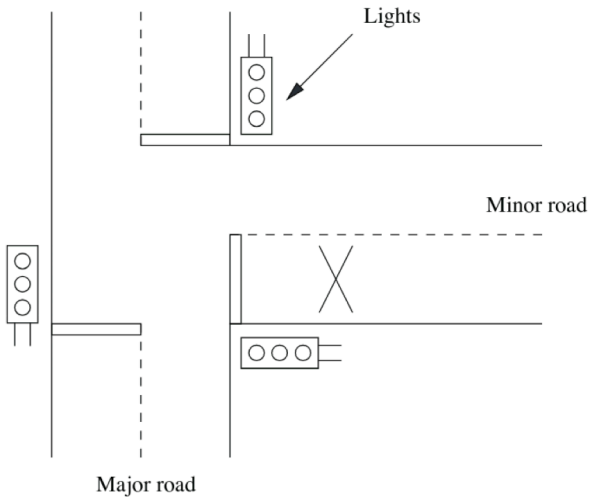
Modelling and verifying behaviour in UPPAAL

System Verification 2025/2026, José Proença, FCUP, Portugal

(based on a previous assignment from Renato Neves, U.Minho, Portugal)

1. The T-Junction Scenario

Recall the same scenario of traffic lights in a T-junction from the previous assignment in mCRL2. In this task you will have to **model** and **analyse** a variation of this system, also taking into account the **moment in time when actions can occur**.



Consider the same traffic constraints as before, but extended with **timing constraints**:

1. The lights will be always set to green on the major road and to red on the minor road, **unless** a vehicle is detected by the sensor.
2. In the latter case, the lights will switch in the standard manner and allow traffic to leave the minor road. After a **suitable time interval (30s)**, the lights will revert to their default position so that traffic can flow on the major road again.
3. Finally, as soon as a vehicle is detected by the sensor, the latter is ignored until the minor-road lights are red again.

Finally, consider the following **updated** **behavioural** constraints:

1. Each traffic light has a green, a yellow, and a red light. **Interim lights stay on for 5s.**
2. **There exists 1s delay between switching one light off and the next one on.**
3. The major-road light must remain green **for at least 30s** in each polling cycle, even if the sensor is triggered; after that, it must respond immediately when the sensor is triggered.
4. the sensor can *always be triggered*, even when the major road has red light, although it will not affect the lights until the major road has green light.

What do do

1. Model in UPPAAL the system of traffic lights described previously, using a network of timed automata. **Include a picture of your automata** and **the code declarations** in your report.

2. Express in UPPAAL's CTL the following properties and check if they hold. Note that they do not necessarily have to hold.
   a) [reachability] *The major-road light **can** go red.*
   b) [reachability] *The major-road light **can** become green three times **in three minutes**.*
   c) [safety] *The system **never** enters in a deadlock state;*
   d) [safety] *The minor-road and major-road lights **cannot** be green at the same time.*
   e) [liveness] *If there is any vehicle waiting, it will **eventually** have green light.*
3. Can you think of other desirable properties? If so please register at least one property and check whether they hold or not in UPPAAL.

2. Extension: modelling vehicles and scenarios

To enrich our system, we will now include an explicit representation of **vehicles** arriving and leaving. For this purpose, you will include two new components (automata): one that periodically signals an incoming vehicle in the major-road, and another one that periodically signals an incoming vehicle in the minor-road. Furthermore, we assume that, when the major-road has green light, a vehicle can pass every 2 seconds, or 4 seconds for the minor-road. You can introduce new assumptions or simplifications, explaining and motivating them.

What do do

1. Adapt your UPPAAL model to take into account the incoming and outgoung vehicles. You should create **three scenarios**, each using different incoming periodicities for the vehicles.
2. For each of these scenarios, check if the properties above still hold.
3. Specify and verify a new property, stating that the **number of waiting vehicles is bounded**, and find a scenario where the property holds and another scenario where the property fails (creating a new scenario if needed).
4. *[Valorisation]* Recall that UPPAAL supports propabilistic/stochastic modelling. Use a probabilistic variation to **model** the arrival of vehicles with some random periodicity, and to **verify** some probabilistic queries in UPPAAL. **Explain** your model and queries, and if these queries hold.

3. Submission instructions

Write a report for the first and second part of the assignment that explains (1) your design choices, (2) your models, (3) the formulae that you used for benchmarking your systems, and (4) the conclusions obtained.

The report in PDF **and** the respective UPPAAL models. Send by email (jose.proenca@fc.up.pt) a unique zip file "`SV2526-N1-N2.zip`", where `N1` and `N2` are your student numbers. The subject of the email should be "**`[SV] UPPAAL assignment`**".

Deadline: 2 Jan 2026 @ 23h59