# SUMO Based Platform for Cooperative Intelligent Automotive Agents

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# Motivations and Aims – Problems of Urban Traffic

- On Hungarian roads, traffic increased by 400% since 1995
- Improper timing of TLSs and frequent change of lanes slows the traffic
- Traffic congestion is becoming a permanent state of affairs

# Motivations and Aims – Communication

- Development of V2X communication is funded and enforced by EU-laws
- Automotive OEMs started R&D projects in the field of V2V and V2I communication

→ These modules can be used to share information and command, to ensure safety or to increase the traffic flow

# Multi-agent Based Approach

**Vehicles *(Smart Cars)*:**

- Sometimes competing (eg. at intersections)
- Sometimes cooperating (eg. when changing lanes or platooning)

**Traffic Lights *(Judges)*:**

- Optimalization problems
- Can cooperate with each other

# Interesting Aspects of MAS Approach

## Regarding smart cars:

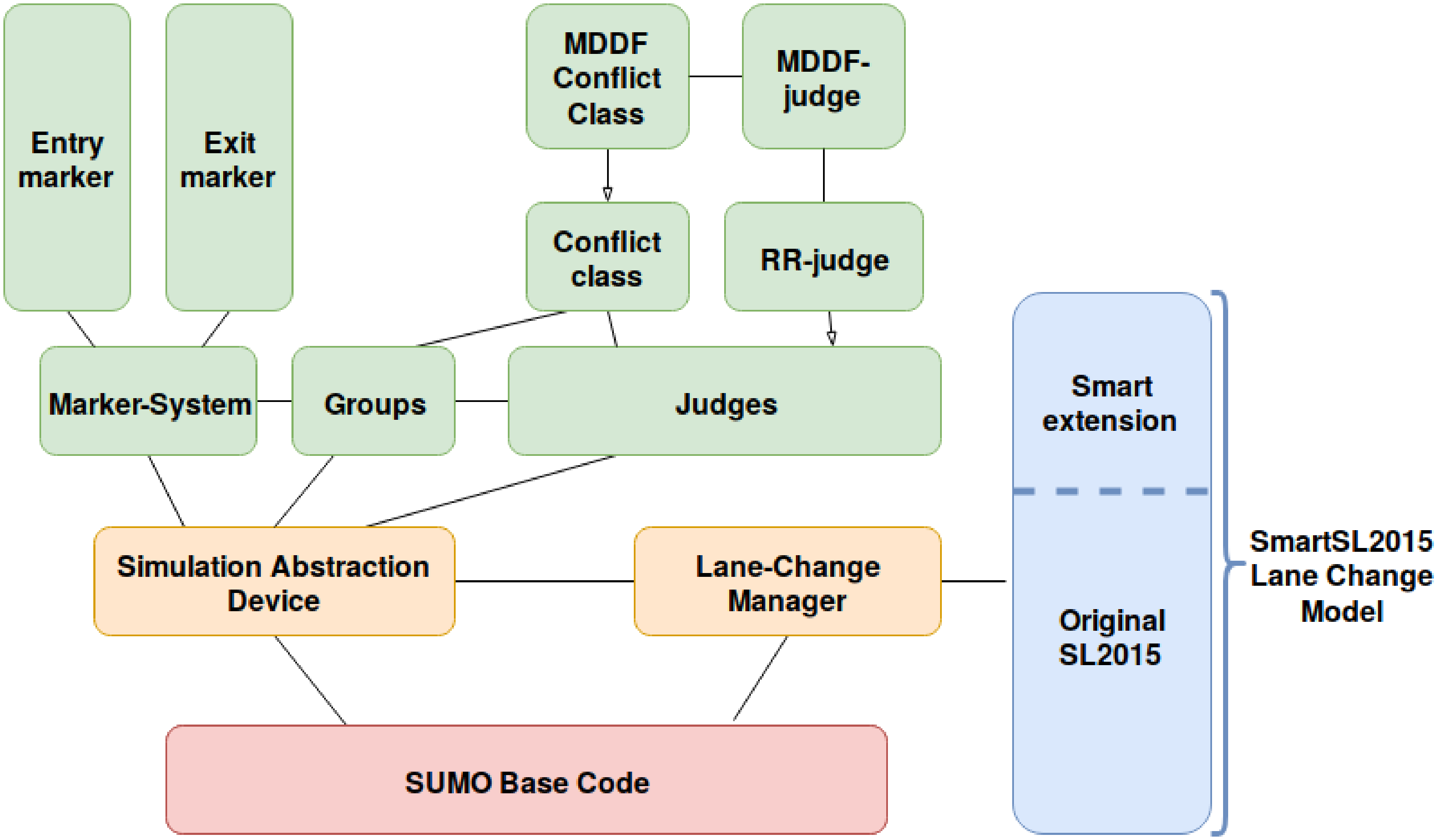
- Ad-hoc platooning in urban traffic

## Regarding judges:

- Scheduling theorem
- Game theoric approaches
- Inter-judge communication and joint scheduling

**→ A simulation platform is needed to investigate these issues.**

# Implementation in SUMO – An Overview



# Implementation in SUMO – SAL Device

## Simulation Abstraction Device *(SAL Device)*

- Every smart car is equiped with this device
- It connects the basic SUMO simulator to the Intelligent Layer
- It provides a representation of the simulated vehicles to the members of the intelligent layer

# Implementation in SUMO – Grouping I.

**Ad-hoc platooning *(Grouping)*:**

- Is formed by smart cars which have exactly the same trajectories through an intersection,
- Cars are duly following each other.
- The number of group members can be limited accordingly.
- **Between markers:**
  - Entry and exit markers
  - Practically the name of the proper edges in SUMO
  - May have additional informations (eg. they provide a pointer to the judge of the intersection)

# Implementation in SUMO – Grouping II.

**Groups:**

- Have 1 group leader (can decide to change lanes)
- Can have many group members (shall follow the group member/leader ahead of them)
- Change lanes together, like a chain to improve traffic flow

**→ New LC-model is needed:**

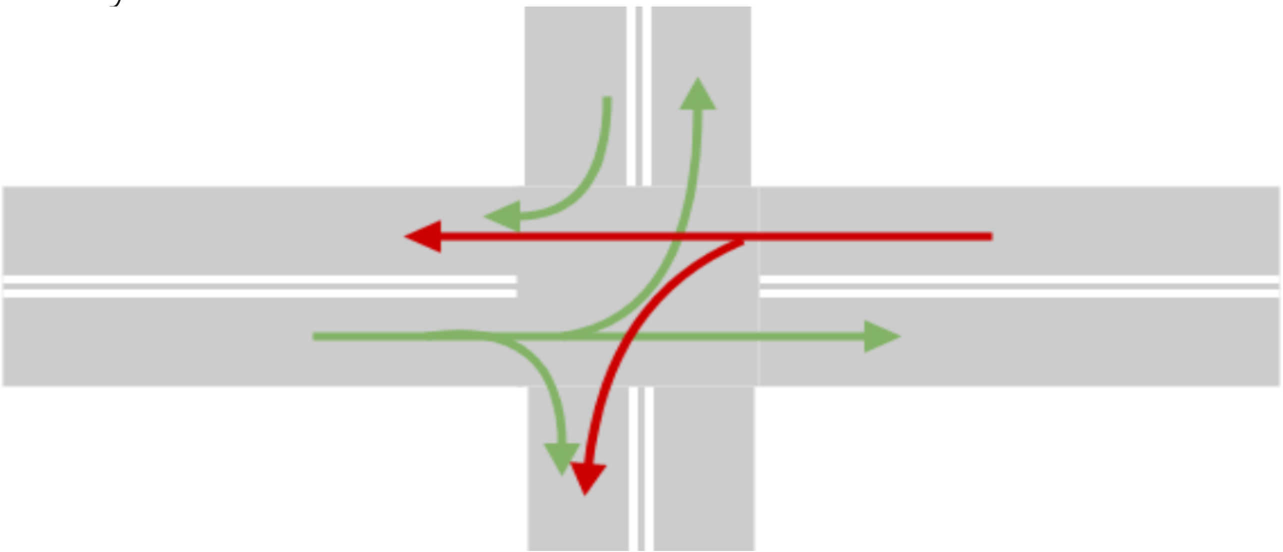
- Extended SL2015
- Lane Change Manager as an abstraction layer

# Implementation in SUMO – Judges I.

## Intelligent Traffic Lights *(Judges):*

- Analogous to the OS schedulers
- **Schedule Conflict Classes:**

  Group of smart cars which can pass through an intersection simultanously.

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# Implementation in SUMO – Judges II.

## Round Robin (RR) Judge:

- Preemptive (when the time slice has elapsed)
- Predefined order and green phase timing
- Also changes when a conflict class has no more car to go

## Minimal Destination Distance First (MDDF) Judge:

- Conflict class which has the car nearest to its destination can pass first
- Two decision layers to be fair (RR is of higher priority, Minimal Destination is of lower; change after 90 s of waiting)



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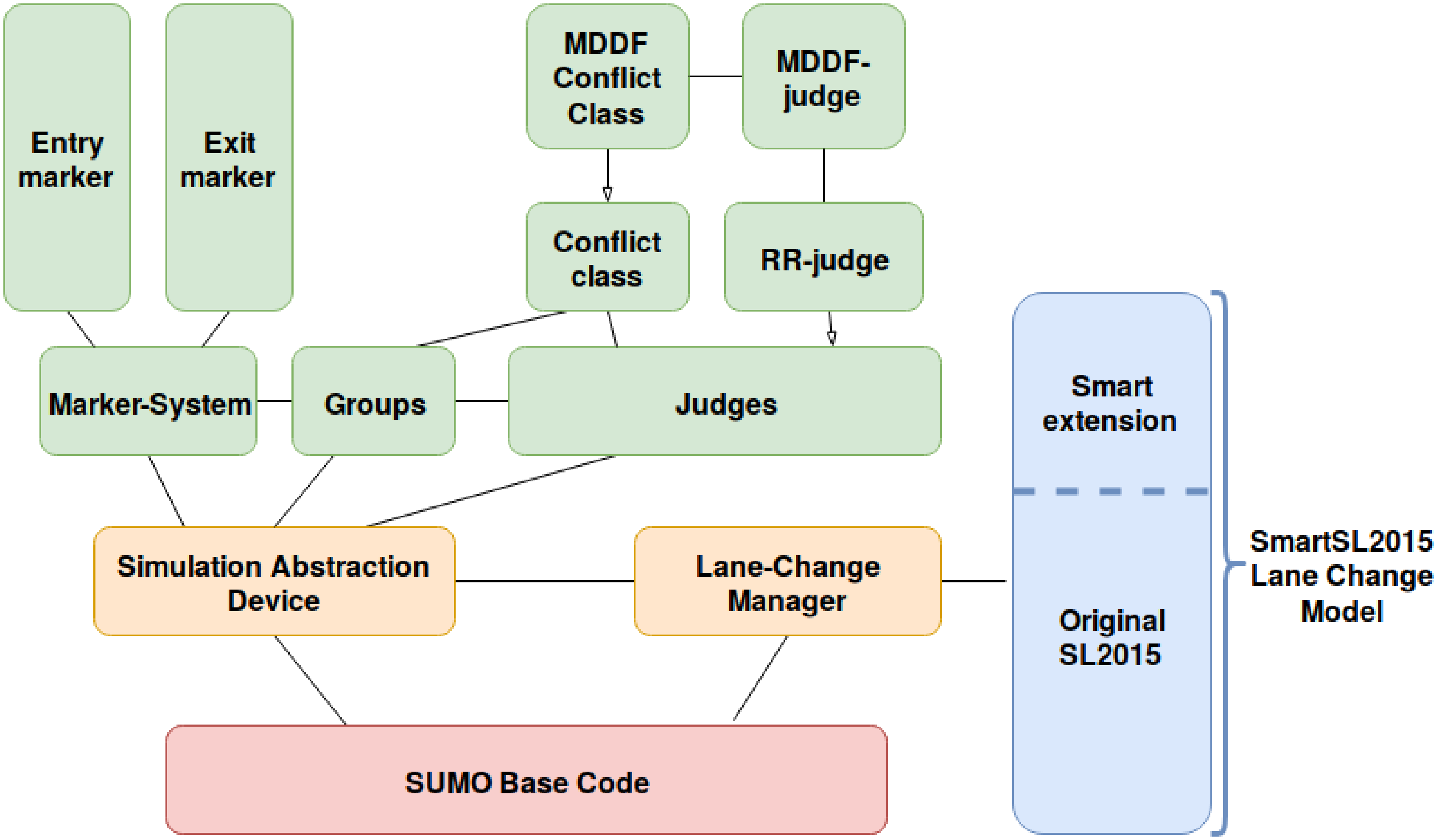
# Implementation in SUMO – An Overview



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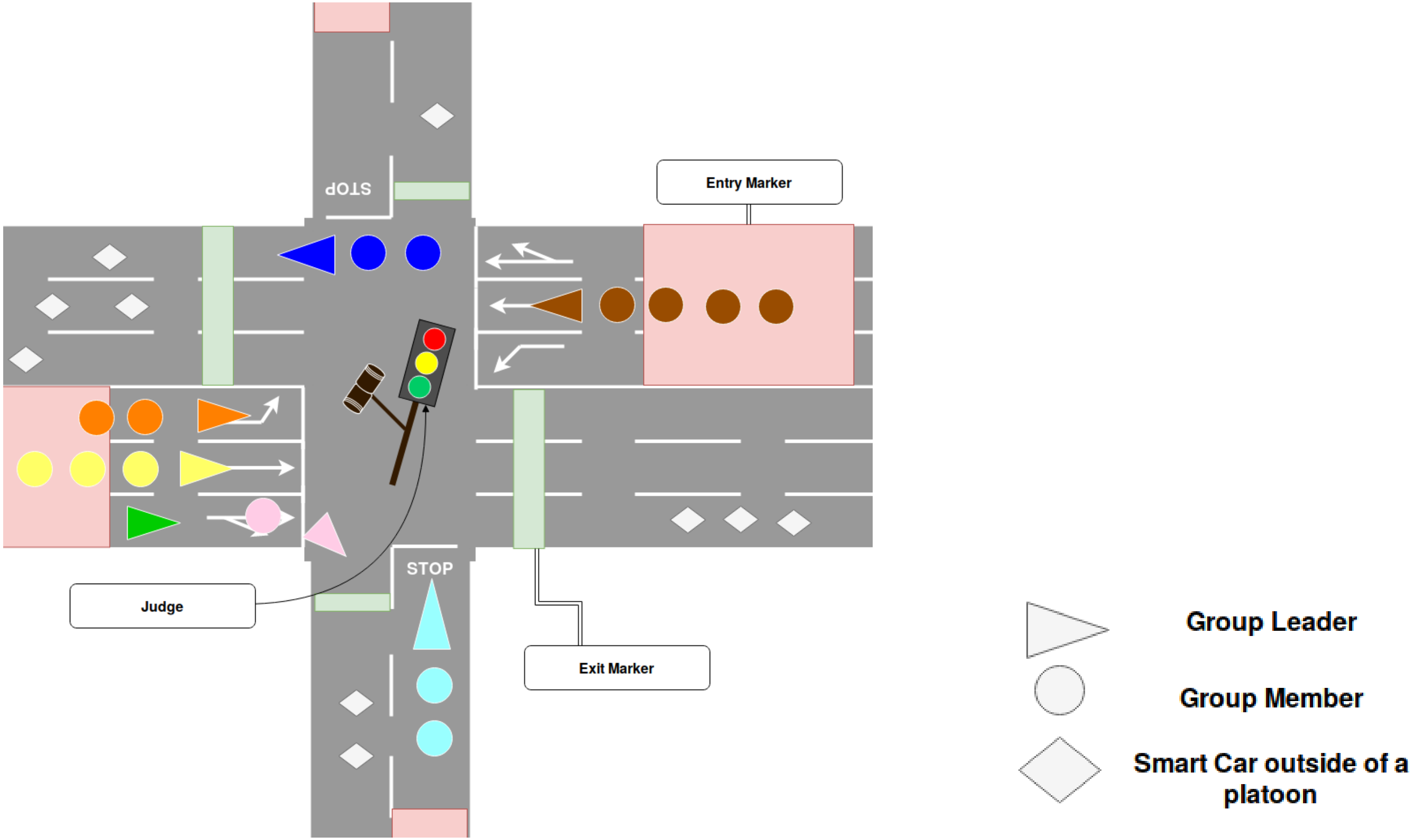
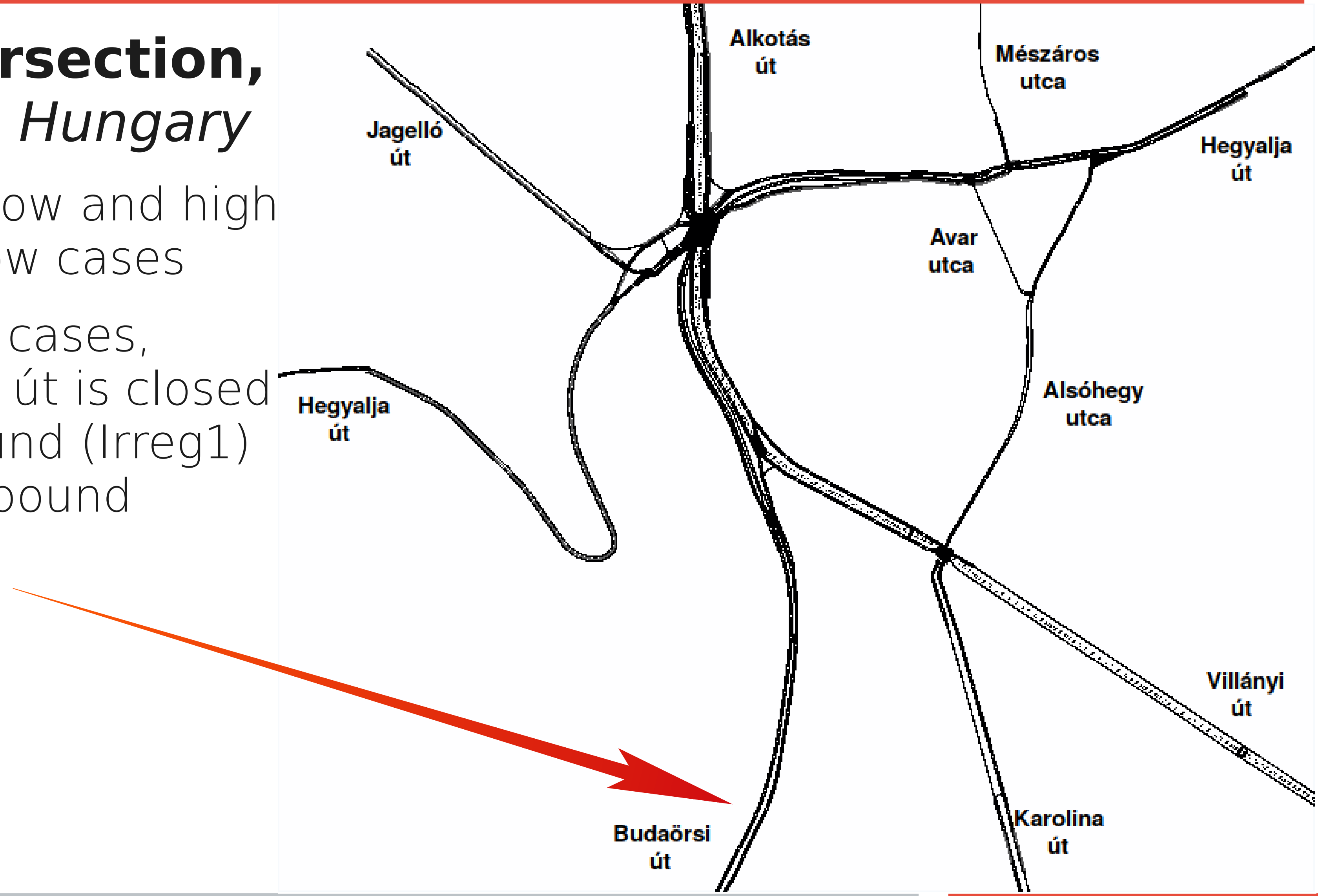


# Measurements – Simulated Network

**BAH Intersection,**
*Budapest, Hungary*

- Regular low and high traffic flow cases
- Irregular cases, Budaörsi út is closed northbound (Irreg1) or southbound (Irreg2)





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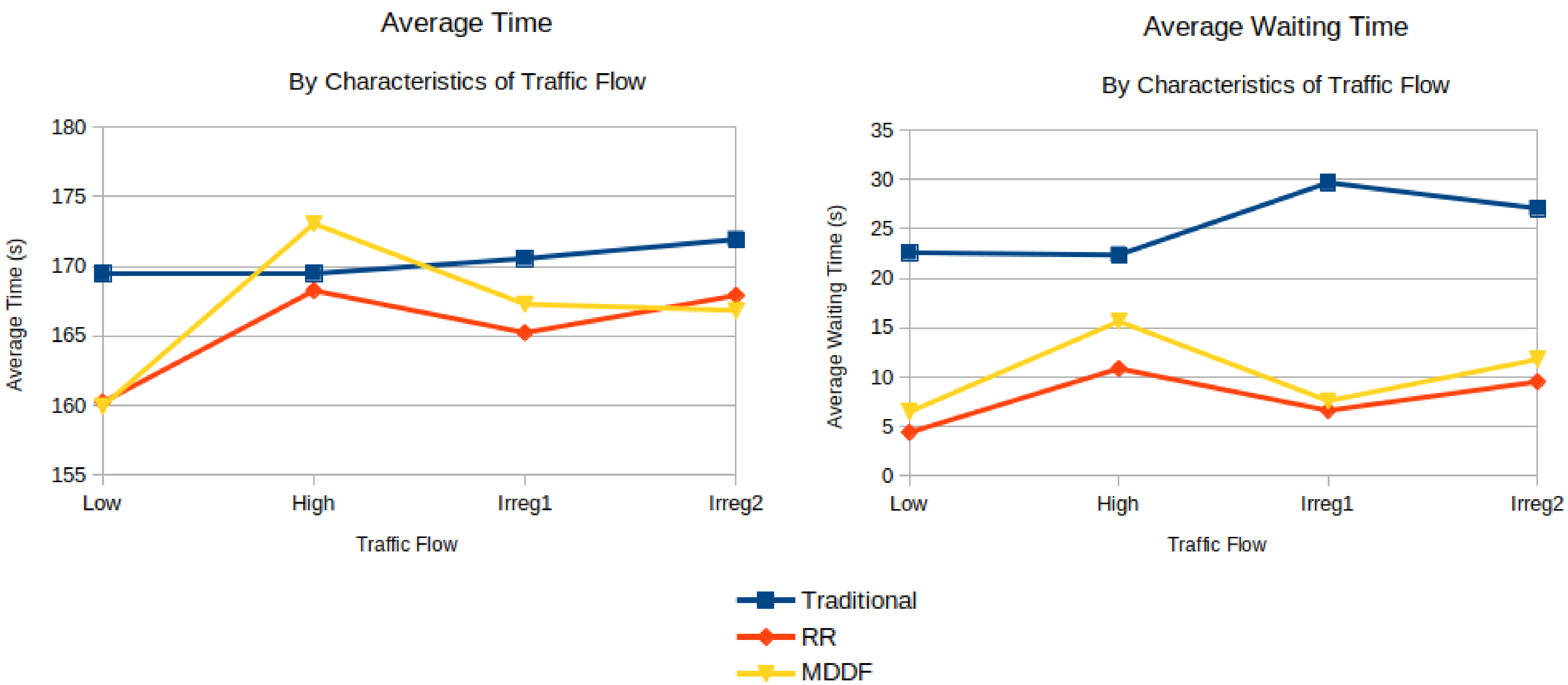
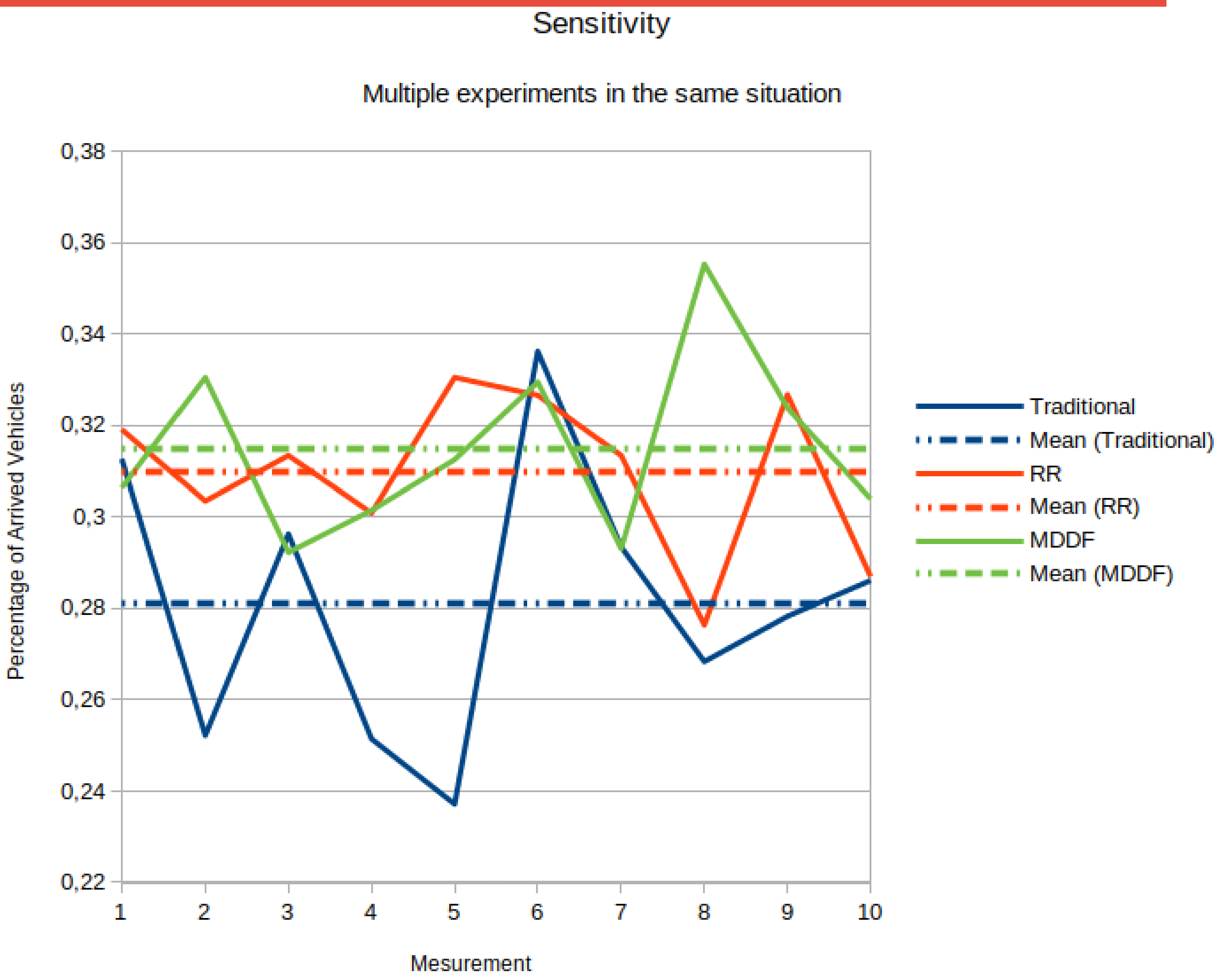
# Measurement Results



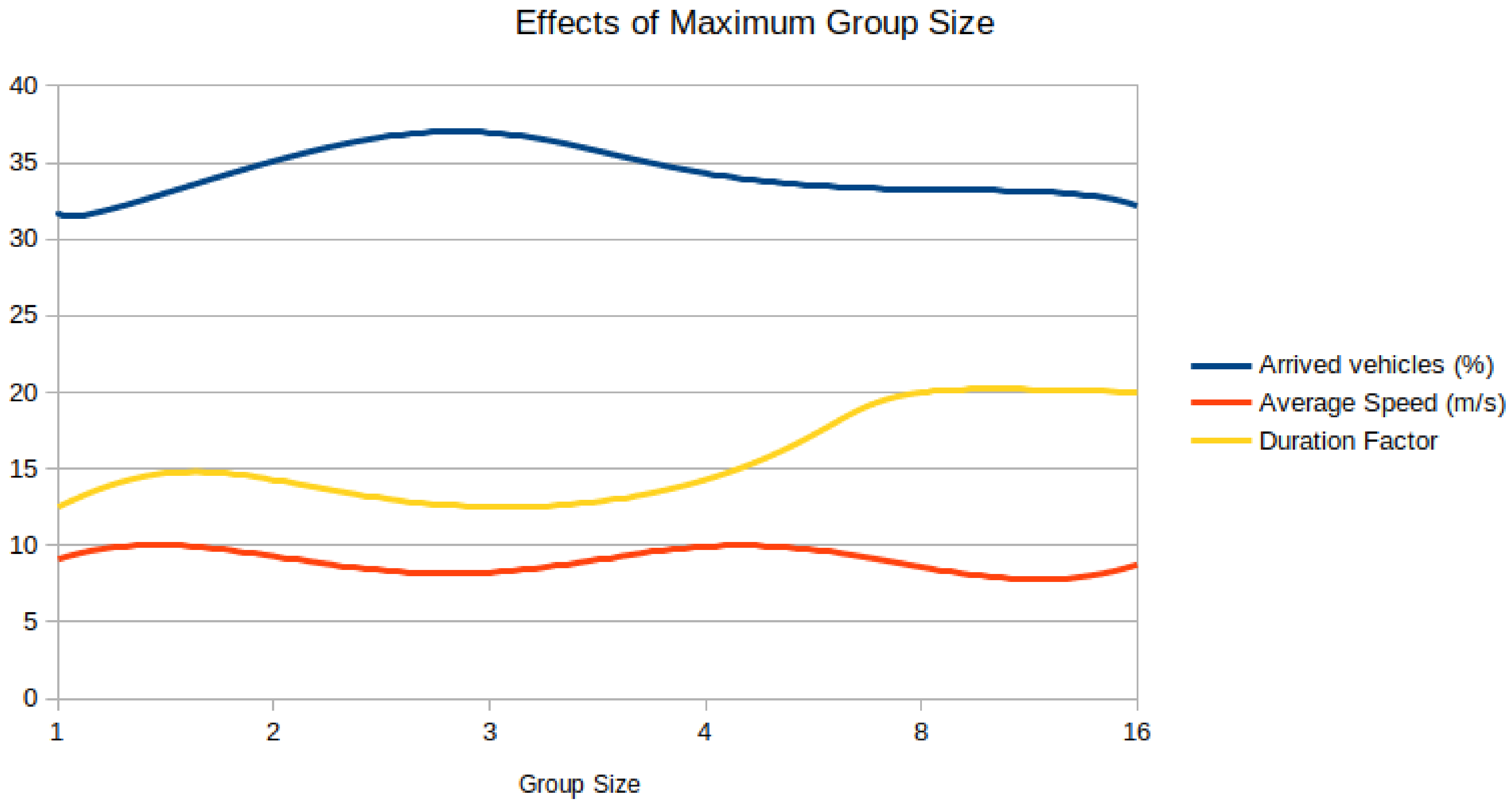
# Measurement Results




## In regular, high traffic flow scenario

- Sensitivity (Rate of Arrived Vehicles) of the proposed intelligent control outperforms the traditional intersection control

# Measurement Results





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# Summary

- A SUMO-based platform supporting multi-agent systems was implemented
- This platform can be extended according to future's research aims
- The measurement results gained with simulation of a major Budapest intersection seem convincing. Ad-hoc platooning in congestion prone urban intersections is expected to work.
- Further measurements (inter-judge communication) are planned and the platform can be improved to run faster

# Thank you for the attention!

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