Agent Based Urban Traffic and Transportation Control with Cloud Computing

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Abstract -The agent computing paradigm is rapidly emerging as one of the powerful technologies for the development of largescale distributed systems to deal with the uncertainty in a dynamic environment. The domain of traffic and transportation systems is well suited for an agent-based approach because transportation systems are usually geographically distributed in dynamic changing environments. Our paper shows that the techniques and methods resulting from the field of agent and multiagent systems have been applied to many aspects of traffic and transportation systems, including modeling and simulation, dynamic routing and congestion management, and intelligent traffic control. This paper examines an agent-based approach and its applications with cloud computing in different modes of transportation, including roadway, railway, and air transportation. This paper also addresses some critical issues in developing agent-based traffic control and management systems, such as interoperability, flexibility, and extendibility. Finally, several future research directions toward the successful deployment of agent technology in traffic and transportation systems are discussed.

Keywords - Agent, Cloud computing, Urban transportation.

I. INTRODUCTION

Agent- based computing is one of the powerful technologies for the development of distributed complex systems [1]. Many researchers believe that agents represent the most important new paradigm for software development since object-oriented design [2], and the concept of intelligent agents has already found a diverse range of applications in manufacturing, real-time control systems, electronic commerce, network management, transportation systems, information management, scientific computing, health care, and entertainment. The reason for the growing success of agent technology in these areas is that the inherent distribution allows for a natural decomposition of the system into multiple agents that interact with each other to achieve a desired global goal. The agent technology can significantly enhance the design and analysis of problem domains under the following three conditions : 1) The problem domain is geographically distributed; 2) the subsystems exist in a dynamic environment; and 3) the subsystems need to interact with each other more flexibly.

The domain of traffic and transportation systems is well suited to an agent-based approach because of its geographically distributed nature and its alternating busy-idle operating characteristics. From the traffic and transportation management perspective, the most appealing characteristics of agents are autonomy, collaboration, and reactivity. Agents can operate without the direct intervention of humans or others. This feature helps to implement automated traffic control and management systems. Agents are collaborative. In a multiagent system (MAS), agents communicate with other agents in a system to achieve a global goal. Agents can also perceive their environment and respond in a timely fashion to environmental changes. Agent-based transportation systems allow distributed subsystems collaborating with each other to perform traffic control and management based on real-time traffic conditions. A distributed vehicle monitoring testbed presented in [3] is an early example of the distributed problem-solving network. Recently, more and more agent-based traffic and transportation applications have been reported. Our literature survey shows that the techniques and methods resulting from the field of agent system and MAS have been applied to many aspects of traffic and transportation systems, including modeling and simulation, intelligent traffic control and management, dynamic routing and congestion management, driver-infrastructure collaboration, and decision support.

II. ARCHITECTURE OF AGENT – BASED TRAFFIC CONTROL AND MANAGEMENT SYSTEMS

The operation of agents is supported and managed by distributed software platforms known as agent systems. The name of MASs usually refers to systems that support stationary agents, and mobile agent systems support mobile agents. An agent system provides mechanisms for agent management, agent communication, and agent directory maintenance. A mobile agent system provides additional mechanisms to support the migration and execution of mobile agents. In an agent system, agencies are the major building blocks and are installed in each node of a networked system, in which agents reside and execute. To facilitate the interoperation of agents and agent systems across heterogeneous agent platforms, agencies designed to comply with agent standards are highly desired.

Although more and more studies have been reported to apply agent approaches to traffic and transportation systems, only few researches address the system architecture and the platform issues of agent-based traffic control and management systems. Garcia-Serrano *et al.* [4], Tomas and Garcia [5], and Chen *et al.* [6] are three MASs that are designed for roadway traffic detection and management and are compliant with the IEEE Foundation for Intelligent Physical Agents (FIPA) standards, which is one of the major international agent standards. Several Traffic Agent City for Knowledge-based Recommendation (TRACK-R) agents are designed to provide traffic route recommendation for humans or other agents. Each TRACK-R agent is responsible for a geographical area. Tomas and Garcia [5] propose an MAS to help traffic operators determine the best traffic strategies for dealing with nonurban roadway meteorological incidents. The agents in these two systems are implemented using the Java Agent DEvelopment Framework (JADE) agent platform . Chen *et al.* [6] developed a mobile agent system called Mobile-C and designed an agent-based real-time traffic detection and management system based on Mobile-C. Mobile-C is an IEEE FIPA standard compliant multiagent platform for supporting C/C++ mobile agents in networked intelligent mechatronic and embedded systems. Mobile-C was originally developed to enhance the distributed computing and information fusion capability for a laser-based highway vehicle-detection system . Although it is a generalpurpose multiagent platform, Mobile-C is specifically designed for real-time and resource-constrained applications with interface to hardware.

Commonly used control architectures of intelligent agentbased systems can be classified into hierarchical, heterarchical, and hybrid. Generally, the hierarchical approach decomposes the overall system into small subsystems that have weak interaction with each other. On the other hand, the heterarchical approach is a completely decentralized approach in which agents communicate with each other to make independent decisions. Since the distributed agents only have a local view, it becomes difficult to predict the network state from a global perspective. The hybrid approach combines the features of hierarchical and heterarchical approaches. Hernandez *et al.* [7] study and compare centralized hierarchical and decentralized heterarchical agent-based architectures for intelligent traffic management in an urban traffic network. Two agent-based intelligent traffic management systems, i.e., InTRYS and TRYSA2, target the same problem domain but differ significantly in the way that the traffic agents of the system are coordinated. InTRYS achieves agent coordination based on a traditional centralized mechanism, whereas TRYSA2 employs the decentralized coordination. Their experience shows that the decentralized architecture has advantages in synchronization, reusability, and scalability. However, regarding the complexity of the coordination task, the InTRYS approach defeats the decentralized system TRYSA2. This is because the TRYSA2 strategy may imply an exhaustive search for plans to be selected by the involved agents [7].

To achieve flexible and intelligent control of traffic and transportation systems, Wang [4], [5] developed an agentbased networked traffic-management system. The agent-based control decomposes a sophisticated control algorithm into simple task-oriented agents that are distributed over a network. The ability of dynamically deploying and replacing control agents as needed allows the network to operate in a "control on demand" mode to adapt to various control scenarios. The system architecture employs a three-level hierarchical architecture. The highest level performs reasoning and planning of task sequences for control agents; the middle level dispatches and coordinates control agents; and the lowest level hosts and runs control agents. The control agents are represented by mobile agents that could migrate from remote traffic control centers to field traffic devices or from one field device to another.

For the rapid prototyping of multiagent control systems in road traffic management, van Katwijk *et al.* [8] developed a testbed to allow designers ofMASs to experiment with different strategies and examine the applicability of developed systems. The testbed consists of intelligent models for modeling intelligence of agents, a world model for representing traffic process, and an interaction model for modeling the interactions between agents. The communication in the testbed conforms to the FIPA standards.

III. URBAN TRAFFIC AND TRANSPORTATION CONTROL USING INTELLIGENT TRAFFIC CLOUDS

We propose urban-traffic and transportation management systems using intelligent traffic clouds to overcome the issues computing power and storage. Urban-traffic management systems based on cloud computing have two roles: service provider and customer. All the service providers such as the test bed of typical traffic scenes, ATS, traffic strategy database, and traffic strategy agent database are all veiled in the systems' core: intelligent traffic clouds. The clouds' customers such as the urban-traffic management systems and traffic participants exist outside the cloud.
Figure 1 gives an overview of urban traffic management systems based on cloud computing. The intelligent traffic clouds could provide traffic strategy agents and agent-distribution maps to the traffic management systems, traffic-strategy performance to the traffic-strategy developer, and the state of urban traffic transportation and the effect of traffic decisions to the traffic managers. It could also deal with different customers' requests for services such as storage service for traffic data and strategies, mobile traffic-strategy agents, and so on.

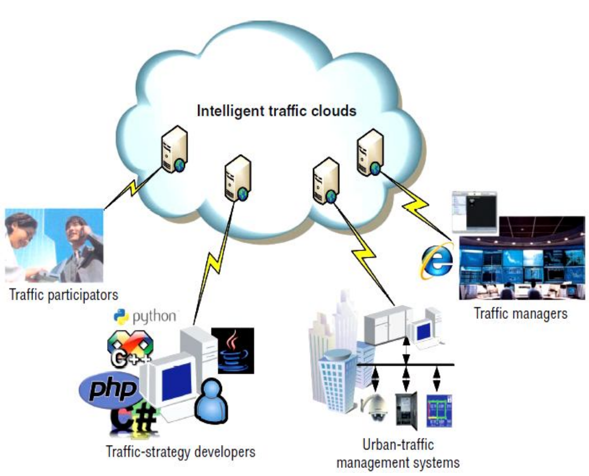

Figure 1. urban-traffic management systems based on cloud computing.

With the development of intelligent traffic clouds, numerous traffic management systems could connect and share the clouds' infinite capability, thus saving resources. Moreover, new traffic strategies can be transformed into mobile agents so such systems can continuously improve with the development of transportation science.

According to the basic structure of cloud computing, an intelligent traffic clouds have four architecture layers: application, platform, unified source, and fabric. Figure 2 shows the relationship between the layers and the function of each layer.

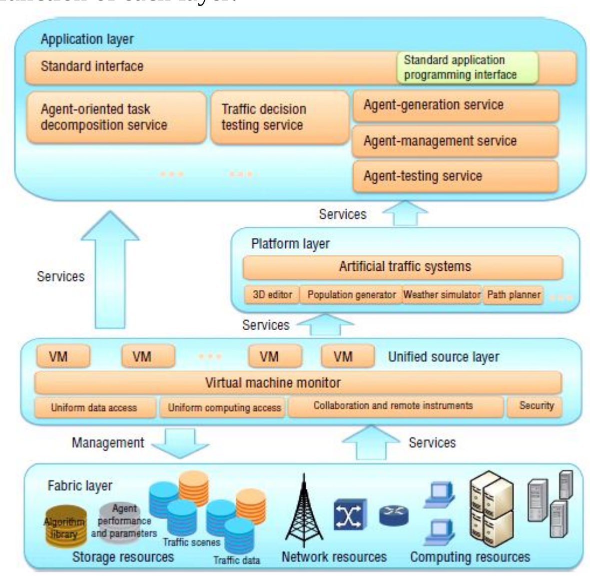

Figure 2. Intelligent traffic clouds structure has application, platform, unified source, and fabric layers.
The *application layer* contains all applications that run in the clouds. It supports applications such as agent generation, agent management, agent testing, agent optimization, agent oriented task decomposition, and traffic decision support. The clouds provide all the services to customers through a standard interface. The *platform layer* is made of ATS, provided platform as a service. This layer contains a population synthesizer, weather simulator, path planner, 3D game engine, and so on to provide services to upper traffic applications and agent development. The *unified source* layer governs the raw hardware level resource in the fabric layer to provide infrastructure as a service. It uses virtualization technologies such as virtual machines to hide the physical characteristics of resources from users to ensure the safety of data and equipment. It also

provides a unified access interface for the upper and reasonable distribute computing resources. All those will help solve information silo problems in urban traffic and help fully mine useful information in the traffic data. Lastly, the *fabric layer* contains the raw hardware level resources such as computing, storage, and network resources. The intelligent traffic clouds use these distributed resources to cater the peak demand of urban-traffic management systems, support the running of agents and ATS test beds, and efficiently store traffic strategy agents and their performances.

IV. CONCLUSION

Software agents and their applications in traffic and transportation systems have been studied for over one decade. A number of agent-based applications have already been reported in the literature. These applications propose and investigate different agent-based approaches in various traffic and transportation related areas. The research results clearly demonstrate the potential of using agent technology to improve the performance of traffic and transportation systems. Most agent ased applications, however, focus on modeling and simulation. Few real-world applications are implemented and deployed. In general, the design, implementation, and application of agent based approaches in the area of traffic and transportation are still immature and need to be further studied. The integration of new technologies, such as mobile agent technology, should be considered to enhance the flexibility of systems and the ability to deal with uncertainty in dynamic environments.

REFERENCES

[1] F. Zambonelli and H. Van Dyke Parunak, "Signs of a revolution in computer science and software engineering," in Proc. 3rd Int. Workshop Eng. Soc. Agents World, vol. 2577, Lecture Notes in Computer Science, P. Petta, R. Tolksdorf, and F. Zambonelli, Eds., 2003, pp. 13–28.

[2] M. Luck, "Guest editorial: Challenges for agent-based computing," Auton. Agents Multi-Agent Syst., vol. 9, no. 3, pp. 199–201, Nov. 2004.

[3] E. H. Durfee, Coordination of Distributed Problem Solvers. Boston, MA: Kluwer, 1988.

[4] A. M. Garcia-Serrano, D. Teruel Vioque, F. Carbone, and V. D. Mendez, "FIPA-compliant MAS development for road traffic management with a knowledge-based approach: The TRACK-R agents," in Proc. Challenges Open Agent Syst. Workshop, Melbourne, Australia, 2003.

[5] V. R. Tomas and L. A. Garcia, "Agent-based management of non urban road meteorological incidents," in Proc. Multi-Agent Syst. Appl. IV, 2005, vol. 3690, pp. 213–222.

[6] B. Chen, H. H. Cheng, and J. Palen, "Integrating mobile agent technology with multi-agent systems for distributed traffic detection and management systems," Transp. Res. Part C: Emerging Technol., vol. 17, no. 1, pp. 1–10, Feb. 2009.

[7] J. Z. Hernandez, S. Ossowski, and A. Garcia-Serrano, "Multiagent architectures for intelligent traffic management systems," Transp. Res. Part C: Emerging Technol., vol. 10, no. 5/6, pp. 473–506, Oct.–Dec. 2002.

[8] R. T. Van Katwijk, P. Van Koningsbruggen, B. De Schutter, and J. Hellendoorn, "Test bed for multiagent control systems in road traffic management," Transp. Res. Rec., vol. 1910, pp. 108–115, 2005.

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