# **­EcoTraffic: smart urban mobility for a greener future**

* 1. **The problem**

Two urgent global concerns are environmental sustainability and climate change; because of air pollution and greenhouse gas emissions, transportation—especially urban commuting— contributes to worsening those issues.

* 1. **The Goal**

We want to dynamically modify the duration of traffic lights on the main roads in the city depending on the directions from where we observe the main traffic movements. For instance, if, at a certain point in time, we observe that the traffic flow on a certain road A is significantly higher than in the crossing roads, then we may decide to extend, for instance, for one hour, the duration of green lights on A (and, consequently, extend the duration of red lights in the crossing roads).   
We want to analyze the daily traffic patterns and identify possible optimizations in terms of one-way roads, traffic lights configuration, and public transport schedule.   
We want to collect information about the planning of events attracting large crowds (e.g., important sport events, concerts, fairs) and define event-specific configurations for traffic lights, roads and public transport schedules.

* 1. **Stakeholders**

Drivers: for reduced waiting times stuck in the traffic

Citizen: for air pollution, public transport

Urban Traffic manager: for optimization of city viability

Events planner: for a better management of events attracting large crowds

**2 Requirement Analysis**

**2.1.1 Human Actors**

Drivers: benefit from the EcoTraffic system

Citizen: benefit from the EcoTraffic system

Urban Area manager: monitors type2 and type3 actions

**2.1.2 Non-Human Actors**

Traffic Lights: get its state set from the ET system for a determined time period

Sensor Infrastructure: send sensor information to the ET system via data bus

Public Transport Microservice: sends public transport schedules to the ET system via function calls

News Channel: transmits city events information to the ET system

* 1. **Use Cases**
     1. **Scenarios**

**Traffic light duration adjustment**

1. During peak traffic hour, cars take more than the necessary to cross a particular intersection coming from a busy road, while the crossing road are less used.
2. The system sensor measures this data and publish them on the data bus.
3. EcoTraffic retrieves the data from the data bus and stores them into a database.
4. EcoTraffic compares the data with the previous one.
5. If a misbehaviour is detected, then EcoTraffic compute the new routines time for the traffic light which has to be modified.
6. EcoTraffic connects to the traffic light system interface.
7. EcoTraffic provides to the traffic light system the serial numbers of the traffic lights which must modify the routine with the amount of time interval to be changed.
8. EcoTraffic writes into a log file the modifications done.

**Traffic Zone Optimization**

1. The Urban Area Manger asks to EcoTraffic to verify if the traffic light system is optimized in a certain zone.
2. EcoTraffic retrieve from the database the time needed to cross all the intersection in the provided zone.
3. EcoTraffic analyses the data retrieved and tries to minimize the medium amount of time taken to cross an intersection into the zone.
4. EcoTraffic performs the getScheduleByStreet and the getScheduleByLine offered by the microservice to get all the bus lines that has a stop into the area to optimize.
5. After the information arrived, EcoTraffic tries to reschedule the timetable of the bus lines in such a way to minimize the traffic. (i.e if in the zone there’s a school, then the system could anticipate the timetable of the stops near that to avoid the students to arrive late or could suggest increasing the number of buses in the area).
6. EcoTraffic presents to the UAM the recommendations and waits till the UAM decide to accept or to reject the recommendation and store the decision.
7. EcoTraffic writes into a log file the recommendations approved and the one rejected for yearly reporting.

**Event-specific configurations**

1. News channel publishes information about upcoming event with the expected attendance.
2. EcoTraffic receives the event information via integration with news channel.
3. EcoTraffic automatically categorizes the event by the attendance.
4. EcoTraffic analyzes historical traffic patterns from similar events.
5. EcoTraffic retrieves public transport schedules via microservice using getScheduleByStreet operations.
6. EcoTraffic generates event-specific configuration recommendations for traffic lights and roads.
7. EcoTraffic notifies Urban Area Manager about new event-specific configuration.
8. UAM reviews the configuration and decides to accept or to reject.
9. If accepted EcoTraffic schedules the configuration changes for event day.
10. EcoTraffic store the changes suggested and the decisions made by the UAM.
11. EcoTraffic logs the action for yearly reporting.

**System monitors traffic during special event**

1. EcoTraffic detect the presence of a special event happening today.
2. Traffic sensors detect traffic flow.
3. Traffic sensors publish data to message bus.
4. EcoTraffic receives sensor data from message bus.
5. EcoTraffic retrieve the data in the area near the event.
6. EcoTraffic implements temporary traffic light timing changes if needed.
7. EcoTraffic logs all adjustments and their effectiveness
8. EcoTraffic updates event-specific configuration data based on observations for future similar events

**Citizen views public traffic reports**

1. Citizen accesses EcoTraffic public portal.
2. EcoTraffic presents options for viewing reports.
3. Citizen selects the preferred option.
   1. Citizen selects "Daily Traffic Reports" and choose the date and time.
      1. EcoTraffic retrieves daily report data from database service.
      2. EcoTraffic displays report showing:
         1. Average traffic flow on main roads.
         2. Visualization of peak congestion periods.
         3. List of actions taken automatically.
         4. Traffic prediction for tomorrow.
   2. Citizen selects "Yearly Reports" option.
      1. EcoTraffic displays yearly report options.
      2. Citizen selects "Traffic optimization and events planning actions".
      3. EcoTraffic retrieves yearly report data from database service.
      4. EcoTraffic displays comprehensive report showing:
         1. Suggested actions that were accepted.
         2. Suggested actions that were rejected.
4. Citizen can navigate back to the main reports page using a dedicated "Back" button.
   * 1. **Use case diagrams**
        1. Traffic light duration adjustment

Actors: Sensors, Traffic lights

Entry condition: New data arrives on the bus.

Flow of events:

* Sensors measure crossing times.
* Data is sent through the bus to EcoTraffic.
* EcoTraffic compares the crossing time of the incoming roads in the crossing.
* When traffic load imbalance is detected, the system computes the green light duration to optimize vehicle flow in the more congested direction.
* The system sends the adjusted times to the traffics lights control system.

Exit condition: The system sends the adjustment.

* + - 1. Traffic zone optimization

Actors: Urban area manager, Public transport microservice

Entry condition: UAM requests optimization of a certain area.

Flow of events:

* System retrieves data from previous log files and from the microservice using the appropriate function calls.
* The system analyses the data and reschedules the timetable of the bus lines.
* The system analyses the data and reconfigures the one-way roads system.
* The system analyses the data and reconfigures the traffic light configuration.
* The system sends the new scheduling and configurations proposal to the UAM for approval.
* Once the response is taken, the system logs the answer.

Exit condition: Successful write of the log.

* + - 1. Event-specific configurations

Actors: News channel, UAM, Public transport microservice

Entry condition: News channel publishes information about upcoming events.

Flow of events:

* The system receives the event information from the news channel.
* The system categorizes the scale of the event by attendance.
* The system looks for historical traffic patterns of similar events in previous log files.
* The system retrieves public transport schedule via microservice.
* Using the collected data, the system generates event-specific configurations.
* The system notifies the UAM about the suggested configuration.
* The system waits for a response.
* Once the response is taken, the system logs the answer.

Exit condition: Successful write of the log.

* 1. **Domain assumption**

1. The sensor infrastructure works correctly and with low latency 24/7.
2. The traffic lights are not faulty and set their state correctly in time from the ET system.
3. Drivers behave accordingly to the traffic light state.
4. No car can obstruct the passage in the crossing no matter the reason.
5. Events planners always report to the news channel up to date events in the city.
6. The public Transport Microservice always returns the right timetable given a line or the name of a street.
   1. **Requirements**
      1. **Functional Requirements**

* In any circumstance the system must not allow two orthogonal traffic lights to be green at the same time.
* The system must modify the duration of the green lights to reduce traffic.
* The system shall process and aggregate traffic data to identify traffic flow patterns.
* The system should send adjustment commands to the traffic light control system.
* The system should be able to write to a log file what needed.
* The system shall generate optimization suggestions for one-way road and traffic light configurations.
* The system shall generate optimization suggestions for public transport schedules.
* The system shall continuously receive data from both the message bus and the news channel.
* The system has to gather data from the microservice.
* The system must assess the potential traffic impact of planned events.
* The system shall generate event-specific suggestions for public transport adjustments.
* The system shall present suggestions to urban area managers for review.
* The system shall record and apply the acceptance or rejection of the proposal by the urban area managers.
* The system shall generate daily reports on average traffic flow.
* The system shall generate yearly reports on suggestions proposed and their outcome.
* The system shall publish reports for public access.

**2.4.2 Non-Functional Requirements**

* The system shall process sensor data in real time.
* The system should be available 24/7.
* The system shall implement traffic light adjustments in 15 seconds.
* The system shall generate reports within 1 hour after midnight.
* The system should maintain data consistency during communication with external systems.
* The system should be scalable regarding the addition of sensors and bus lines.

**2.4.3 Constraints**

* The setLight function has to be atomical.