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A Scenario-Reconfigurable Simulator for Verifying Service-Oriented Cooperation Mechanisms and Policies of Connected Intelligent Vehicles

Kailong Zhang, School of Computer, Northwestern Polytechnical University, Xi'an, China
Xiaowu Li, School of Computer, Northwestern Polytechnical University, Xi'an, China
Ce Xie, School of Computer, Northwestern Polytechnical University, Xi'an, China
Yujia Wang, School of Computer, Northwestern Polytechnical University, Xi'an, China
Liuyang Li, School of Computer, Northwestern Polytechnical University, Xi'an, China
Chao Fei, School of Computer, Northwestern Polytechnical University, Xi'an, China
Arnaud de La Fortelle, Centre for Robotics, MINES ParisTech, Paris, France
Zongtao Duan, School of Information Engineering, Chang'An University, Xi'an, China

ABSTRACT

With the emerging vehicular network and the possible diverse applications, intelligent transportation systems (ITS) have been evolving to Cooperative ITS (C-ITS) with connected intelligent vehicles, and the topics in this field have raised more and more research interests recently. However, subjecting to the immaturity of V2X communication technology, the difficulty and high cost to deploy such large scale ITS with intelligent vehicles, emerging studies are stuck with the verification of these big C-ITS. As more and more expected, intelligent vehicles will play important roles in the future smart cities and societies, as diverse mobility carriers. Focusing on new features of these carriers, mainly covering cyber-physical fusion, vehicular networking, service-carrier and so on, one new ITS simulator QoS-CITS for such service-oriented C-ITS is designed and developed. To enhance the adaptability, a scenario reconfigurable architecture is firstly designed, in which scenes can be described via XML file. On this basis, the authors have implemented all reservation-based models of traffic objects, state-driven behaviors, cooperation mechanisms, and policies, which are proposed for service-oriented C-ITS. Through a series of experiments are conducted with different parameters and typical scenes, all simulation functions are efficiently verified. And finally, some important conclusions drawn from large amount of experiments via QoS-CITS are exhibited. It's important to note that, researchers can conduct various experiments, both the traditional Passing-Through-Intersection (PTI) problem and service-oriented cooperation, via setting parameters of QoS-CITS according to their requirements, and can also analyze the performance with statistics data recorded automatically.

KEYWORDS

Cooperation, Cooperative ITS, Intelligent Vehicle, Model, Policy, Service, Simulator, Traffic Cloud, V2X

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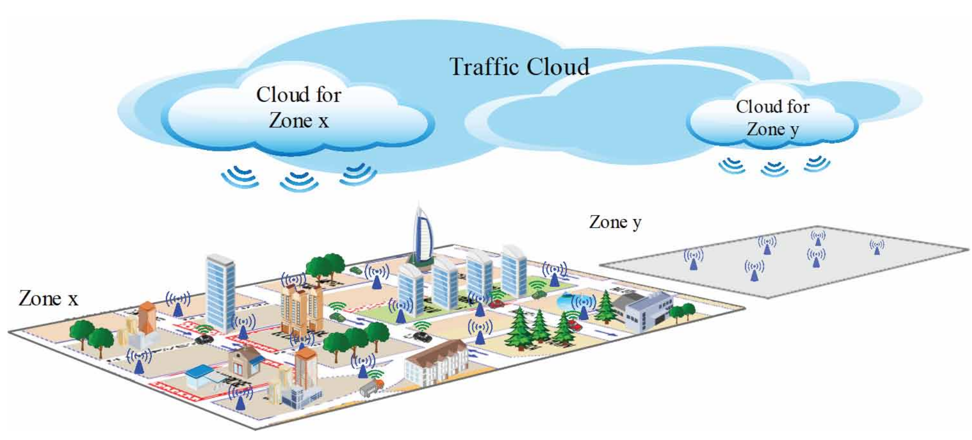
1. INTRODUCTION

With the rapid development of autonomous driving and new emerging technologies, such as vehicular network, traffic-cloud, traffic big data system and so on, Intelligent Transportation Systems (ITS) of autonomous connected vehicles have been marching toward the more efficient Cooperative ITS (CITS) (De La Fortelle et al., 2014), and further have been envisioning to be more and more service-oriented according to the possible diverse applications in smart cities as shown in Figure 1. In such trend, cooperative planning and control mechanisms of heterogeneous vehicles are increasingly concerned by researchers. However, one vital challenge for researchers is the verification of proposed models and algorithms because of the impossibility to construct a real large-scale CITS environment for studies. This is also very different from the verification of current autonomous driving technologies. Therefore, model-driven computer simulation becomes one important verification way for the study on ITS, which can facilitate the evaluation and analysis before the real deployment.

Simulative verification is one vital aspect much concerned in the domain of C-ITS because of the difficulty for constructing a real large-scale transportation environment with intelligent vehicles and infrastructures. Besides the studies on the ontology of intelligent vehicles and VANET-based cooperation mechanisms (Torres & Malikopoulos, 2017; Zohdy & Rakha, 2016), recently, the thoughts of model-driven traffic-related simulation have been widely employed (Ramos, Ferreira, & Barceló, 2012), and several typical traffic-related simulators, such as SUMO, OMNET++, Veins, MovSim, PanoSim and VISSIM etc. (TszChiu & Peter, 2010; Li, Chitturi, Zheng, Bill, & Noyce, 2013), have been designed and used. Based on the conventional traffic simulation model, Lee et al. (2004) proposed a four-layered modeling and simulation approach, and the performance and flexibility of which are verified via two typical cases: advanced traffic management systems (ATMS) and advanced traveler information systems (ATIS). Isabel and Fernández (2015) proposed a framework for a model-driven development of simulation to overcome the issues of traditional simulation ways, such as unintended mistakes in the transition from models to code, platform consistency, difficulties to compare works based on different models and tools etc., and then analyzed ITS using simulation method. In these frameworks, vehicles, roads, pedestrians, infrastructures and traffic flows are also abstracted or presented with special mathematic models, mainly covering vehicle dynamics models, traffic models, and environmental sensor models. In addition, some research has verified the safety of the generated traffic map (Kubo, Dan, Sato, & Namatame, 2016). 3D visualization technologies have been also widely adopted, which will make simulation procedures more visualized and vivid, such as Pro-SiVIC, SimWalk, TrafficJam3D and so on.

Figure 1. Typical scene of Cloud-based C-ITS



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