MULTI-AGENT BASED VEHICULAR CONGESTION MANAGEMENT

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Overview

Application and Impact Areas

Multi-agent techniques for Congestion Management

Essential Elements

System Architecture

Causes of Congestion and Congestion Management

Conventional Techniques for Congestion Management
### Application and Impact Areas of Intelligent Transportation Systems

<table>
<thead>
<tr>
<th>Application</th>
<th>Impact Areas</th>
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<tbody>
<tr>
<td>Collision Avoidance</td>
<td>Safety and Emergency Service</td>
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<tr>
<td>Incident Detection &amp; Management</td>
<td>Environmental benefits</td>
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<tr>
<td>Pedestrian Support</td>
<td>Climate change</td>
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<tr>
<td>Emergency vehicle warning/efficiency e.g.: Emergency Vehicle Warning, Pedestrian Safety, Collision Avoidance systems</td>
<td>Environment</td>
</tr>
<tr>
<td>Reduction in vehicle emission</td>
<td>Congestion Avoidance</td>
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<tr>
<td>Reduction in fuel consumption e.g. Eco-driving, AERIS</td>
<td>Optimal Route Planning/Selection</td>
</tr>
<tr>
<td>Congestion Avoidance</td>
<td>Reduced travel times</td>
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<td>Maximising capacity of existing infrastructure e.g. Ramp metering, probe vehicle</td>
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<td>Reduced travel times</td>
<td>Support for public transport</td>
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<td>Improving efficiency</td>
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<td>Support for public transport</td>
<td>Improvement in travel time</td>
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<tr>
<td>Improving efficiency</td>
<td>Boosting productivity and economic growth</td>
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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

![Variable Message Sign](image)

**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

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

[www.autocrc.com](http://www.autocrc.com)
## Essential Elements of Congestion Management Solution

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

Source: Chen et al. IEICE TRANS. INF. & SYST., 2005
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 learn 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

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### Summary of Application of MAS based Congestion Management Techniques

<table>
<thead>
<tr>
<th>Technique</th>
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<tbody>
<tr>
<td>Agent Based Traffic Simulator</td>
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<tr>
<td>Congestion Avoidance</td>
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<td>Traffic Flow Regulation</td>
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<tr>
<td>Driver Modelling</td>
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<tr>
<td>Negotiation of Traffic Strategies</td>
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<tr>
<td>Route Planning</td>
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<tr>
<td>Congestion Prediction</td>
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<tr>
<td>Traffic Pattern Detection</td>
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<tr>
<td>V2V and V2I based coordination</td>
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<tr>
<td>Intelligent Processing of information</td>
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<td>Information Dissemination</td>
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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
References


Questions

Thank-you for your attention!