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DBSMA Approach for Congestion Mitigation in VANETs

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Abstract

A high rate of historical accidents on public roads motivated the advent of the Wireless Acces in Vehicular Environment (WAVE) standard. The main objective of WAVE was to develop strategies and protocols to enable inter-vehicular communication in view to reduce accident on public roads. Moreover, a successful message exchange can only be possible if the transmission medium is collision free. Under the Intelligent Transportation System (ITS), the cooperative Awareness messages (CAM) have to be transmitted at the rate of 10 Hz as per standard. To account for congestion management, the Distributed Congestion Control (DCC) mechanism was proposed. However, under higher node density, the DDC becomes inefficient and dramatically contribute to the deterioration of the VANET environment. The present work proposes a Dynamic Broadcast Storm Mitigation Algorithm (DBSMA) which can be used to combat the broadcast storm problem in a Vehicular Network (VN). Results from several simulations confirmed that the DBSMA has a potentiality to conquer the effect of broadcast storm by offering higher robustness compared to DCC with about 130% improved efficiency. Beside its computational simplicity, the DBSMA is easy to implement.

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Keywords: WAVE; DSRC; CBR; VANET; Congestion

1. Introduction

The Wireless Access in Vehicular environment (WAVE) or Dedicated Short Range Communication (DSRC) was merely motivated by the desire to reduce risks of road accidents [1]. WAVE refers to a set of emerging standards for

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mobile wireless communications supporting the Intelligent Transportation System (ITS) [2]. Under the ITS framework, a vehicle can directly communicate with its peers referred to as Vehicle-to-Vehicle (V2V) or communicate directly with other existing telecommunication infrastructure also known as Vehicle-to-Infrastructure (V2I) communication. The WAVE standard is a combination of two other standards namely the IEEE 802.11p and the IEEE 1609 [3]. The former is designed to handle all operations related to the Medium Access Control (MAC) and Physical (PHY) layers while the later concerns more the operations related to upper layers.

Dedicated Short-Range Communication (DSRC) [4] was initially coined in USA [5] by the Federal Communication Commission (FCC) [6]. It was developed to support vehicle-to-vehicle and vehicle-to-infrastructure communications. This standard supports vehicle speeds up to 190 km/h, a data rate of 6 Mbps (up to 27 Mbps) and a nominal transmission range of 300 m (up to 1000 m). Tremendous efforts in term of strategies development and techniques to ensure successful design, implementation and integration of the WAVE technology in modern cars have already been done. However, there are still numerous challenges to overcome in order to ensure effective integration of this technology into modern vehicles. One of the most common challenges hindering the successful implementation of the WAVE standard is the excessive collision of safety messages as a result of Broadcast Storm (BSt). Naturally the BSt occurrence is the resultant of the standard provision which allow each vehicle to relay or broadcast safety messages at the frequency rate of 10 Hz. This is because a WAVE Short Message Protocol (WSMP) dedicated for safety application must be broadcasted every 50 ms during the Control Channel (CCH) time interval. This phenomenon generally arises during peak hour when the road is congested as a result of road work, car accident or crash. When several cars are stuck in a traffic jam, the BSt becomes unavoidable.

Several works have been done in the field VN congestion management. Some of them include the Proactive-Ad hoc On Demand Distance Vector (Pro-AODV) approach proposed in [8]. A Pro-AODV is a protocol that uses information from the AODV routing table to minimize congestion in VANETs. Authors in [9] presented and contrasted two classes of congestion control reactive (Decentralized Congestion Control) and adaptive (LIMERIC). Both approaches control safety message transmission as a function of channel load (i.e. Channel Busy Ratio, CBR). The work developed in [10] is enhanced in [11] by providing a study of the convergence to propose a distributed algorithm for the adaptation of transmission probabilities which takes into account the safety benefit of packets transmitted on each wireless link. In [12], a Machine Learning Congestion Control (ML-CC) strategy consisting of three units which include congestion detection, data control and congestion control was proposed to address the congestion that may occur at intersections. A distributed congestion control strategy based on congestion game theory in a single channel vehicular communication environment where periodical broadcasts play the dominant role for driving safety awareness and notifications was proposed in [13]. Authors in [14] proposed an intelligent multi-hop broadcast protocol which employs a fuzzy logic-based approach to determine relay (forwarding) vehicles. The parameters used in the protocol are tuned using a Q-Learning-based mechanism where rewards are determined by checking the reception status at the selected relay nodes [15]. A study performed in [7] demonstrated that when several mobiles in the vicinity are sending Cooperative Awareness Messages (CAM) and Decentralized Environment Notification Message (DENM), the wireless channel for C-ITS is said to be full at 2000 packets/sec given a packet size of 400 bytes transmitted at a rate of 6 Mbps. The highest throughput however is achieved at 1200 packets/Sec. A direct inconvenience and implication of BSt is wastage of resources and channel bandwidth.

The work presented in this paper merely focus on the category of CAM type message used for cooperative awareness. A new approach called DBSMA used to mitigate the broadcast storm problem in a Vehicular Network (VN) is proposed. The DBSMA approach is simple and easy to implement. The DBSMA take into consideration a safety following distance based on a 3 second rule as well as a mobile velocity to compute a corresponding safety message broadcast time.

The remainder of this paper is organized as follows. A brief review of the WAVE standard is presented in section 2. The proposed DBSMA development is described in section 3. Simulation and analysis are presented in section 4. Finally the conclusion is presented in section 5.

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