STUDY ON URBAN TRAFFIC MANAGEMENT BASED ON MULTI-AGENT SYSTEM

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Abstract:
Multi-agent system (MAS) technology is adopted in constructing the model of group decision support system in distributed urban traffic management. The presented system is composed of segment agent, crossing agent, section agent and central decision agent. It can realize an intelligent traffic management, by sharing information and implementing complicated traffic control in a region. The system can achieve the global optimization of the region, alleviate traffic jam, reduce the emission of vehicles and then increase the efficiency of traffic management. The result of this paper can be used in traffic management to alleviate the urban traffic congestion in China.

Keywords:
Group decision support system; Multi-agent system; Distributed urban traffic management; Communication; Traffic management

1. Introduction

The present urban traffic is aggravated with great economic development in China. Serious traffic congestions and frequent traffic accidents always exist. The extension and construction of roads cannot solve the problem. However, ITS (Intelligent Transportation System) is the most suitable way to solve the problems in transportation all over the world. The traffic management strategy, as an important constituent of ITS, greatly benefit and improve traffic management.¹

The goal of traffic management is to maintain a well-ordered traffic in a region. Based on the traffic law, traffic management must make decisions according to the going and traffic condition, then guide and organize the traffic in an optimized and reasonable way. Therefore, a clear traffic without obstruction is realized by improving the utilization of urban road, optimizing the timing strategy of the traffic network, alleviating traffic congestion and reducing the consumption of fuel and the emission of vehicles.²

However, the involvement of humans in the traffic and the non-linear, random, vague and uncertain feature of urban traffic characterize traffic management in a distributed manner. Therefore, the integration of the Multi-agent system and group decision support system is a best way to scientifically solve the unstructured problem and to establish a distributed group decision support system for urban traffic management. In this way, the quality of traffic management can be improved.³

2. Decision System based on MAS

2.1. Multi-agent system (MAS)

Agent refers to the physical or abstract entity with the feature of autonomy, cooperation and initiative. The multi-agent system is an important branch in distributed intelligent field. MAS is a series of agents with different functions, which share information and coordinate each other to complete complicated tasks.

Multi-agent model is presented in Fig. 1. In the Fig., server agent not only collects and analyzes the information from client agents and transmits information to client agents; but also exchanges the real-time data with databases and stored and retrieved the data. Client agent always provides operations for data processing to server agent, changes system parameters in certain time and then makes

Fig. 1 Multi-agent Model
corresponding management based on the received information from server agent. Route agent mainly deals with registration of clients and maintenance of databases for on-line user, user address, news list and news buffer.

2.2. Group decision support system (GDSS)

GDSS is one of the systems based on the integration of knowledge on computer, communication and decision-making in management. It can solve problems in a reasonable and systematic way based on the experience and wisdom of different members. It has two patterns for decision-making: central pattern and distributed pattern. In central pattern, group members’ work for a common problem. The pattern is mainly used for guiding and harmonizing the influence and interaction of the participants. But it is unsuitable for solving complex problems and the subsystems also lack of flexibility and initiative.

Therefore, the distributed pattern for decision-making is more available to the transportation system.

2.3. Decision support system based on agent

The system is mainly composed of decision agents and global coordinate agent. All decision agents have the equal positions because the system is in a symmetrically distributed structure. Therefore, they can interact each other and independently solve some simple problems because of their own decision-making ability. The global coordinate agent is responsible for the coordination of decision agents. The working procedure for the distributed decision-making is from problem division, duty assignment, problem solving individually to synthesis of individual’s solution.

Internet/intranet benefits traffic management and the decision group to acquire and utilize external information and resources. Therefore, it can effectively reduce the conflicts and smooth the decision-making process.

3. Construction of Urban Traffic Management Based on MAS

3.1. System structure

Group decision support system of distributed urban traffic management based on MAS is composed of segment agent, crossing agent, section agent and central decision agent. Its logical and functional structure is shown in Fig. 3. The information from agents is exchanged in the programming language KQML.

![Fig. 2. The model of distributed GDSS based on MAS](image)

![Fig. 3. The model of GDSS of Distributed Urban Traffic Management Based on MAS](image)

3.2. Basic structure of agents

The decision system for traffic management provides a macroscopic viewpoint and related information for a multi-agent group to solve problems. Therefore, the agents can work cooperatively. The basic framework of each agent is shown in Fig. 4. In the decision-making process, every decision needs approval from databases and the successful ones will be added into databases in time.

3.3. Functions of agents

There are four types of agents in the system in order to complete complicated traffic management and traffic tasks.

Segment agent isolates at the bottom of the system, among which there are no information exchange. It only collects the data from sensors and reports the analyzed data to crossing agents as a reference for timing allocation.

Crossing agent comprehensively analyzes the data about four segments of a crossing. It predicts the future traffic going and works out an advisable plan to section
agent. Then section agent makes an integrated decision on the traffic of the administrative region based on the synthesized analysis and suggested plan from crossing agent. The information in the database is also a useful reference for section agent to make decisions.

Central decision agent analyzes all the decisions from section agents and then makes a suitable traffic direction for the city. Meanwhile, the final decision must in the consideration of weather, unexpected events and accidents. Sometimes it is necessary to give a direct order to segment agent and impose to fulfill. [7]

Fig. 4. The basic structure of Agent

4. Working mechanism of different agents in the system

4.1. Region Agent cooperation principle of work

Section agent deals with all the decisions from every crossing agent. However, crossing agents in the system are distributed and every crossing has different requirements. Therefore, section agent must consider the real situation of each crossing and make decisions from a macroscopic viewpoint so that the traffic will be clear without congestion and obstruction. Its mechanism is shown in Fig. 5.

4.2. Working mechanism of central decision agents

Central decision agent is on the top of the system and in charge of the coordination of all the traffic in a city. It must guarantee the city in a good traffic condition and give a real-time control to unexpected accidents and events, such as ball games, gatherings, parades, etc. It also controls all the management processes and facilitate the communication among group members. Its structure is presented in Fig. 6.

Traffic decision producer can conveniently communicate with the group members, stores the information from the members, grasp the process and the details of decision-making, deduces and reasons suggestions and plans proposed by section agents, consults examples in the databases and revises deficiencies according to the feedback.

In order to create a reasonable traffic management, traffic decision producer must take different measures to different situations and eliminate the conflicts of group members based on the stored information in databases. [9]

Fig. 5. Area Agent Coordinate Theory

Fig. 6. Centric-Agent Coordinate Theory

4.3. Communicative form among agents

In traffic communication, how to effectively coordinate the information from crossing agents, section agents, and central decision agents is the key to decision making.
The normal communication structure of the multi-Agent system is the fig.7.

In the MAS, each agent may communicate with a number of other agents. Communications uses the KQLM language, which provides a number of different message types, such as requests and information messages.

KQLM is divided into three layers: communication, information and content. In content layer, information is the main part. In information layer, language is the core. In communication layer, communication parameters are transformed into code, such as the identification of sending code and receiving code.

KQML, an effective communication language, is a basis to guarantee the coordination of agents in the system. It defines the format of information transformation and the processing protocol. It also provides a set of standard and original language in which agents can interact each other.

Next is an example to explain the application of KQML in the communication among agents.

The interactive process between crossing agent 1 and crossing agent 2 is carried out in KQML language in terms of the number of cars, as follow:

```
evaluate
  sender: crossing Agent1
  receiver: crossing Agent2
  language: KQML
  content: cars
  reply: with q1
    content: ? carNumber
```

```
reply
  sender: crossing Agent2
  receiver: crossing Agent1
  language: KQML
  in: reply-to q1
  content: carNumber (5)
```

From this example above, may see the communication between the agent member is based on the fixed meaning model form, between other types communications intelligent body and this similar.

From the above example, it is found that the communication among agents is developed in fixed semantic models and he communication among other kinds of agents also shares the similarity in terms of form of communication.

5. The implement of the Traffic Control Model Based on the MAS

The MAS used in the traffic management represent in the traffic light. All the Traffic lights ’s work is cooperative.

5.1. Traffic light based on the agent

Each Traffic light is an agent; they must be built as the fig.8.
5.2. Traffic lights’ cooperative work

Here give an Example of the Road Traffic lights Cooperative through messages. The Example is as the Fig.9. In the Fig. 9., the 1 stand for agent 1, 2 and 3 stand for the agent 2 and agent 3. The communication is mainly deployed during traffic jams. Traffic density is high in Road A (coming from Agent 1); therefore ask agent 1 for a red light (stop inflow) ask agent 3 for a green light (increase outflow). Agents 1 and 2 receive a request for a traffic light change in Road A: if local situation is OK (using default timer) then act on the request.

![Fig. 9. The Road Structure](image)

6. Conclusions

The Urban Traffic Management Based on Multi-agent system in this paper can automatically adapt the changes from environment and take different strategies towards various events. Therefore, it can lighten the pressure to the traffic management government and alleviate traffic congestions. Integrating computer science, MAS and GDSS with the concept of traffic management, the decision support system provides a new perspective for traffic management. As a result, it can be applied into the real traffic and play a great role in traffic management to improve the current traffic in China.

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References