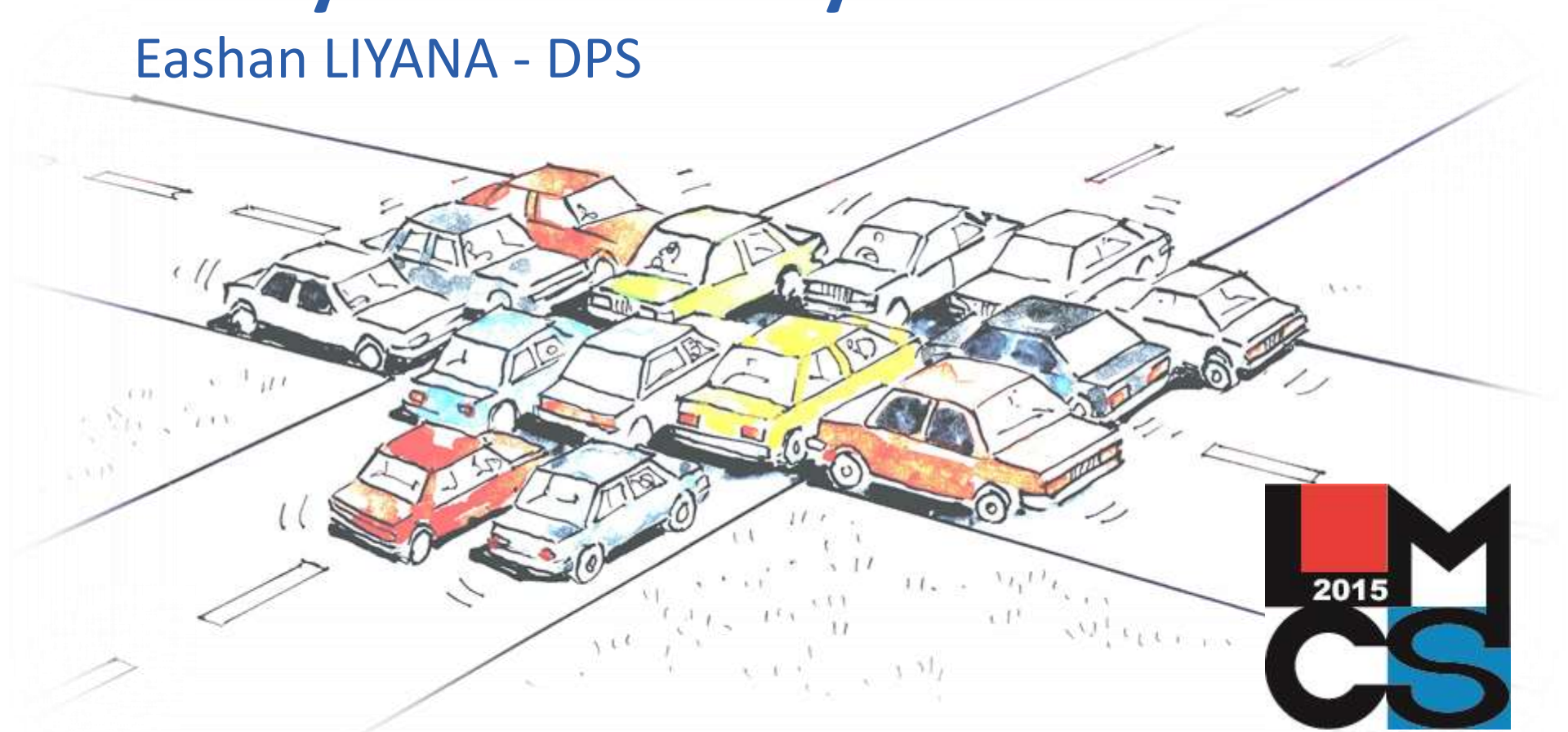
A City Traffic Library

Eashan LIYANA - DPS



A City Traffic Library

Outline

1. Project background
2. Library overview
3. Use case
4. Conclusion & Outlook

Project Background

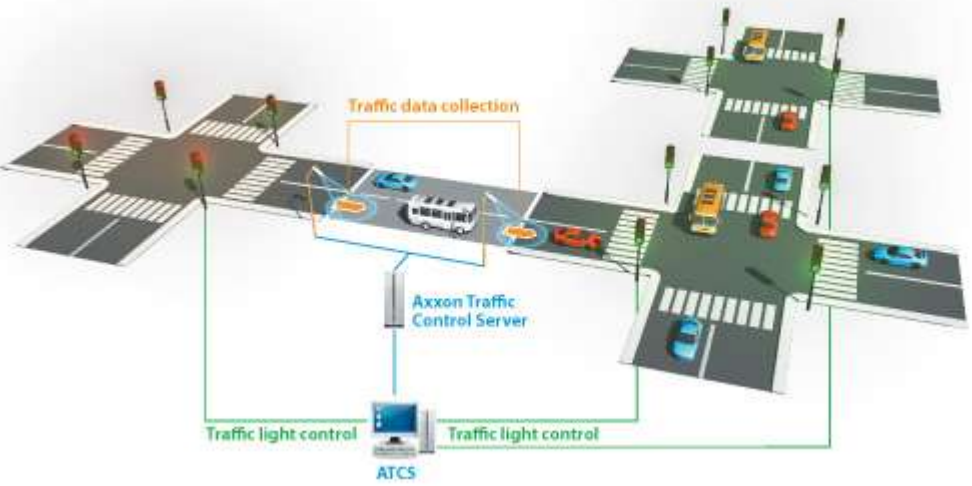
The development is part of the ITEA2 project MODRIO aiming to extend modeling and simulation tools based on open standards from system design to system operation

MODRIO

ITEA 2

INFORMATION TECHNOLOGY FOR EUROPEAN ADVANCEMENT

Develop a new and innovative library



City traffic management and vehicle emissions reduction are more newsworthy than ever.

"Because of congestion, there is a serious risk that Europe will lose economic competitiveness. The most recent study on the subject showed that the external costs of road traffic congestion alone amount to 0.5% of Community GDP. Traffic forecasts for the next 10 years show that if nothing is done, road congestion will increase significantly by 2010. The costs attributable to congestion will also increase by 142% to reach 80 billion a year, which is approximately 1% of Community GDP" [Papageorgiou, 2003].

Library overview

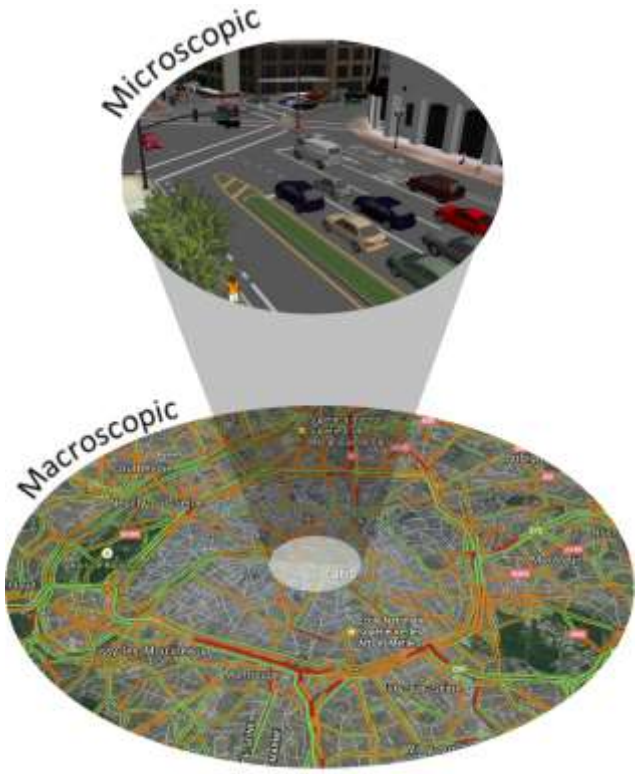
CityTraffic Library is designed for the development and evaluation of :

- Various infrastructures configuration
- Control strategies for traffic lights
- Control strategies for navigation systems
- Etc…

By using CityTraffic library, cities can decrease the number of traffic jams on their road network, and improve the overall impact of the traffic on the environment.

Library overview

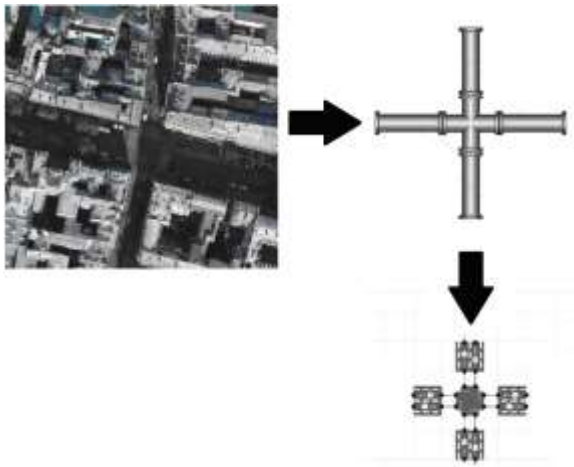
CityTraffic library is divided in two main packages which are the **Microscopic** scale and the **Macroscopic** scale



Library overview

Macroscopic environment

This modeling scale encompasses an overview of the urban traffic, considering **vehicles flow rate** (veh/h)



It is based on an **analogy with hydraulics** where roads behave as pipes, intersections are loads, and where vehicles are represented as a fluid.

Macroscopic components are used to model areas where interactions between vehicles are low ➔ for example **highways**

Library overview

Macroscopic environment

First order model : **LWR model** (Lighthill, Whitham et Richard, 1956)

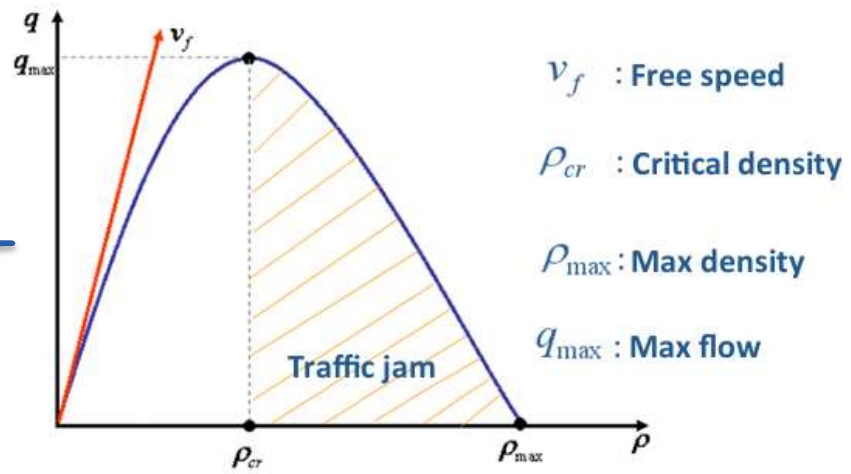
Variables :

- Density **ρ (veh/km)**
- Velocity **v (km/h)**
- Flow rate **q (veh/h) = ρ.v**

Continuity Equation $\frac{\partial \rho}{\partial t} + \frac{\partial (\rho \cdot v)}{\partial x} = 0$

Velocity law $v = V_e(\rho)$

Chandler, Greenshields, May…



Fundamental diagram

Library overview

Microscopic environment

Microscopic scale is based on an insider point of view of the urban traffic.

It enables to visualize **the journey of each vehicle** and to model interactions between vehicles as well as interactions between vehicles and urban infrastructures (crossroad, red light, stop sign...).

Microscopic components are used to model areas where interactions between vehicles are high➔ for example a **roundabout**

Library overview

Microscopic environment

Map creation

Vehicles initialization

Intersections placement

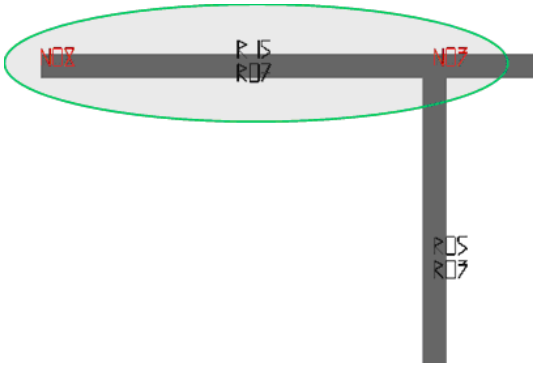
Library overview

Microscopic environment

- The Map is composed of **nodes** whose Cartesian coordinates (x,y,z) are given by the user
- Those nodes are then linked with each other, and circulation **lanes** can be defined (one way street or two way traffic).

- Map data are stored in a spreadsheet (CSV file), which is a **matrix** with nodes coordinates on the diagonal.
- Other coefficients represent the maximum velocity in m/s for the section between two nodes.

0,0,0	13.88	0	0	0	0	0	0	0
13.88	0,100,0	13.88	0	13.88	0	0	0	0
0	13.88	0,200,0	0	0	13.88	0	13.88	0
0	0	0	100,0,0	13.88	0	0	0	0
0	13.88	0	0	**100,100,0**	13.88	13.88	0	0
0	0	13.88	0	0	100,200,0	0	0	13.88
0	0	0	0	13.88	0	200,100,0	0	0
0	0	13.88	0	0	0	0	-100,200,0	0
0	0	0	0	0	13.88	0	0	200,200,0



Library overview

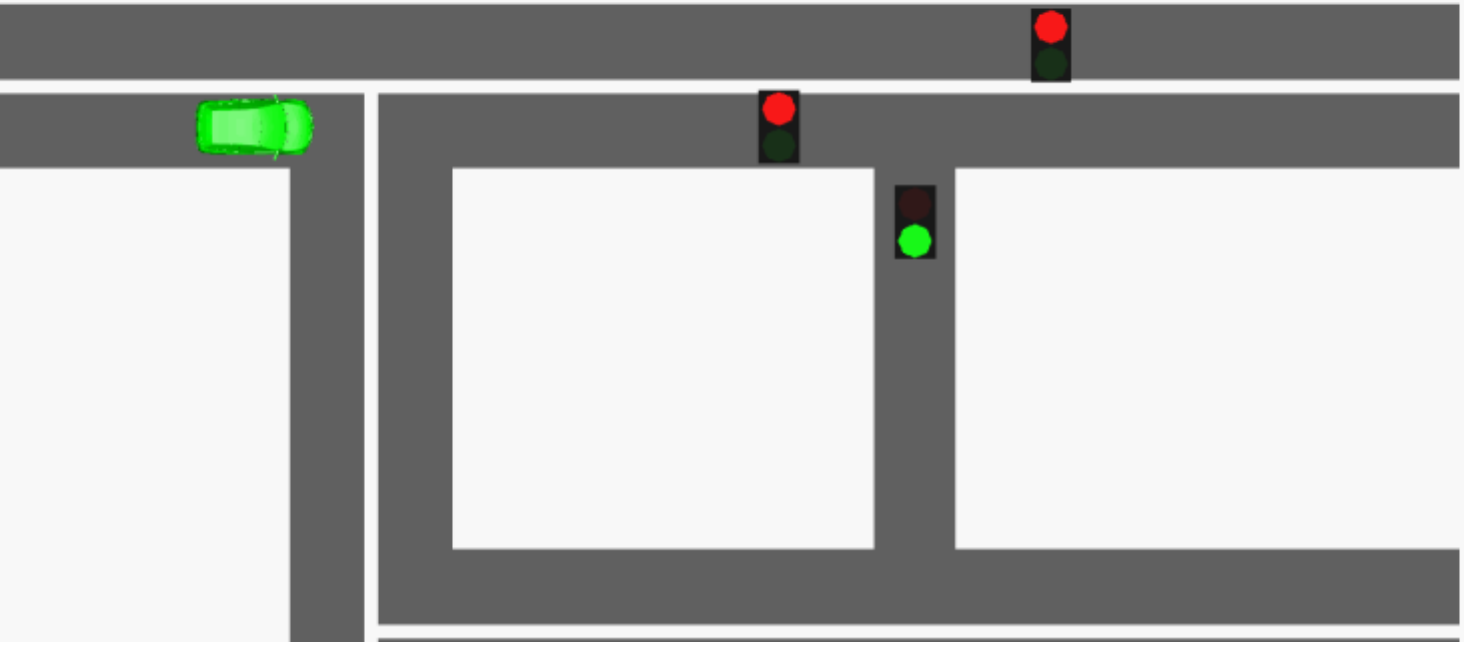
Microscopic environment

Definition of :

- **The Type of vehicles** : Car, Bus, Delivery van
- **Origin and Destination** of each vehicle
- **The Navigation Algorithm** : calculate vehicles' path
  - Dijkstra
  - Free
- **The Velocity Model** ➔ Car-following models
  - Gipps
  - Krauss
  - Constant speed (other vehicles not taken into account)

Library overview

Microscopic environment



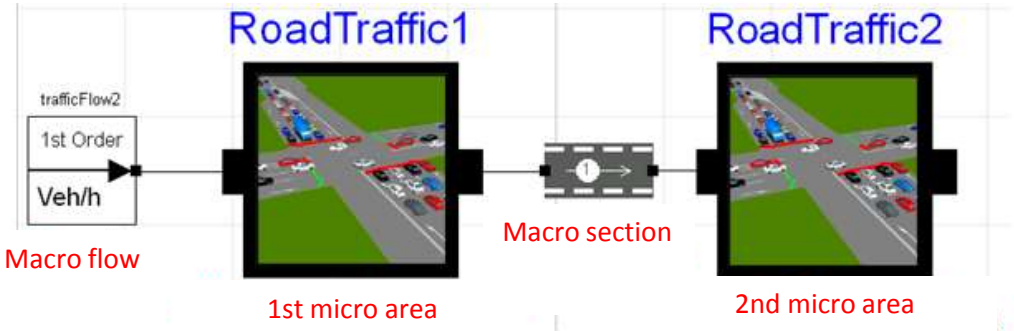
Library overview

Microscopic vs Macroscopic

Macroscopic components are well-suited for areas with low interactions and compute quickly

Microscopic components are well-suited for areas with high interactions but compute slowly

➔ **A connection between the two environments has been developed**



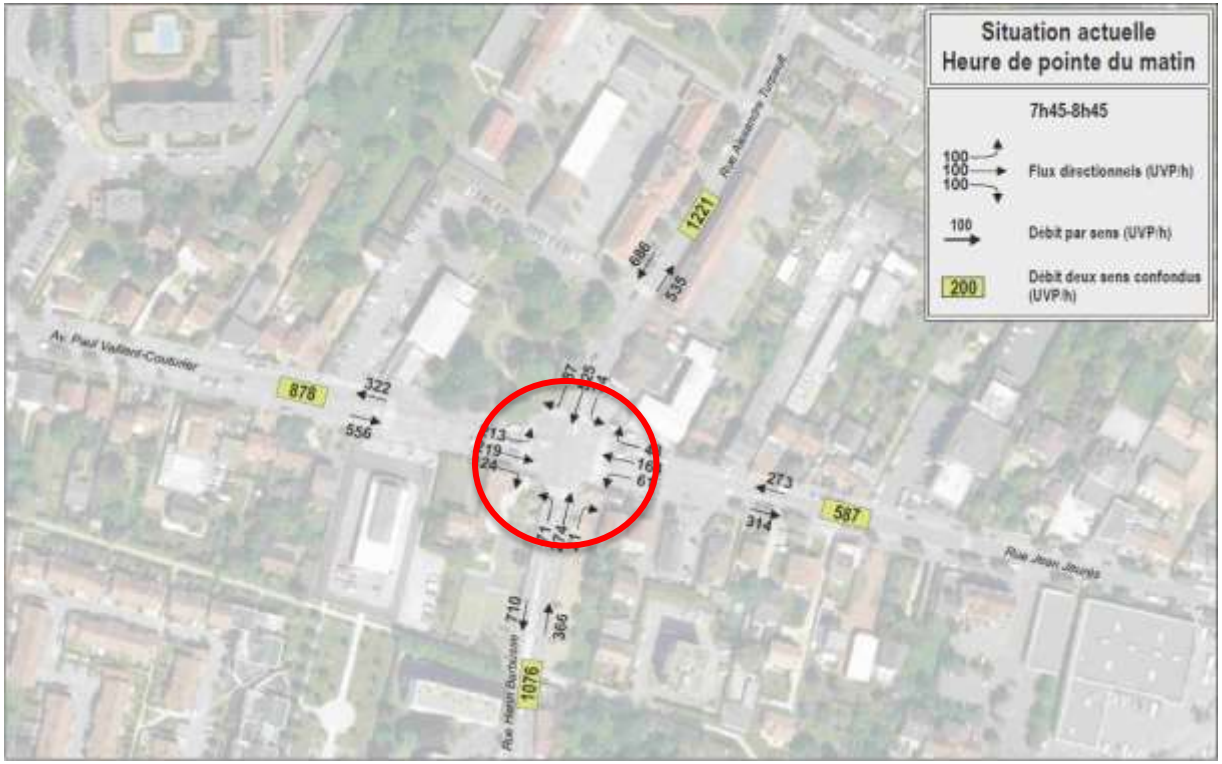
Use case

Model

Bois d'Arcy downtown

Currently uses a traffic light

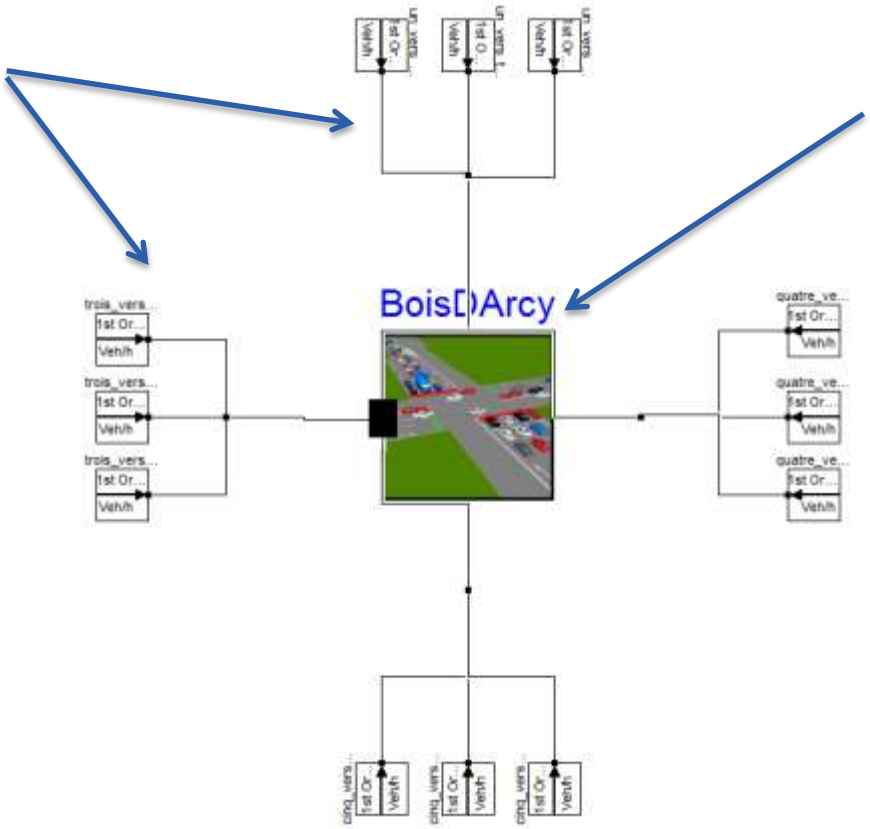
New roundabout evaluation
➔ Minimize traffic jam



Use case

Model

Vehicle flow coming from north, west



Map, Crossroad and vehicles parameters

Use case

Results

Use case

Results

Use case

Conclusion

Roundabout is a good candidate ➔ Traffic jams are minimized

BUT this junction is close to a school ➔ A roundabout is not suitable for pedestrians

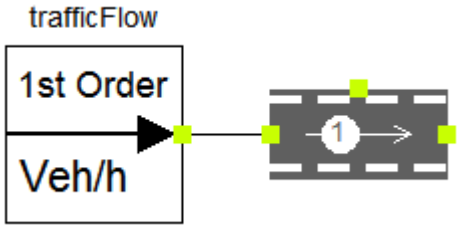
And to build a roundabout will be very expensive for the city…

An alternative solution is to reduce traffic lights period ➔ Effective and Cheaper

Performance issues

Solutions

1. Mix macro and micro components



=

1 vehicle on a 100m lane

0.01 sec to compute < 5 sec to compute

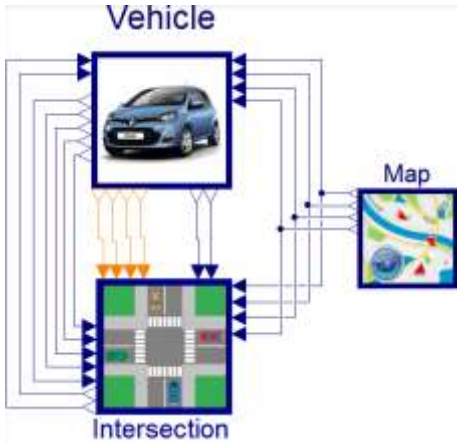
2. Choose the best solver

Many events during simulation due to communication between vehicles and the environment ➔ fixed step integrator

Performance issues

Solutions

3. Parallelize the simulation
   a. Split the model



1st test : 1 vehicle on lane with a stop	**24.4 sec**	**23 sec**
2nd test : 10 vehicles with 5 crossroads	**686 sec**	**567 sec**

Performance issues

Solutions

3. Parallelize the simulation
   b. Simulation on multi-core processor with DYMOLA ➔ Advanced.ParallelizeCode=true

	Not parallelized code	Parallelized code
1st test : 1 vehicle on lane with a stop	23 sec	22.7 sec
2nd test : 10 vehicles with 5 crossroads	567 sec	601 sec

Performance issues

Solutions

3. Parallelize the simulation
   c. Generate FMUs and simulation on xMOD

	Dymola	xMOD
1st test : 1 vehicle on lane with a stop	23 sec	11.7 sec
2nd test : 10 vehicles with 5 crossroads	567 sec	X

Conclusion & Outlook

- CityTraffic enables a quick overview of the traffic in a city using Micro or Macro approximation

- It can help cities to evaluate their network and improve it

❑But there are some performance issues due to interactions between vehicles ➔ number of cars on the map is limited
  - Some solutions have been suggested

❑Map creation can be improved by enabling users to import a map from Google or OpenStreetMap

❑Currently there is only one type of driver (Perfect Driver)