Urban Traffic Management Approach Based on Ontology and VANETs

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Abstract—Everyone knows the important role of transport in the economic and social development, at the level global this sector is considered among the principal criteria for country rankings. But control and management of traffic in urban areas remains a major challenge to rise, especially accuses rapid development of the transport sector. On the other hand, many alternative solutions have been proposed within the intelligent transportation systems (ITS) to optimize traffic safely. To address this problem, among them Vehicular Ad-hoc NETwork (VANET), that will implement new innovative applications and services. In this paper, we propose an approach using ontologies and VANET to enable more efficient and optimal use of road infrastructure.

Keywords—Ontology, Traffic Management, Vehicular Ad-hoc Networks, Safety.

I. INTRODUCTION

No one can ignore today the crucial role of transport in developing countries, whether it’s on the economic or social plane. At the global level this sector is considered among the principal criteria of development, also this sector is growing rapidly and continuously. However, the transport sector is currently confronted with significant challenges, particularly in urban areas.

These transport problems reduce the economic development opportunities, and quality of life of citizens who are affected psychologically and physically. Among these problems that may be mentioned traffic congestion, increased energy consumption, waste of time, limited mobility and degradation of air quality. Moreover, transport accidents are the most serious problems because of their socio-economic damages, including property damage and human losses.

To remedy this problem, intelligent transportation systems (ITS) become an alternative to optimize traffic safely.

ITS have emerged as an effective way to improve circulation, it will help to use less energy in the travel, less distance to reach the desired position with a time and money, while respecting nature. And one of the effective ways possible to have these benefits at lower cost, are Vehicular Ad-hoc NETwork (VANET) [1].

VANET are based on mobile ad hoc networks (MANET), where each vehicle is equipped with wireless communication devices, which are designed to ensure communication between vehicles and the road infrastructure, and therefore play a crucial role in providing innovative applications and services [1, 2, 3] in the road transport sector. These applications and services are designed not only to improve road safety but also for comfort, support and entertainment.

VANETs uses specialized short-range protocol communications (DSRC) [4, 5] to broadcast messages at high speed in several directions [6, 7] because its latency is low, but the coverage of this solution is very limited. To overcome this problem, researchers proposed V2V communication [8, 9], so that vehicles can further communicate with Road Side Unit (RSU), and VANETs does not require a significant investment for implementation. In addition to high-speed connectivity at lower cost, vehicles equipped with VANET devices can take advantage of multiple location technologies with high accuracy [10], either with a relative location [12,11, 13] or even a global location [14, 15,16].

In this paper, we propose an approach using ontologies and VANET to enable more efficient and optimal use of road infrastructure. The rest of this article is organized as follows. First, we give a literature review of traffic management systems. Second, we give an overview of the ontologies we show the main solutions based ontologies. In section 3 we present our approach. Finally, the conclusions and future research are shown in section 4.

II. LITERATURE REVIEW

In recent years, several articles have been published about the management of urban traffic, these articles fall into two broad categories: Estimated circulation and the optimization of traffic.

The traffic estimate is mainly based on analytical modeling of data collected by sensors installed all along the roads, or even vehicles.

The information collected in real time are also used in the optimization of traffic, but the techniques and methods change.

For example, the works presented in [17,18] the road is...
defined congested state when the vehicle travel time exceeds the normal travel time of this road, the normal travel time of each segment of a road must be calculated by the vehicle for a day and then stored in a centralized entity.

In [19,20] the authors introduced mechanisms to detect traffic jams, which are mainly based on messages regularly broadcast by vehicles. The estimate of the traffic and the status of various routes are evaluated by analysis of the information broadcast messages.

However, the problem that arises in these mechanisms is overload of the communication channel, because they require the exchange of a large number of packets.

In [21] authors propose an Adaptive Traffic Control Systems (ATCSs) utilize real time traffic data in an attempt to optimize the timing and length of the traffic light signals. As a result, effective ATCSs aim to minimize stop times and delays in a bid to reduce traffic congestion in major urban areas.

Another strategy in urban traffic management is to optimize traffic signals [22, 23, 24] deployed at intersections by analyzing the data collected in real-time traffic. The goal of this optimization is to minimize waiting times in an intersection and increase the number of vehicles crossing the intersection. Then you have to synchronize the lights different intersections to improve traffic in all directions.

However, a local synchronization for an intersection influence on all other intersections of the road network, thus the optimizing desired goals include the minimizing of the waiting time and the length of the queue will not be achieved in other intersections, which could cause more congestion. For this, researchers have proposed to favor roads with high demand but for special events or temporary changes such as road closures due to construction or other, which results inadequacy of this strategy if the traffic is huge.

III. ONTOLOGIES IN INTELLIGENT TRANSPORTATION SYSTEM

Nowadays, ontologies are highly valued in almost all areas, for this reason we find many definitions of an ontology, the simplest and most popular since 1993 until now is the definition of Tom Gruber [25] who has said: “An ontology is a formal, explicit specification of a shared conceptualization.”

In other words, an ontology is a structured set of terms and concepts representing the information and the relations between them, in a specific domain, these relations can be semantic relations, or relations of composition and inheritance. The power and usefulness of ontology is the reuse of information and the definition of a common vocabulary, and in addition any domain can be modeled using ontologies.

The main element required for the construction of ontology is language, it is designed to describe the information and allow their reuses. In the last few years, many languages have been developed to the implementation, these languages are classified into four levels: informal, semi-informal, semi-formal and formal, this is why the ontologies are not all built by the same way, but the choice of language is a challenge for construction.

Otherwise, several articles have been published on ontologies as solutions to the problems and the challenges of ITS. In [26] authors present the VEHicular ACCident ONtology (VEACON) designed to improve traffic safety, and for enabling interoperability between vehicles, RSUs, authorities and emergency vehicles. This ontology combines the information collected when an accident occurs, and the data available in the General Estimates System (GES) accidents database.

In [27] authors present an ontology for a reliable Traffic Information System. This ontology had been developed in OWL, and it is based on road traffic, and on possible scenarios of vehicles traveling in a highway. It is composed by classes, properties, attributes and relations between classes. The ontology is included in each agent executing the Traffic Information System. Each agent may ask for traffic information based on the ontology, and also based on its knowledge base.

In [28] authors propose a method to increase situation awareness during emergency transportation of patients. Their approach combines semantic reasoning with the emerging Car-2-X technology. The developed system continuously matches data retrieved from inter-vehicular communication with structured knowledge from vehicular ontologies and OpenStreetMap.

In [29] authors present the Car Accident lightweight Ontology for VANETs (CAOVA). The instances of our ontology are filled with: (i) the information collected when an accident occurs, and (ii) the data available in the General Estimates System (GES) accidents database. We assess the reliability of our proposal in two different ways: one via realistic crash tests, and the other one using a network simulation framework.

In [30, 31] authors propose ontology-based approaches for adding reasoning capabilities to autonomous vehicles. The main use case is at self-assessment of the perception system to monitor co-driving. The module designed for situation assessment formalizes knowledge such as: environment conditions, moving obstacles, driver state, navigable space, which are also relevant concepts for VANET.

IV. OUR APPROACH

Improving road safety requires constant supply of traffic information to the driver, this information should also improve the driving quality and keep traffic moving. But it is difficult to acquire all information and interpreted by the pilot in this context our approach is involved to enable more effective use of road infrastructure safely.

VANET can provide information faster and more pertinently in real time, but the interpretation of this information by the driver and his reflexes are not always precise. For this we propose an ontology that will ensure the best presentation of collected information.

A. Overview

We propose an ontology using VANET in order to facilitate
driving and interpretation of messages to the driver. This ontology is integrated directly into each vehicle, and it also communicates with the infrastructure to obtain traffic information in real time.

So our proposed approach consists of three main phases:

A learning phase is to collect information on the infrastructure, in order to reconstitute the map and the connections between roads.

A phase of knowledge acquisition of acquiring the information necessary for the driver.

And finally a Knowledge Representation phase.

This ontology “Fig. 1” consists of four subclasses: vehicle, infrastructure, traffic control, and message. These concepts that relate to each other.

B. Language

We choose the Web Ontology Language (OWL) as a language to describe and organize knowledge for our ontology, it is developed and recommended by the World Wide Web Consortium (W3C). OWL is designed for use by applications that need to process the content of information instead of just presenting information to humans. OWL facilitates greater machine interpretability of the content that supported by XML, RDF, and SRDF.

C. Design

Our ontology was designed using Protégé [32], it begins with a super class named Thing “Fig. 2”, which all other classes are subclasses. This brings us directly to the concept of inheritance, therefore inherited classes are: Vehicle, infrastructure, message, and traffic control.

The first class is Vehicle “Fig. 3”, which include the properties of Vehicle, such as priority, position, and speed. Vehicle comes in three types: simple car, bus, and emergency vehicles. TypeVehicle describes the vehicle's physical properties and their priority.
The class Infrastructure “Fig. 4”, which is composed of Road, Parking and BusStop for bus station, and each Road has a number of lanes for the rolling of the vehicle, and a maximum speed not to exceed by vehicles, and her type which include the properties of road.

The class Message “Fig. 5”, which include the type of Message, it can be an AlertMsg for emergency situations, Warning for unpredictable situations or NotificationMsg for the information. These messages are sent by the other driver in the event of a request or change of situation.

The class Traffic Control “Fig. 6”, which include the Panel of Traffic Control and Traffic Light to provide important information as a message to help drivers to respect traffic law.

V. CONCLUSION AND PERSPECTIVES

Traffic management is the most critical problems in urban areas. Advanced techniques and methods as VANET have the potential to solve this problem, but the interpretation by the driver does not reach the desired goal. Our solution is to integrate ontology in vehicles, to facilitate the interpretation of the information collected by the driver. Our approach will also allow the implementation of traffic management solutions more efficient and reliable.

Currently our ontology does not contain sufficient concepts for complex scenarios, our ontology can be extended so that it includes several concepts. Thereafter we propose to build a platform for validation of our approach, which could show the effectiveness of our approach, which provides a way to improve safety and traffic fluidity.

REFERENCES


[27] Sérgio Goreneder, Ícaro Silva; “AN ONTOLOGY FOR A FAULT TOLERANT TRAFFIC INFORMATION SYSTEM”, 22nd International Congress of Mechanical Engineering (COBEM 2013), November 3-7, 2013, Ribeirão Preto, SP, Brazil.


