Multi-Hop Broadcasting in VANET for Safety Applications: Review and Classification of Protocols

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ABSTRACT

Intelligent Transportation Systems (ITS), which rely on vehicular ad hoc communication networks (VANETs), have the potential to alleviate road accidents and to save lives. Several use cases to VANETs safety applications have been proposed. Most of these applications use multi-hop broadcasting communications to disseminate safety information as far as needed in zones of relevance. A wide variety of multi-hop broadcasting approaches have been proposed in recent years. In this paper the authors review, characterize and categorize multi-hop broadcast protocols. A set of classification criteria is proposed to highlight the design principles and performance of broadcasting protocols.

Keywords: Broadcasting, Multi-Hop, Safety Applications, Vehicular Ad Hoc Communication Networks (VANETs), Vehicular Ad Hoc Networks

INTRODUCTION

The main goal of intelligent transportation systems (ITS) is to provide capabilities to improve safety on roads, thus significantly alleviating the number of road accidents. As human lives are at the forefront of all stakeholders, safety applications have two major requirements -timeliness and reliability- that must be met by the underlying communication networks.

ITS cover multiple facets among which wireless communications play a role of paramount importance. Consequently, vehicle manufacturers are more and more committed to make their vehicles wireless communication capable.

Vehicles exchanging information (including traffic congestion, accidents, and safety warnings) with neighboring vehicles together form a VANET (Vehicular ad hoc network). VANETs may be seen as the biggest new commercial application of ad hoc networks with concrete applications. The more a vehicle exchanges information with its neighbors the more accurate is the view the vehicle has on its environment and the more are efficient and well-anticipated actions taken by the drivers. However, information exchange comes with a

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cost (i.e. more packet collisions) because the vehicles use the same transmission medium (i.e. the air). One of the challenges of VANETs is efficient information dissemination at reasonable resource utilization.

Messages maybe exchanged periodically or on an event-driven basis. The scope of dissemination and timing constraints depend on safety exchanged messages. For example Pre-Crash Sensing message must be disseminated at 50 meters within 20 ms maximum delay while Approaching emergency vehicle warning message must be disseminated at 1 km within 1 second maximum delay (CAMP, 2005). Periodic messages are also referred to as cooperative awareness messages and event-driven messages as decentralized environmental notification messages (ETSI, 2010).

In contract to the conventional Internet access where messages are typically exchanged on a unicast basis, dissemination of information in VANET safety applications requires broadcasting because the information (in particular alert messages) is of interest to all the vehicles in the zone of relevance. In addition, to reach all the vehicles in the zone of relevance, some of them being out of the transmission range of the message source, multi-hop broadcasting is required to deliver messages.

In the last ten years, a huge variety of protocols have been proposed in literature to consider different requirements in information dissemination to vehicles. The main goal of broadcasting protocols is to provide timeliness and reliability guarantees to safety applications while optimizing resource utilization.

This paper is aiming at providing an updated review of the proposed multi-hop broadcasting protocols. Our work extends the previous proposed reviews (Chen, 2010; Kumar 2012; Panichpapiboon, 2012). It includes new classification criteria and metrics to better characterize broadcasting protocols dedicated to disseminating safety information in multi-hop VANETs.

The paper is organized as follows. Road safety messages are depicted in the next section. It should be noticed that the characteristics of safety messages yield the requirements that must be fulfilled by broadcasting protocols. The section after presents the main characteristics of VANETs to be considered when broadcasting protocol design is of concern. The section following that provides a set of classification criteria and metrics used to characterize and categorize broadcasting protocols. The section after that presents synthetic review of existing protocols. The last section is a conclusion.

OVERVIEW OF ROAD SAFETY APPLICATIONS

Present and future wireless communication technologies provide opportunities to deploy a huge number of applications dedicated to road users. Road safety applications are the main target of VANETs, though other applications (such as leisure services and Internet access) are envisaged (Toor, 2008; Willke, 2009). Road traffic oriented applications can help to improve road safety by providing drivers with information on the status of road traffic. This information allows the driver to avoid congested roads and make traffic flow fluid. Infotainment applications like internet access or peer-to-peer applications are dedicated to passenger comfort, and they can bring added value, which will help increase VANET market penetration rate. This paper is limited to safety applications.

Number of papers partially presented safety applications and services provided over VANETs. The most complete publication on categorization of safety applications is the report published by the CAMP Vehicle Safety Communications Consortium, USA (CAMP Consortium, 2005). The latter identified 34 types of applications (i.e. message exchanges) that are likely to be considered safety applications based on their ability to reduce traffic accidents and to improve general public safety. These applications are categorized into five classes (see Tables 1-5 for more details on safety messages):
Weightless: The Technology to Finally Realise the M2M Vision
www.igi-global.com/article/weightless-technology-finally-realise-m2m/67575?camid=4v1a