A Review of the Applications of Agent Technology in Traffic and Transportation Systems

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***Abstract*—The agent computing paradigm is rapidly emerging as one of the powerful technologies for the development of large-scale 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 literature survey 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 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.**

***Index Terms*—Agents, intelligent transportation systems (ITS), mobile agent systems, multiagent systems (MAS).**

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 [3]: 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.

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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 [4], [5]. 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 [6] 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.

This paper reviews agent applications in traffic and transportation systems. These applications are classified into five categories: 1) agent-based traffic control and management system architecture and platforms; 2) agent-based systems for roadway transportation; 3) agent-based systems for air-traffic control and management; 4) agent-based systems for railway transportation; and 5) multiagent traffic modeling and simulation. The selected projects in each category are listed in a tabular format with information of project name, research group, application domain, and key features.

II. Architecture and Platforms 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