SEVENTH FRAMEWORK PROGRAMME

COLOMBO

Cooperative Self-Organizing System for low Carbon Mobility at low Penetration Rates

Swarm-based Controller for Traffic Lights Management

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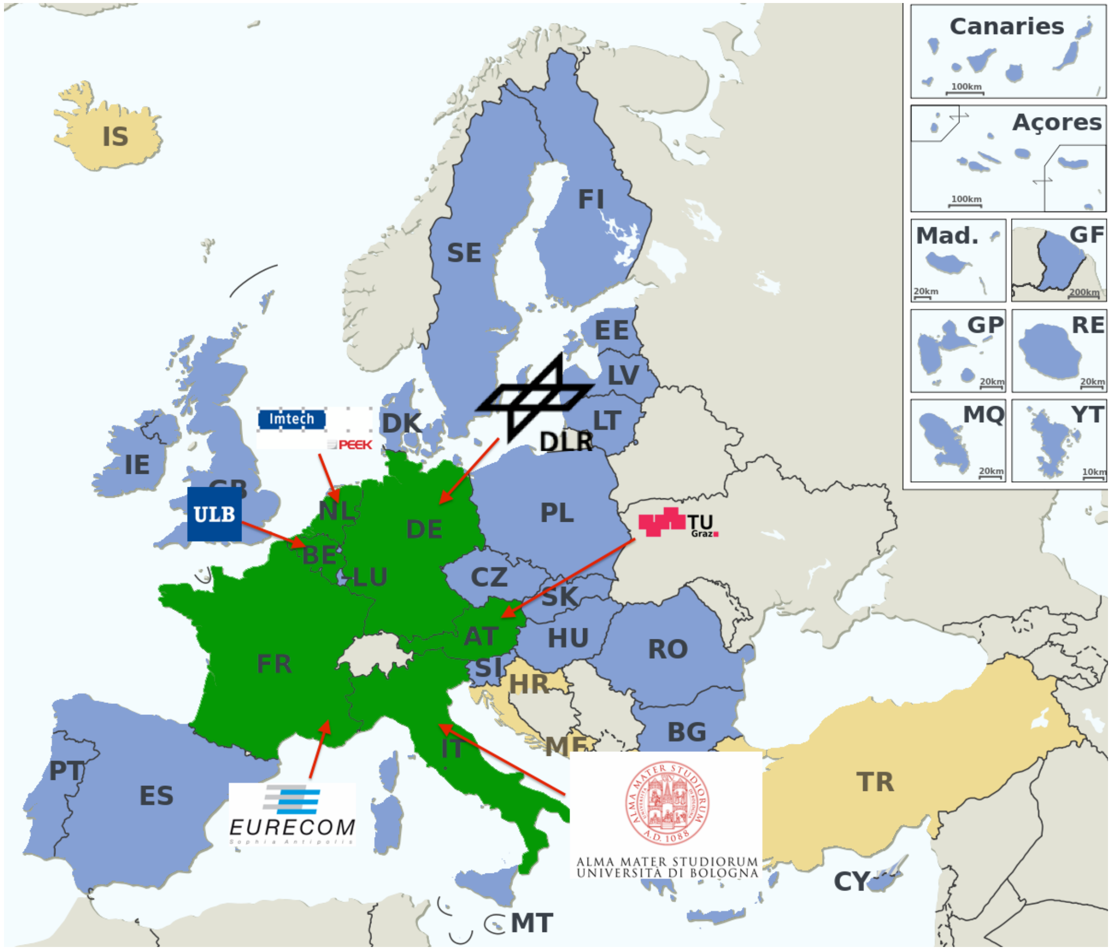
COLOMBO consortium



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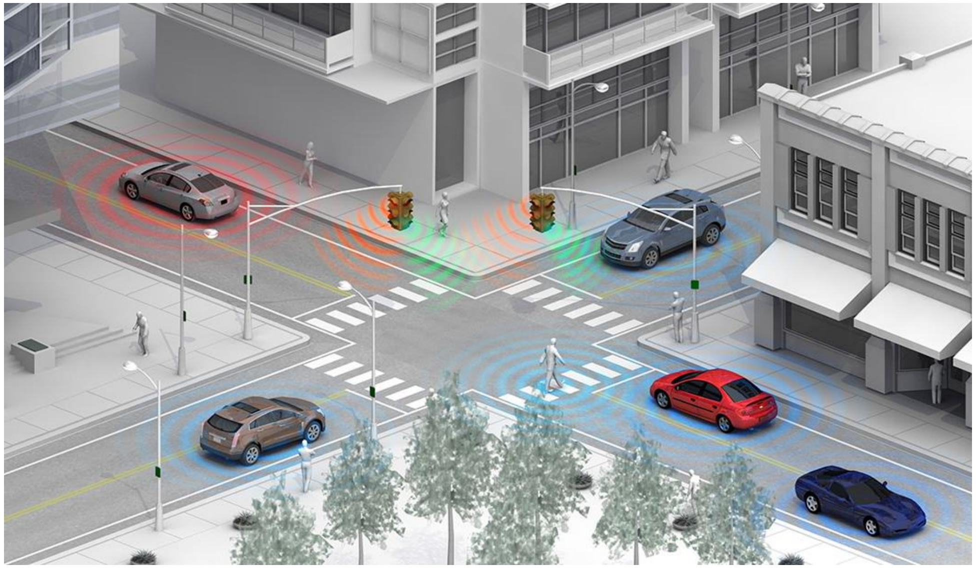
Main objective

Design and implement a self-organizing, adaptive, distributed and monitoring-aware approach to **traffic light control**

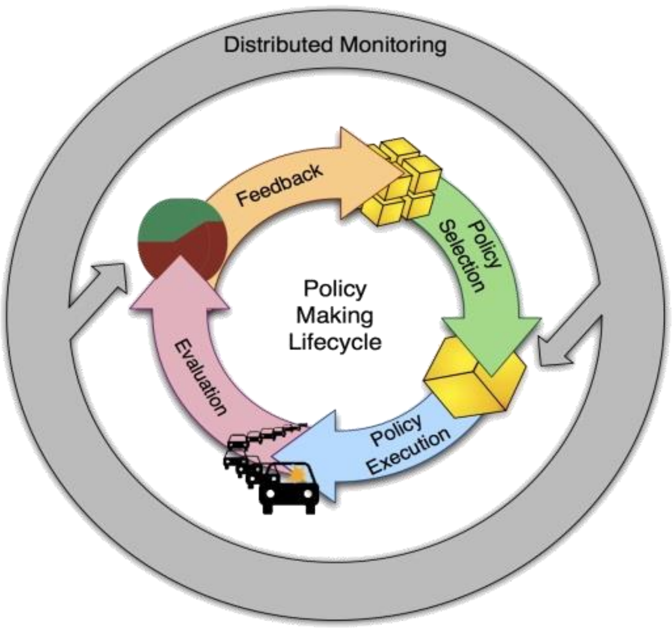
- Based on information coming from V2X communication
- Automatically selecting the proper policy
- Receiving feedback on its choice
- Automatically tuned



Self-organizing traffic light control: the concept

Control Loop

- Sensing
- Policy selection
- Policy execution
- Evaluation
- Feedback



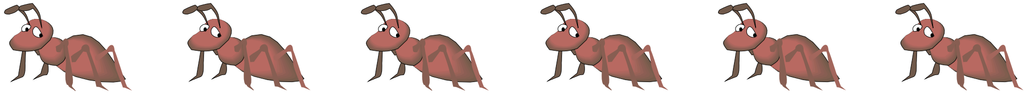
We developed the **Swarm controller** based on swarm intelligence concepts

Traffic light controller policies

- Different traffic situations need different policies
  ➔ Policy specialization
  - Low traffic
  - High traffic
  - Not homogeneous traffic
  - Congestions & burst
- Selection of the lanes and the length of the green phase

Pheromone

- **Pheromone** abstracts traffic conditions
- Every car leaves a **virtual pheromone trail** on the road
- Pheromone proportional to the **level of congestion**
- More robust than simply counting vehicles (w.r.t. incomplete information)

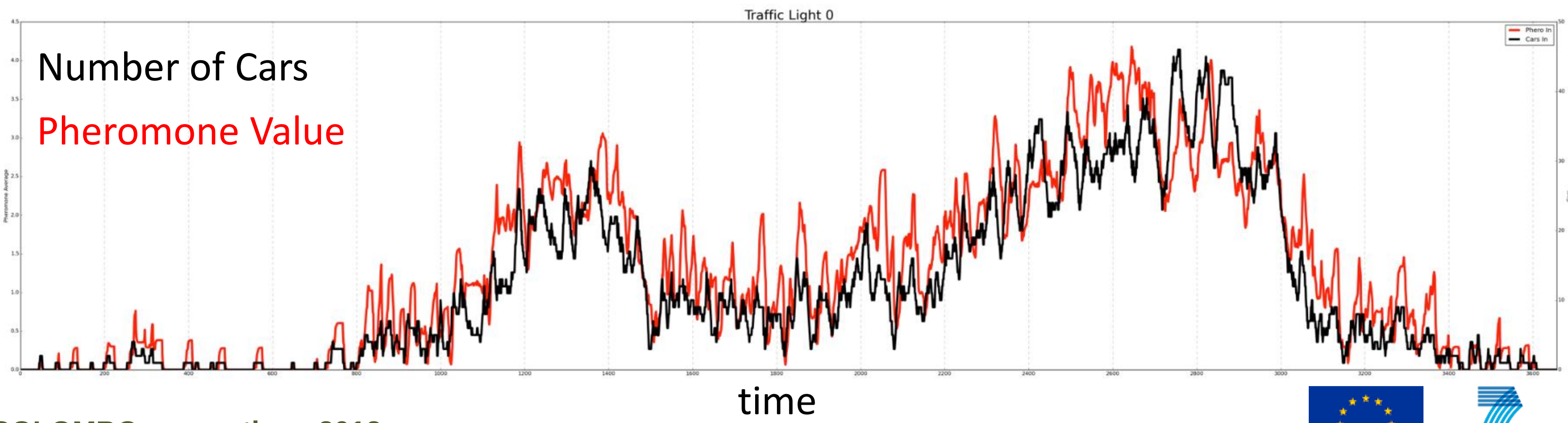


Pheromone

The pheromone computation relies on the **average speed** and its derivative (**acceleration**) of the vehicles.

$$f_l(k+1) = \beta f_l(k) + \gamma v(l,k);\ f_l(0) = 0$$

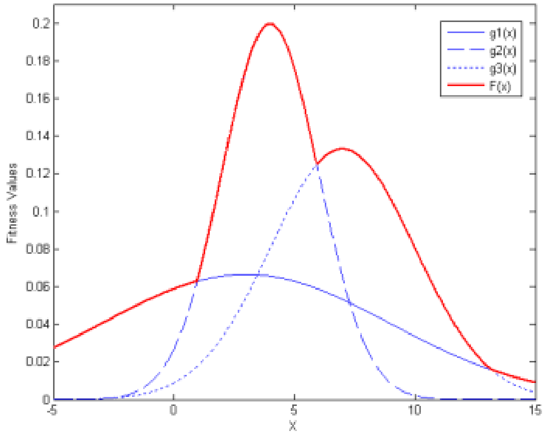
$$v(l,k) = \frac{MaxSpeed(l) - MeanVehicleSpeed(l,k)}{\frac{dMeanVehicleSpeed(l,k)}{dk}}$$



Policy selection

- **Specialized policies** for every traffic conditions
- The controller is pushed to **chose a policy**
- Probabilistic selection
- Each policy has its own stimulus function
- The **stimulus functions** are represented by a set of Gaussians in the pheromone space

$$s_{i,j}: [0, f_{max}]x[0, f_{max}] \rightarrow \mathbb{R}^{+}$$



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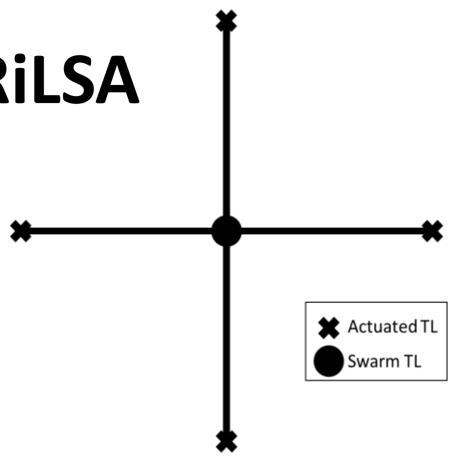
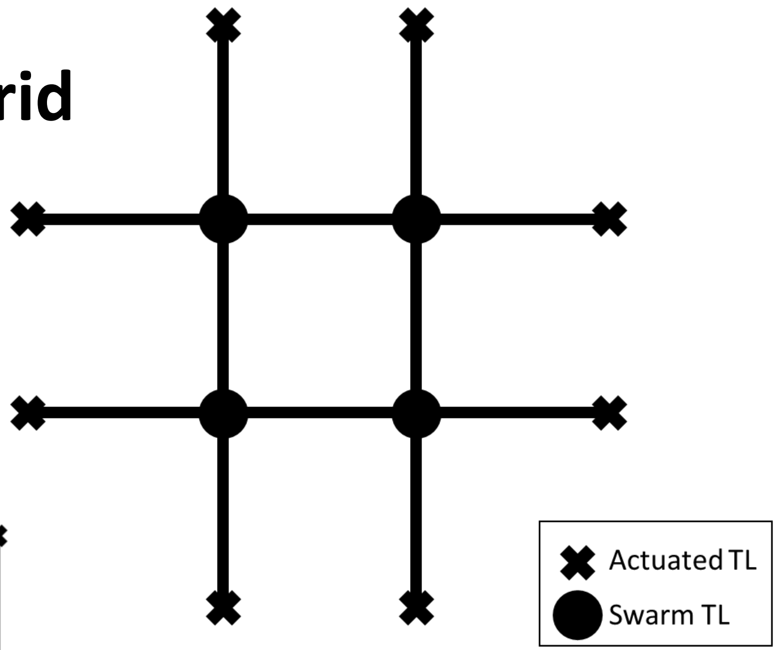
Synthetic but realistic scenarios

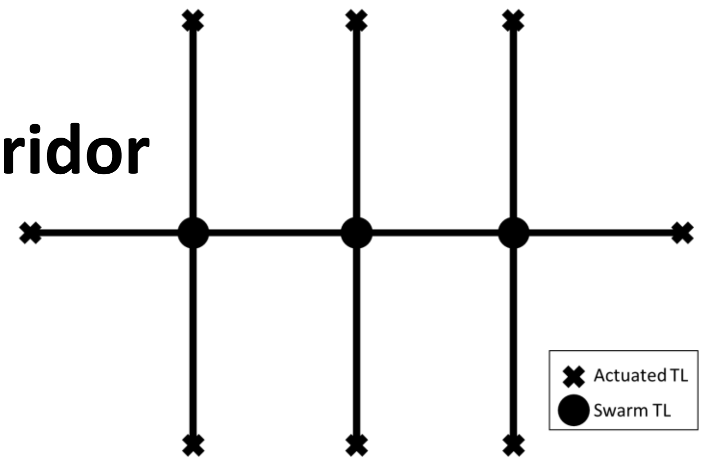
RiLSA



Grid



Corridor



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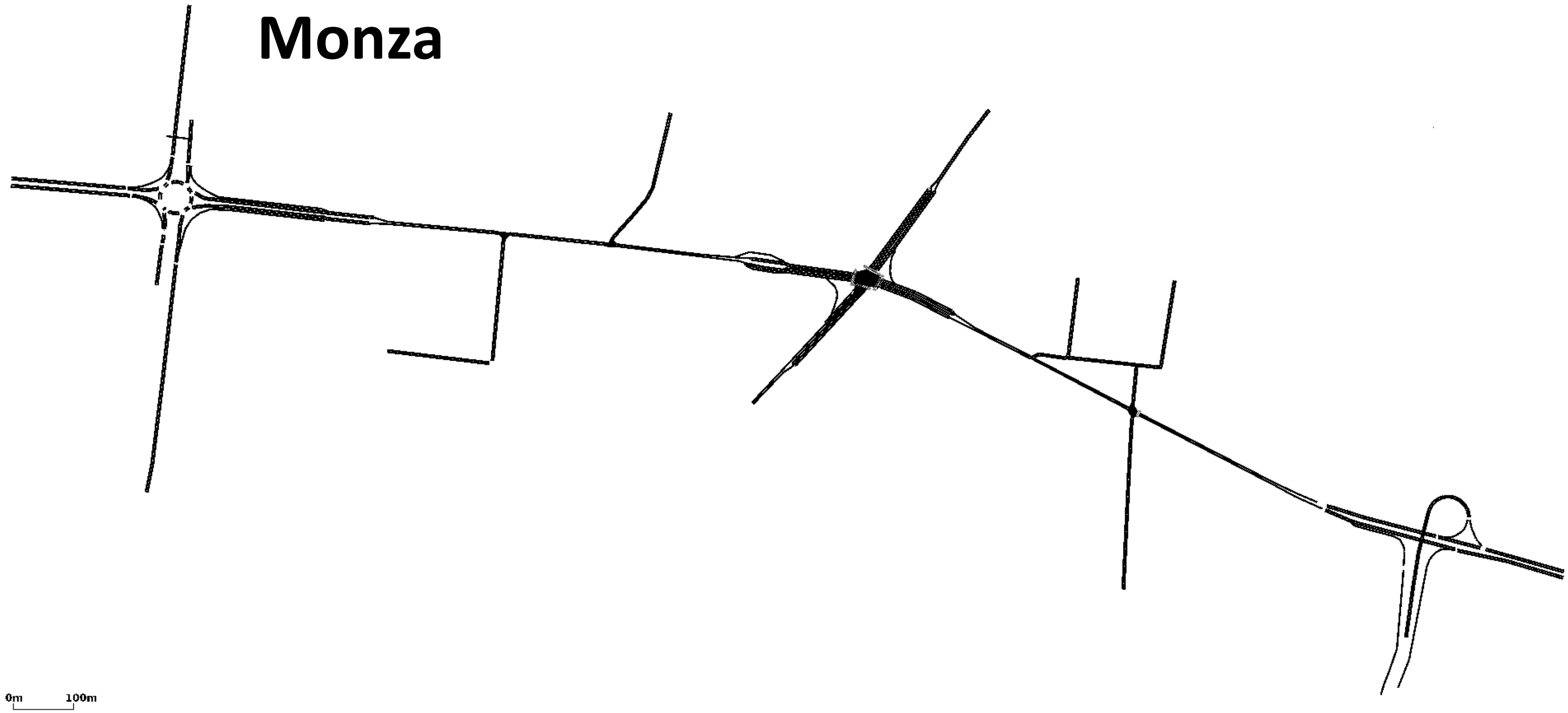
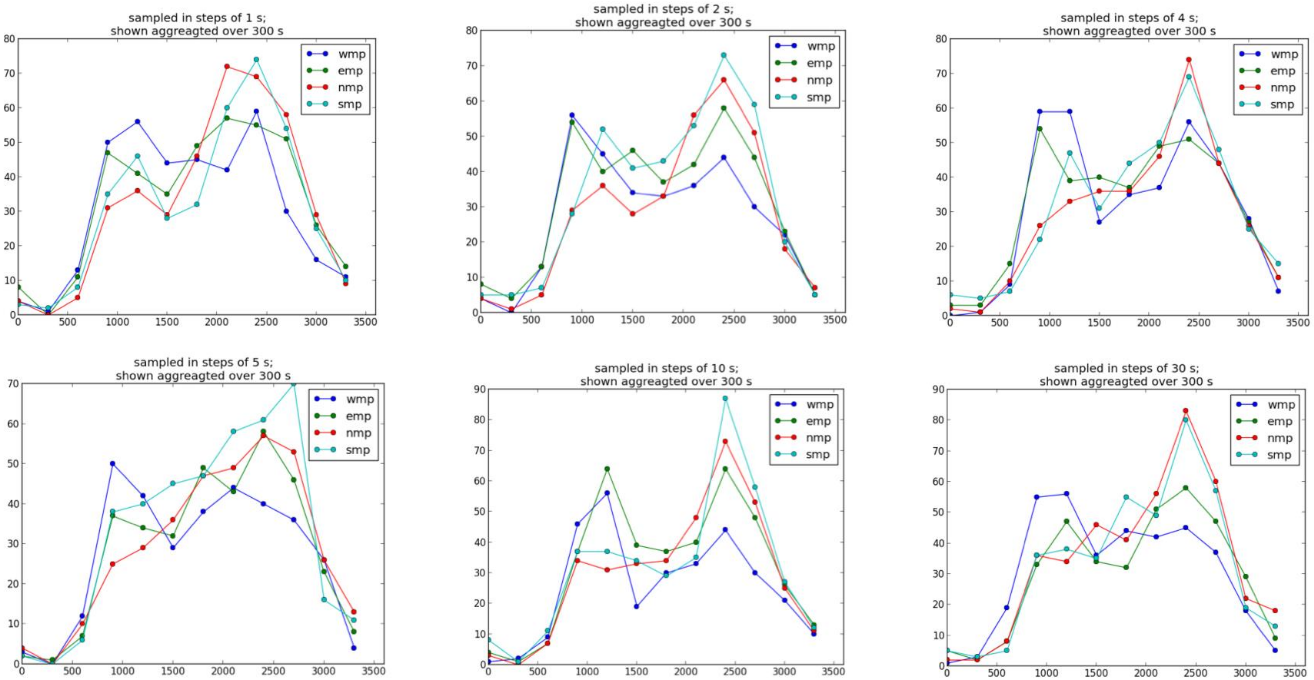
Monza scenario: a real world example



Realistic traffic conditions

Considering realistic daily load curves



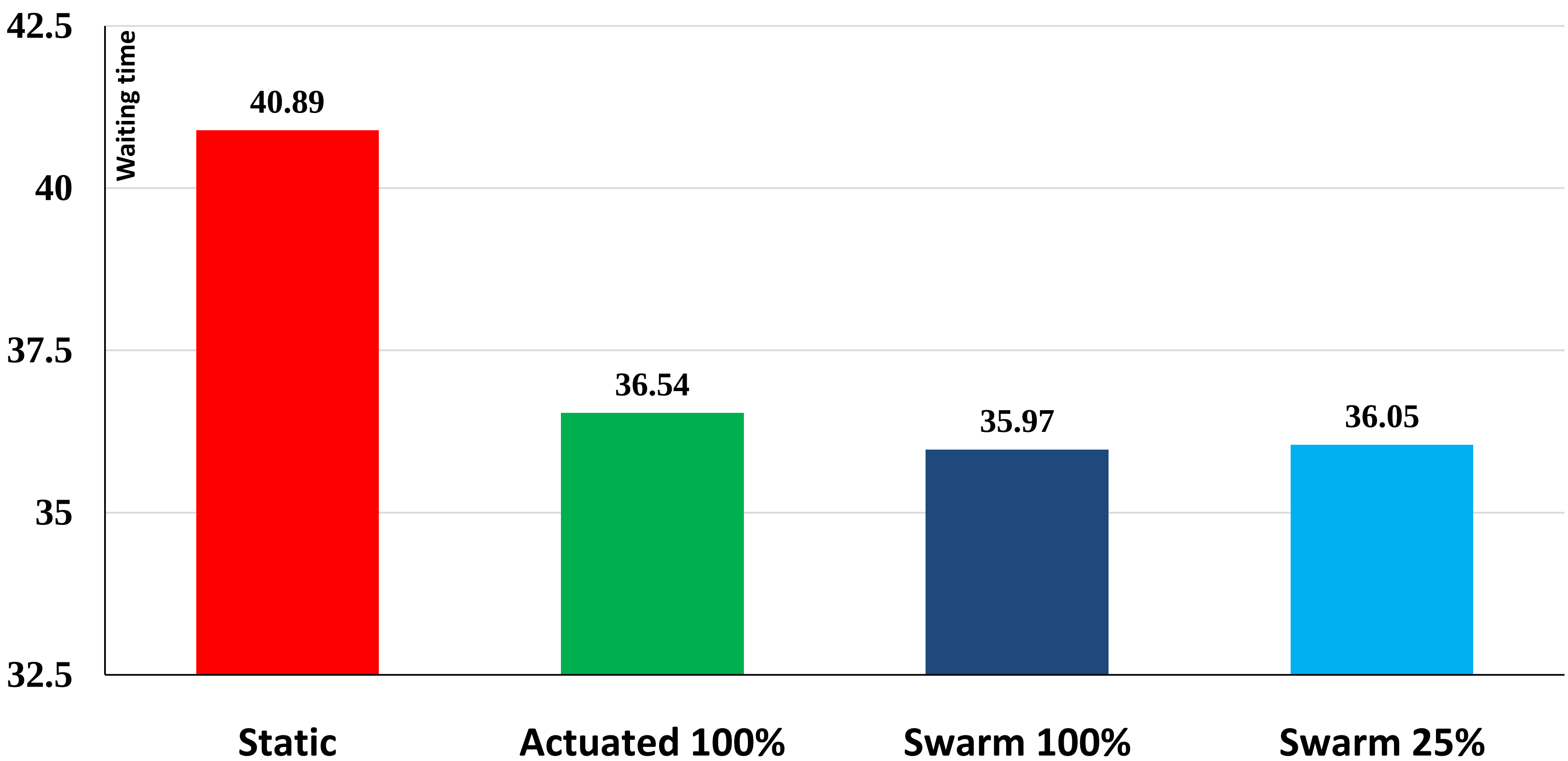
Penetration Rate

Comparing the Swarm Controller With:

- **Classic Static** Controller
- **Actuated** Controller (inductive loops knowledge → **100%**)
- **Swarm** Controller (inductive loops knowledge → **100%**)
- **Swarm** Controller (incomplete knowledge → **25%**)

Evaluation on the average waiting time

Monza results



Conclusions

- We developed a swarm based traffic light controller
- Extensive evaluations shows promising results
- The system has been extended to manage:
  - Pedestrian
  - Bicycles
  - Emergency vehicles
  - Public transport