



# MULTI-AGENT BASED VEHICULAR CONGESTION MANAGEMENT

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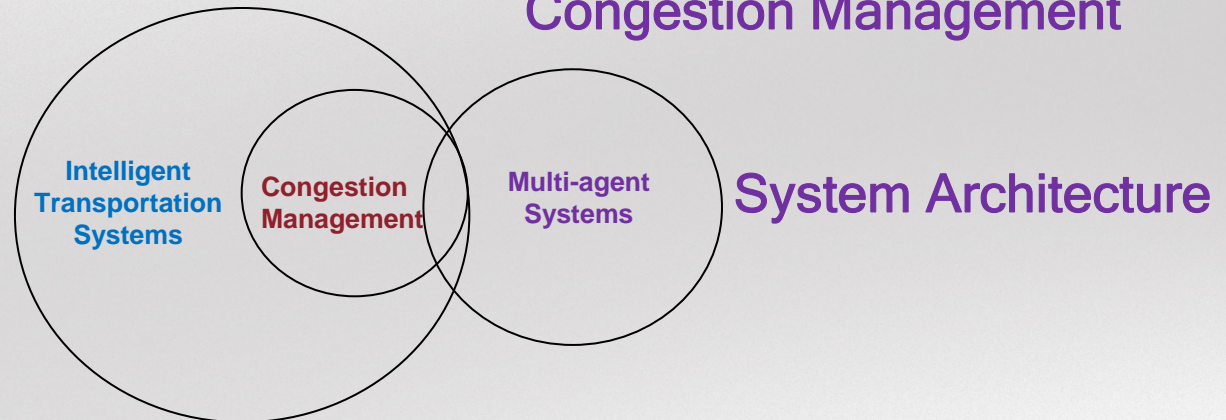
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# Overview

Application and Impact Areas

Multi-agent techniques for  
Congestion Management



Essential Elements

Causes of Congestion and Congestion Management

Conventional Techniques for Congestion Management



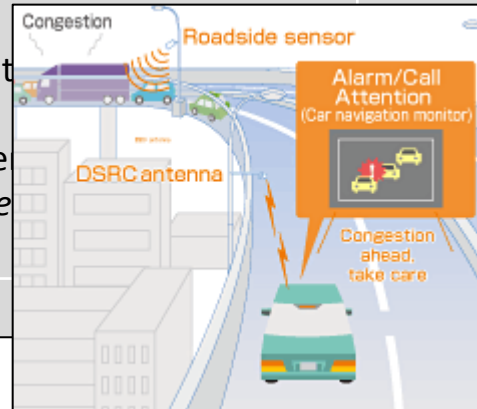
# Application and Impact Areas of Intelligent Transportation Systems

## Application

- ❑ Collision Avoidance
- ❑ Incident Detection & Management
- ❑ Pedestrian Support
- ❑ Emergency vehicle warning/efficiency  
*e.g.: Emergency Vehicle Warning, Pedestrian Collision Avoidance systems*
- ❑ Reduction in vehicle emission
- ❑ Reduction in fuel consumption  
*e.g. Eco-driving, AERIS*
- ❑ Congestion Avoidance
- ❑ Optimal Route Planning/Selection
- ❑ Reduced travel times
- ❑ Maximising capacity of existing roads  
*e.g. Ramp metering, probe vehicles*
- ❑ Support for public transport
- ❑ Improvement in travel time
- ❑ Improving efficiency

## Impact Areas

and Emergency Service



Environmental benefits



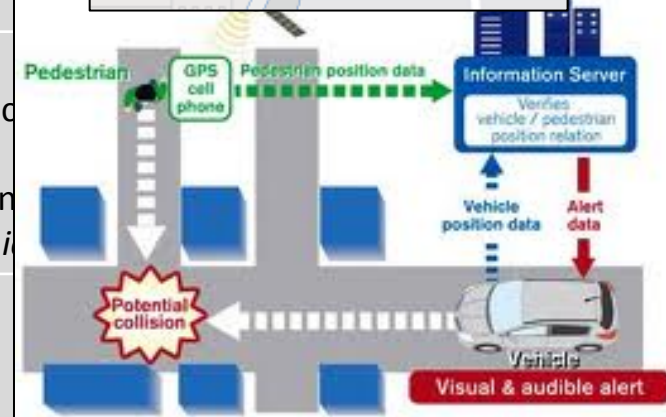
Environment

age

ement

in Operational Performance of Transport structure

activity and economic growth





# *Congestion and Congestion Management*

## **Causes of Congestion**

- Inadequate traffic control infrastructure
- Excessive dependence of the transport infrastructure on external factors
- Inefficient congestion management techniques

## **Congestion management**

- Traffic control infrastructures  
and/or
- Traveller information/route guidance systems

## **Classification of Congestion Management Techniques**

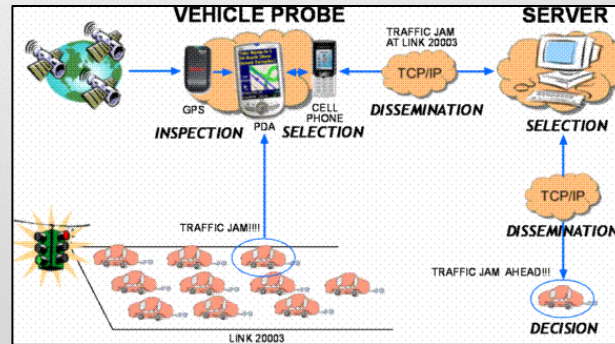
- Conventional Techniques (non-Multi Agent based)
- Multi-agent based (MAS)



# Conventional Techniques for Congestion Management

## Variable Message Sign (VMS)

- Offers generic travel advice without considering driver preferences
- Involves centralised control



Source: P. Fabián, "The End of Congestion: Developing a Large Scale "Floating Car Data" System,"

## Probe Cars

- Requires substantial number of vehicles for extensive route coverage
- Involves centralised control
- Data collection can be affected by latency and leakage

## Other Conventional Techniques:

- Integrated Urban Traffic Control and autonomous navigation systems
- Time spatial Imagery, etc

## ❖ Summary of limitations of existing techniques

- Lack of decentralised control
- Lack of coordination amongst the constituent entities
- Lack of adaptivity



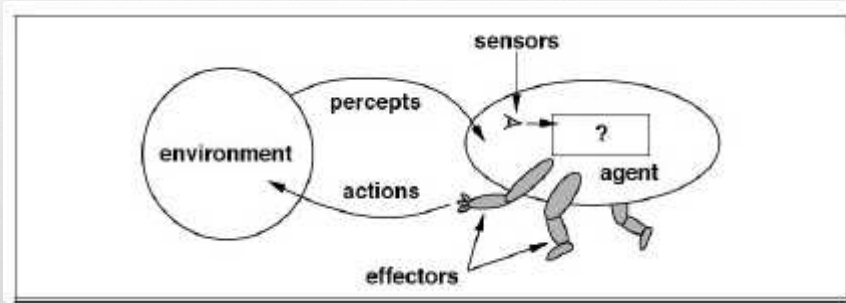
## *Essential Elements of Congestion Management Solution*

<b>Requirement</b>	<b>Possible with Conventional Techniques</b>	<b>Possible with MAS based Techniques</b>
Real-time and dynamic planning for traffic management	Partially	✓ Yes
Autonomous planning and decision-making	Partially	✓ Yes
Distributed intelligence	Mostly not	✓ Yes
Co-ordinated communication	No	✓ Yes
Efficiently handling failure conditions and incomplete information	No	✓ Yes
Understanding user (driver) preferences and giving feedback	No	✓ Yes



# Intelligent Agents and Multi-agent Systems

## Intelligent Agent (IA)

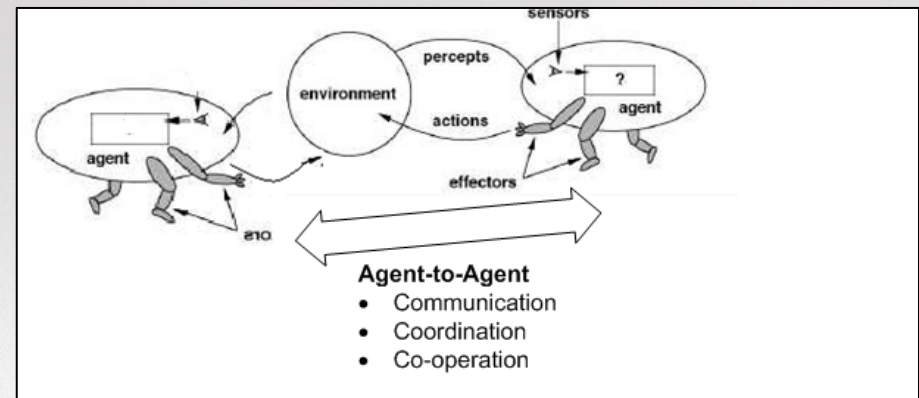


Intelligent Agent (IA) is an **autonomous software entity** which :

- observes** the environment
- acts** upon an environment
- directs** its activity towards achieving goals

## Multi-Agent System (MAS)

A Multi-Agent Systems (MAS) is a **distributed** system that consists of a number of **autonomous** agents each with its individual goals, **communicating**, **coordinating**, and **cooperating** with each other in a **heterogeneous** environment.



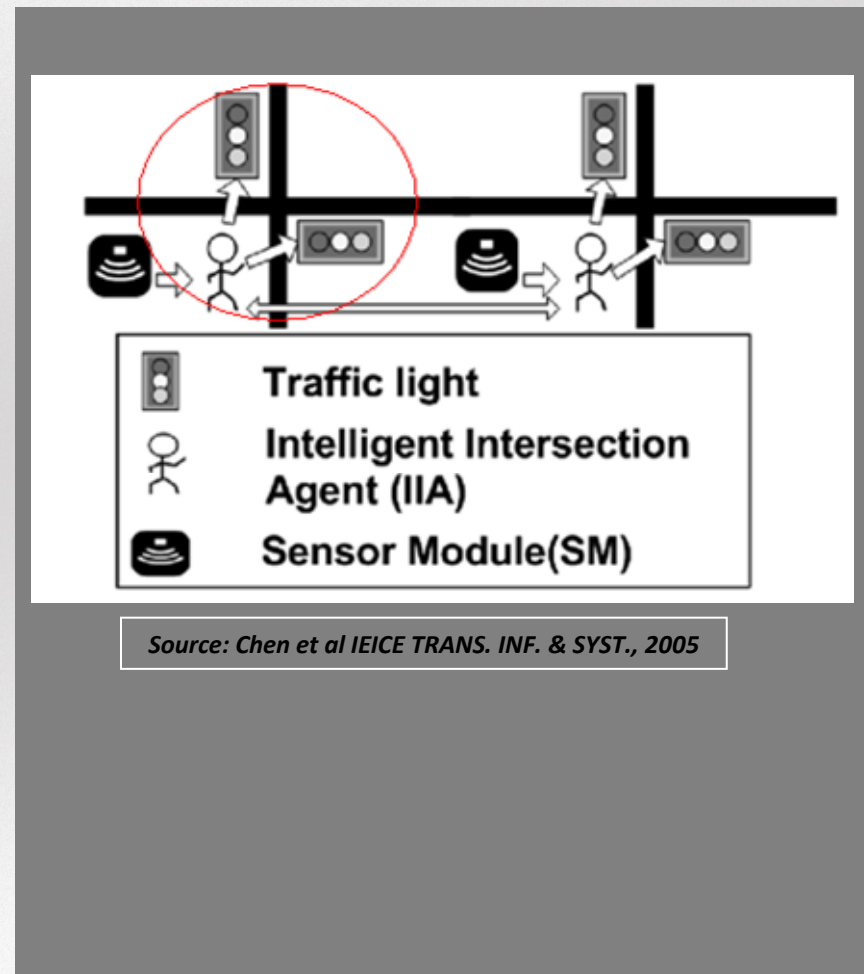


# Multi-agent technique for Congestion Management

## Adaptive and Cooperative Traffic light Agent Model (ACTAM)

Decisions based on :

- Communication with other agents
- Co-operative control strategy
- Short-term and long-term Learning
- Weighted Module control strategy of the traffic
- Forecasting data

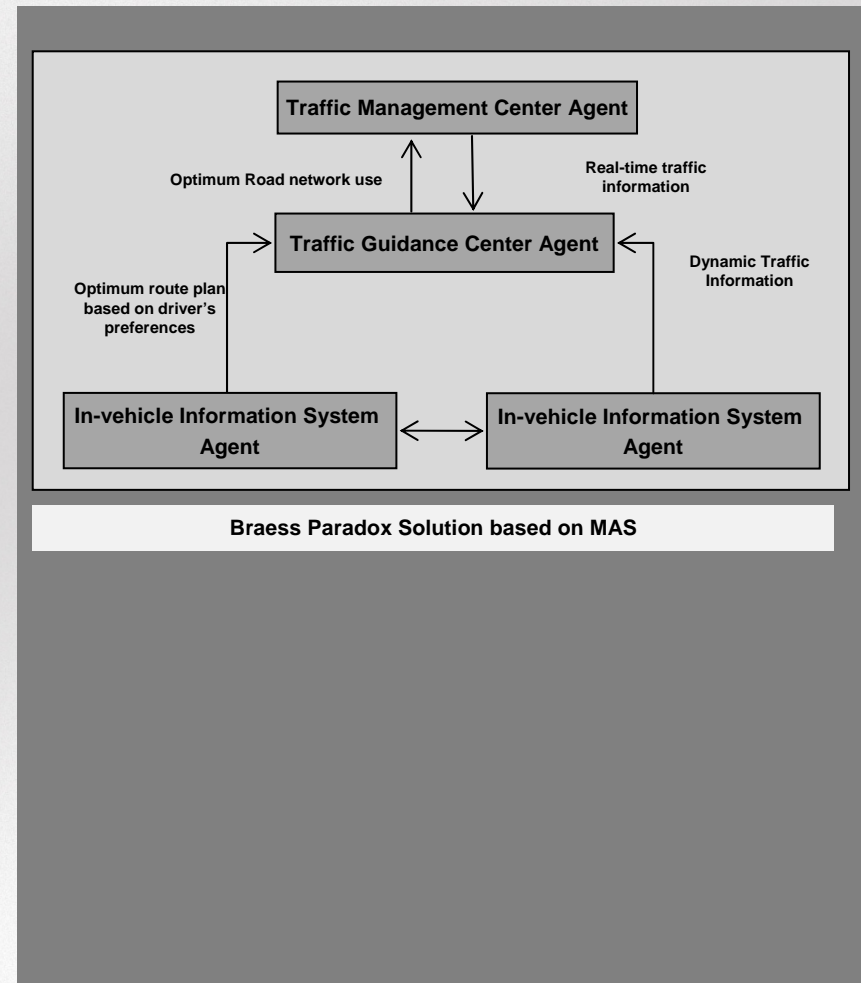




# *Multi-agent technique for Congestion Management*

## **Braess Paradox Solution based on MAS**

- ❑ Involves centrally coordinated route guidance decisions based on the route capacity
- ❑ Takes into consideration the driver preferences





## *Suitability of Agent Solution*

### ➤ Distributed intelligence and autonomous decision-making capability

*Example : Agent based In-vehicle software to manage the geographically distributed traffic patterns and individual driver preferences*

### ➤ Capability to dynamically adapt to changing traffic conditions

*Example : Optimised agent based traffic signals to accommodate the dynamic mobility patterns of vehicles to adapt to the real-time traffic situation*

### ➤ Real-time planning and coordination capability

*Example : Agent based coordination and negotiation mechanisms to manage the dynamic traffic flow at the intersections via V2V and V2I communication*

### ➤ Capability to learning from events (traffic patterns)

*Example : Intelligent agent software to learn about the characteristics of the traffic flow to base future decisions*



## Agents in Traffic Management : Proposed System Architecture

### In-vehicle agent:

- Learns from traffic patterns
- Initiates inter-vehicular communication and negotiation
- Considers local vehicular specifics
- Considers driver preferences
- Designs optimal routing decisions

### V2V Communication:

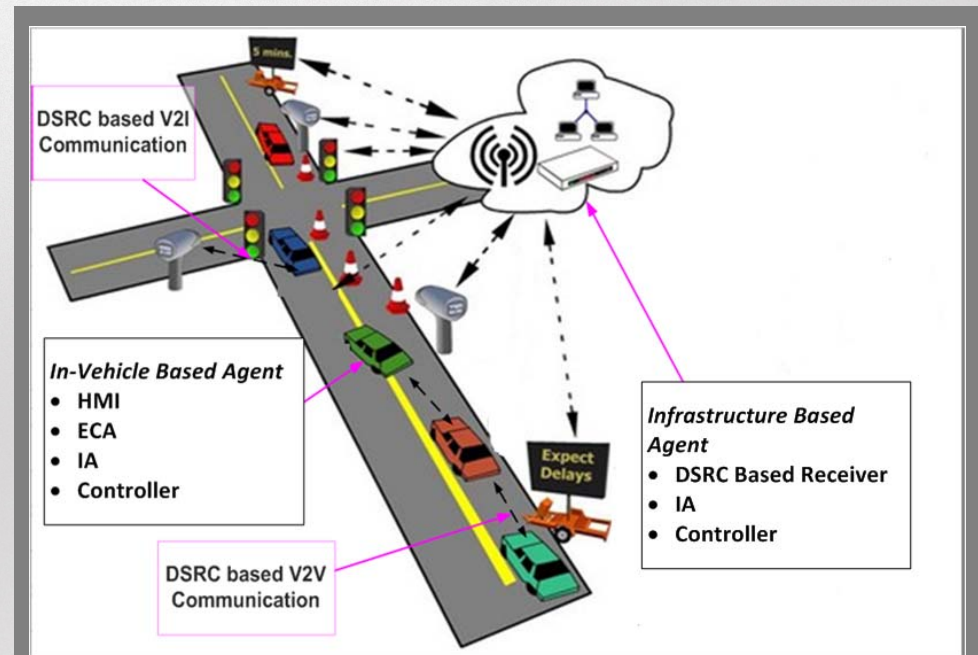
- Exchange driver preferences and vehicle specific information
- Coordinate routing decisions

### Infrastructure agent:

- Collects surrounding traffic information
- Processes and conveys decisions on vehicle re-routing

### V2I Communication:

- Coordination and communication between vehicles and infrastructure
- Processing the vehicle routing decisions and make them available to the on-coming vehicles for use



**DSRC : Dedicated Short Range Communication**

**HMI : Human Machine Interface**

**ECA : External Communication Agent**

**IA : Information Agent**

**V2V : Vehicle-to-Vehicle**

**V2I : Vehicle-to-Infrastructure**



*Summary of Application of MAS based Congestion Management Techniques*

Agent Based Traffic Simulator

Congestion Avoidance

Traffic Flow Regulation

Driver Modelling

Negotiation of Traffic Strategies

Route Planning

Congestion Prediction

Traffic Pattern Detection

V2V and V2I based coordination

Intelligent Processing of information

Information Dissemination



## *Summary & Conclusion*

Multi-Agent Systems possessing the enhanced capabilities can provide a reliable solution for congestion management:

- *Inter-agent coordination via Dedicated Short Range Communication (DSRC)*
- *Robust techniques to handle failures that might arise due to delay-prone and intermittent data exchanges*
- *Learning mechanisms to predict possible driver non-conformance*
- *Enhanced negotiation strategies in case of conflicting traffic control decisions*



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# *Questions*

Thank-you for your attention!