Full length article

Selective epidemic broadcast algorithm to suppress broadcast storm in vehicular ad hoc networks

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1. Introduction

The new kind of intelligent wireless technology adopted among vehicles is known as Vehicular Ad Hoc Networks. The vehicles in this network share their resources either through Vehicle-to-Vehicle (V2V) or Vehicle-to-Infrastructure (V2I) communication. Through this communication the vehicles can transmit and receive the safety and non-safety information that are needed to avoid road accidents or to intimate the drivers about the dangerous situation in the emerging area. In modern Intelligent Transportation System vehicles can automatically detect the emergent situation through On Board Unit (OBU) which is installed inside the vehicle and Road Side Unit (RSU) placed at the roadside [1]. Due to highly moving speed of the vehicles the communication link between the vehicles change frequently and when the vehicles are moving in the high speed the message lost ratio is also increased and communication link is disconnected which can be improved by increasing the transmission power of the source vehicle [2]. The emergency message dissemination can be affected by the vehicles moving at high speed, this problem is discussed in several papers and hence a new method need to be proposed to solve this issue [3].

The excitement about vehicular network is mostly due to their wide range of applications and open challenges that arise in our daily life while driving in bidirectional and multidirectional highways and other urban areas. Basically, in safety message broadcasting several important technical challenges need to be faced like high message delivery ratio, high mobility and high speed of the vehicles, or real-time requirements. Hence, the researchers are motivated to increase their interest in this area to provide a better communication model for the society to improve the public safety while driving [4].

The VANET safety applications are of two types based on the requirements, namely aperiodic and periodic [5]. Aperiodic messages are sent to the vehicles which are in the emergency mode like a road accident, road construction, etc. Periodic messages are used to update the neighbor information or other information related to non-safety applications. These messages are synchronized by the IEEE 802.11p WAVE and ETSI standard by using an intermediate layer called message sub layer and facility layer [6,7]. There are two types of messages in facility layer called as Cooperative Awareness Message (CAM) and Decentralized
Environmental Notification Message (DENM) [8]. CAM is used for single hop communication where as DENM is used for multi hop communication.

In Vehicular Safety Application, the DENM messages have the highest priority within the short period of time, 100 ms and CAM messages have the lowest priority within the time interval of 100–1000 ms. In this approach, there is no guarantee for retransmission of the message after transmitting the DENM message by the RHS. Due to this factor the facility layer faces the problem called as Broadcast Storm Problem. The efficient channel utilization is also an important factor in VANET. To facilitate the use of DSRC Control Channel (CCH) and Service Channel (SCH), the use of multiple channels for efficient data dissemination was discussed in [9].

The effect of Broadcast Storm Problem is discussed in several papers. But not all the proposed solutions provide better results to solve this problem. The Broadcast Storm Problem causes increased message overhead, broadcast collision, dissemination delay, etc. For emergency safety purpose the message should be transmitted the emergency message.

Since most of the proposed algorithms were analyzed for single directional message dissemination schemes, this paper is motivated to propose a new Broadcast Storm Suppression Algorithm (BSSA) in bi/multidirectional highway network scenario. The main objective of this paper is to propose a new BSSA that dynamically adapts the vehicle's position through the adaptive localization technique to broadcast the Emergency Safety Message based on the methodology named as a Selective Epidemic Broadcast (SEB) Algorithm. The SEB algorithm reduces the Broadcast Storm Problem with selecting the vehicles which have sent the passive acknowledgment only. The passive acknowledgment (PACK) [10–12] indicates the vehicle which wants to communicate with the source vehicle that initiated the connection.

The rest of the paper is organized as follows: Section 2 of this paper gives a detail about the Broadcast Storm Suppression Algorithms (BSSAs) used in the existing research work. The proposed “Selective Epidemic Broadcast Algorithm” is explained in Section 3. The simulation results and analysis of the algorithms are shown in Section 4. Finally, Section 5 concludes the paper with further enhancements.

2. Related work

In the literature several Broadcast Storm Suppression Algorithms (BSSAs) are proposed based on the different requirements and scenarios. In vehicular networks broadcasting forms the basic method to disseminate the Emergency Safety Message. Basically Simple broadcasting, Probabilistic Broadcasting, Timer Based Broadcasting, Neighbor Knowledge based Broadcasting and Distance based broadcasting are the techniques referred in the literature. The details about these techniques are discussed in [13] and which also shows the shortcomings of these techniques based on some of the QoS metrics used for the qualitative analysis of the proposed SEB algorithm.

Table 1 shows the comparison of different Broadcast Storm Suppression Algorithms based on the metrics considered in this paper. Hence, this paper considers each technique for the qualitative analysis to show the importance of the proposed Broadcast Storm Suppression Algorithm “SEB”.

DOT is one of the delay based BSSA used to control the high vehicle density by dividing the vehicles into different slots [14]. This algorithm uses large size beacon message and the vehicle density in each slot is not mentioned clearly. DRIVE [15] uses the sweet spot to disseminate the message, but still suffers from increased message overhead and dissemination delay when no vehicles exist in the sweet spot. ADM [16] dynamically adapts the broadcasting based on the priority level of the message sent. This algorithm reduces the latency and does not improve the redundancy rate.

p-Persistence is the probabilistic technique, it suffers from BSP when the vehicles have equal probability ‘p’ to rebroadcast the message, because in this algorithm the vehicle which has the highest probability has a chance to rebroadcast the Emergency Safety Message. When the vehicles are in the same distances all vehicles will have the same rebroadcast probability. In this situation increased BSP is a challenging issue [17,18].

The Last One (TLO) [19] is the famous distance based algorithm referred in most of the papers in the literature. This algorithm uses the distance to choose the next rebroadcasting vehicle. The vehicle which is in the most distant rebroadcast the message. But there is no guarantee for message reliability in TLO and is suitable only for highways and vehicle positioning is also not mentioned clearly [20,21].

Virtual Slotted p-Persistence Broadcasting (VSPB) [22] is the Timer based broadcasting technique which forms the virtual slot based on the position information and moving direction of the neighboring vehicles. VSPB is better than the slotted p-persistence to avoid empty slots due to low density and also vehicle collisions at high density scenarios. So VSPB controls the slot size by assigning a fixed number of vehicles per slot. The vehicles in the farthest slot are assigned the shortest waiting time to rebroadcast. But when the vehicle density increases the collision ratio, broadcast overhead and dissemination delay also increase simultaneously.

Grid based Speed Adaptive Broadcast (G-SAB) [23] is a latest probabilistic broadcasting technique based on the speed parameter. The vehicle density is identified by using the vehicles moving speed. In low density networks the vehicles moving speed are high, but in the high density networks the vehicles moving speed are low. Similar to VSPB, this algorithm also suffered from the simulta-

Table 1
Comparison of broadcast storm suppression algorithms.

<table>
<thead>
<tr>
<th>Broadcast storm suppression algorithms (BSSAs)</th>
<th>Suppression technique used</th>
<th>Reliability (PDR)</th>
<th>Scalability (Broadcast Overhead)</th>
<th>Robustness (Packet Loss Rate)</th>
<th>Dissemination delay</th>
<th>Broadcast storm ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>p-Persistence</td>
<td>Probabilistic</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Slotted 1-persistence</td>
<td>Delay</td>
<td>High</td>
<td>Moderate</td>
<td>High</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Slotted p-persistence</td>
<td>Probabilistic</td>
<td>Dependent</td>
<td>Dependent</td>
<td>High</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>DOT</td>
<td>Delay</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>DRIVE</td>
<td>Delay</td>
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<td>High</td>
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<tr>
<td>ADM</td>
<td>Probabilistic</td>
<td>High</td>
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<td>Moderate</td>
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<td>Moderate</td>
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<tr>
<td>TLO</td>
<td>Distance</td>
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<td>Moderate</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
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<tr>
<td>VSPB</td>
<td>Delay</td>
<td>High</td>
<td>Dependent</td>
<td>Dependent</td>
<td>Dependent</td>
<td>Moderate</td>
</tr>
<tr>
<td>G-SAB</td>
<td>Delay</td>
<td>High</td>
<td>Dependent</td>
<td>Dependent</td>
<td>Dependent</td>
<td>Moderate</td>
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</tbody>
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Please cite this article in press as: Chitra M, Siva Sathya S. Selective epidemic broadcast algorithm to suppress broadcast storm in vehicular ad hoc networks. Egyptian Informatics J (2017). http://dx.doi.org/10.1016/j.eij.2017.04.001
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