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Review article

A comparative classification of information dissemination approaches in vehicular ad hoc networks from distinctive viewpoints: A survey

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ABSTRACT

Vehicular ad hoc networks (VANET) have received tremendous attention due to their potential impact on scientific research and their numerous attractive applications. With the aim of getting the intelligent communication for vehicular networks, VANETs can significantly improve the safety and efficiency issues of road traffic without requiring fixed infrastructure or centralized administration. Information dissemination is the base of communication which plays an important role in VANETs and it has become an active area of research in the recent years. However, information dissemination in VANET environment is a challenging task, mainly due to the rapid changes in the network topology and frequent fragmentation. In this paper, we provide a comprehensive survey on information dissemination in vehicular networks by focusing on some critical issues such as security and privacy, adaptability, scalability and so on. For this, we classify the existing information dissemination solutions into eight new classes based on their design and optimization objectives and give a qualitative overview on each class based on their objectives, forwarding strategy, features and advantages. Finally, we present open research issues to improve the efficiency of information dissemination protocols as much as possible.

1. Introduction

Intelligent transportation systems (ITS) are the integration of telecommunication and information technologies into transportation systems. The major goal of these systems is to address critical issues like passenger safety and traffic congestion [1] (in this paper, by traffic we mean vehicular traffic). They are built on top of self-organizing networks, known as vehicular ad hoc networks (VANETs) [2]. Vehicular ad hoc networks are composed of mobile vehicles connected by wireless links so that vehicles can create a spontaneous network while moving along roads. In fact, VANET provides decentralized environments to disseminate traffic data without requiring fixed infrastructures [3]. Although several modern in-vehicle safety based devices have been introduced recently, but the increasing number of road accidents has become a critical issue. Several researches in this field show that if warning messages are delivered to drivers on time, 60% of the road accidents will be avoided [4–6]. Drivers could obtain vital traffic information about road conditions and the locations of accidents by communicating with other vehicles and roadside units which help to alleviate road accidents and provide traffic monitoring in order to increase safety and traffic flow capacity [5]. Therefore, in order to prevent thousands of disasters and loss of life, it is necessary to disseminate emergency messages to drivers on time [7]. Indeed, information dissemination plays an important role in an effective communication among the vehicles in the network to improve traffic safety and travel comfort [8,9]. It is expected that in the near future, almost all vehicles will be equipped with VANET-oriented communication facilities [10,11].

Although, there exist some survey papers in the literature for information dissemination in the context of vehicular communications [12–17], but to the best of our knowledge, the existing survey papers on information dissemination have not considered some major issues such as secure, authenticated, privacy preserving message dissemination, protecting communication and providing reliable, scalable and adaptive dissemination, group communication on highways, applying timers for reducing access delay and etc. For this purpose, to give a comprehensive study on information dissemination in VANET, in this paper, we classify and provide an in-depth review of these protocols based on some critical parameters such as packet delivery ratio, access delay, communication cost, traffic load and etc. In this respect, we discuss on several important aspects of information dissemination protocols to classify them into 8 classes based on secure, QoS, adaptive, clustering, timer, push, pull and hybrid based protocols. In this section, we give a brief introduction for each class; and then in the following sections we study them in detail. In addition, some effective open issues and future perspectives for vehicular

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List of Acronyms

FCC	Federal Communications Commission
GPS	Global Positioning System
ITS	Intelligent Transportation Systems
MANET	Mobile Ad hoc Networks
QoS	Quality of Service
V2V	Vehicle to Vehicle
VANET	Vehicular Ad hoc Network
WAVE	Wireless Access in Vehicular Environments
V2I	Vehicle to Infrastructure
RSU	Road Side Unit
OBU	On Board Unit
AU	Application Unit
I2V	Infrastructure to Vehicle
V2B	Vehicle to Broadband
GSM	Global System for Mobile Communications
UMTS	Universal Mobile Telecommunications Service
BS	Base Station
MPARP	Mobility Pattern Aware Routing Protocol
P2PCC	Peer To Peer Cooperative Caching
NAVI	Neighbor-Aware Virtual Infrastructure
LIWAS	Life WArning System
DOT	Distributed Optimized Time
AMD	Adaptive Multi-directional data Dissemination
ZoR	Zone-of-Relevance
RPB-MD	Relative Position Based Message Dissemination
DGBR	Directional Greedy Broadcast Routing
CA	Certifying Authority
VMP	vehicular multi hop broadcasting protocol
ABSRP	Address Based Service Resolution Protocol
VADD	Vehicle-Assisted Data Delivery
UMB	Urban Multi-hop Broadcast
DBRS	Distance Based Relay Selection
RISA	Road Information Sharing Architecture
DTN	Delay Tolerant Network
TD-SHT	Time-Decay Sequential Hypothesis Testing
ECLB	Enhanced Cooperative Load Balancing
RN	Relay Node
DP	Dissemination Points
ODAM	Optimized Dissemination Of Alarm Messages
DRIVE	Data dissemination pRotocol In VEhicular networks
AoI	Area of Interest
CCMAC	Clustering Based Cognitive MAC
VBN	Vehicular Backbone Network
DBA	Dynamic Backbone Assisted
DV-CAST	Distributed Vehicular Broadcast
SODAD	Segment-Oriented Data Abstraction And Dissemination
UV-CAST	Urban Vehicular BroadCAST
APAL	Adaptive Probability Alert Protocol
RCP	Road-Casting Protocol

networks are discussed in order to guide new researches and improve information dissemination protocols efficiently.

Security and privacy are the major concerns in VANETs, since a malicious user can track vehicles illegally, report false alarms and create undesirable traffic congestion. By secure dissemination, we mean that the delivery of information to vehicles must obey the access control policies. In fact, in order to protect the critical information in vehicular networks and prevent manipulation of emergency messages by attackers, a set of security mechanisms must be designed for secure information dissemination in VANET [18]. In order to solve the problems of performance loss and increase in overhead rate, access delay and packet losses, designing an adaptive protocol to adapt dynamic vehicular conditions is necessary. The adaptive dissemination protocols offer efficient broadcasting techniques around the area of interest, considering the current vehicular density and the topology of vehicular network which is beneficial to improve the efficiency of the warning message dissemination process and decrease broadcast storm problem [19]. To solve high mobility and sparse distribution on the road, researchers have presented clustering. The major process of clustering is to group vehicles based on some vehicular characteristics such as velocity, direction and location of vehicles in order to disseminate warning messages efficiently [20]. On the other hand, in order to reduce redundant rebroadcasts and avoid the broadcast storm problem, timers are used whose expiration times determine whether a vehicle should relay a message or not. Here, packets are scheduled for transmission in order to reduce access contentions and packet collisions and also to speed up the dissemination process [21]. Finally, in push model, information is disseminated proactively by broadcasting, while in pull model, information is obtained on demand [22]. In other words, in push model, the bandwidth is used efficiently by broadcasting only the critical events such as accidents, heavy rain and etc. to the vehicles, while in pull model, noncritical information like road conditions, vehicle speed and free parking lot can be stored within vehicle itself [14,23,24].

The main contribution of our survey is that we classify information dissemination techniques into new eight classes in terms of some major concerns such as security, adaptability, scalability and etc. where our proposed classes include secure, QoS, adaptive, clustering, timer, push, pull and hybrid based models in VANET. At last, open issues on dissemination optimization strategies are highlighted. According to the author's best knowledge, there is no other VANET study from these perspectives. In other words, such a comprehensive survey covering all these eight classes has not been published in literature, by far.

The rest of paper is organized as follows. Section 2 gives a brief description on vehicular ad hoc networks. Section 3 presents our proposed classification for the existing information dissemination approaches in VANET by representing their characteristics in qualitative evaluation tables. In Section 4, a number of effective open issues and future perspectives for vehicular networks are discussed. Finally conclusions are drawn in Section 5. The outline of the paper is provided in Fig. 1.

2. Background and related works

In this section, we provide the concepts of vehicular networks by presenting different communication types and the main components of these networks. A VANET is an emerging technology which consists of a set of vehicles, each equipped with a communication device called on-board unit (OBU), and a set of stationary units along the road, referred to as road side units (RSUs). Some RSUs can act as a gateway for connectivity to other communication networks, such as the internet, as shown in Fig. 2. Each OBU has a wireless network interface which allows the vehicle to directly connect to other vehicles and RSUs within its communication range, as well as wireless or wired interfaces to which application units can be attached. By applying vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), intra-vehicle and vehicle-to-broadband cloud (V2B) communications, as shown in Fig. 3, VANETs can support a wide variety of applications in road safety, passenger infotainment, and vehicle traffic optimization, which is the main reason that VANETs have received great attention from government, academia, and industrial organizations all over the world [5,12,25].

In general speaking, there are four types of communications in VANETs, as shown in Fig. 3 [27]. In vehicle to vehicle (V2V),