Dynamic Broadcasting in Vehicular Ad hoc Networks

Sara Najafzadeh, Norafida Ithnin, Shukor Abd Razak, and Ramin Karimi

Abstract—**Vehicular Ad hoc Network (VANET) is a subclass of mobile ad hoc networks (MANETs). VANETs provide a variety of interesting applications. Many of these applications rely on broadcasting of messages to other vehicles. The simplest broadcasting algorithm is flooding. Because of a large number of vehicles during peak hour, blindly flooding may lead to packet collision and high contention named broadcast storm problem. This paper presents a broadcasting approach for safety messages that dynamically adjust waiting time of a vehicle according to the number of neighbor vehicles and distance to source. We evaluate the performance of our proposed approach in terms of reachability, reliability. The simulation results show our protocol introduces better performance than flooding and random waiting time protocol.**

Index Terms—**Vehicular Ad hoc Network, broadcast storm problem, network density**

I. Introduction

Vehicular Ad hoc Network (VANET) is a new technology to build a wireless network between vehicles (V2V). VANETs are based on short-range wireless communication (e.g., IEEE 802.11) between vehicles. The Federal Communication Commission (FCC) has allocated 75 MHz in 5.9 GHz band for Dedicated Short Range Communication (DSRC). DSRC was conceived to provide the architecture for vehicles in Vehicular Network to communicate with each other and with infrastructure. In DSRC, subsequently specialized as Wireless Access in Vehicular Environment (WAVE), GPS-enabled vehicles that are equipped on-board units can communicate with each other.

VANETs are a special class of Mobile Ad hoc Networks (MANETs). The major characteristics as compared to MANETs are following: components building the network are vehicles, dynamic topology, geographically constrained topology, vehicle mobility and time-varying vehicle density [1]. VANETs could play an important role in the future of vehicle communications.

VANETs provide a variety of interesting applications from safety to comfort. Many of these applications rely on broadcasting. There are many proposed approaches for broadcasting in MANETs. The simplest one is flooding. In flooding each mobile host rebroadcast the packets when received for the first time. In this scheme the total number of broadcast is equal to N-1, where N is the total number of vehicles [2]. Flooding is simple but it consumes much network resources as it has a large number of redundant messages. It leads to serious redundancy, contention and collision in mobile wireless networks, which is referred to broadcast storm problem [1]. Due to lack of packet acknowledgements, packet retransmission and medium reservation, it is difficult to guarantee that a packet can reach all nodes in vehicular Ad Hoc Networks due to wireless contention.

There are different solutions such as probabilistic, counter-based, distance-based, location-based [3]. Probabilistic scheme is designed to tackle the overhead problem by suggesting that each node re-forwards the packet with some fix probability $p < 1$. The counter-based scheme broadcast a packet when the number of received copies is less than a pre-determined threshold. In the distance-based scheme a node rebroadcast the message when the distance between sender and receiver is larger than a threshold. The location-based scheme rebroadcast the message if the additional coverage is larger than a bound A.

The main problem in Vehicular Ad Hoc Networks is to reduce broadcast redundancy to prevent collision. In this paper, we propose a broadcasting approach that calculates waiting time of each node based on local density and distance that can reduce the number of unnecessary broadcasting messages in Vehicular Ad Hoc Networks. This algorithm is fully distributed means it needs only local information of each node in the network.

The rest of this paper is organized as follow: Section II presents the related work of broadcasting in VANETs. Section III presents details of dynamic broadcasting algorithm in VANETs. In Section IV, performance evaluation and simulation study are shown, finally this paper is concluded in Section V.

II. Related Background

The broadcast storm problem has been previously investigated in MANETs. Various techniques were proposed for mitigating this problem. We will review this method in this part.

In probability based Method each vehicle calculate a probability to decrease redundancy and collision. In [4] a method has been proposed that is similar to simple flooding except that vehicles rebroadcast with a probability. A distributed gossip-based routing is designed to solve the overhead problem. In this scheme each node rebroadcast the packet with a probability $p < 1$ [5].

Zhang and Agrawal [6] have described an adjusted probabilistic scheme. This scheme uses probabilistic and counter-based schemes simultaneously. This scheme dynamically adjusts the rebroadcast probability p at each mobile node according to the value of the packet counter. The

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packet counter value is not the exact number of neighbor form the current node.

Area based method is based on the assumption that most of vehicle will utilize Global positioning System(GPS) , based on the position information GPS each vehicle decides to rebroadcast the message by calculating additional coverage area. Vehicles that can cover a larger area will choose as a relay node. The disadvantage of this method is low reachability in sparse as well as congested networks.

Laouiti *et al.* have proposed a multipoint relay (MPR) protocol [7]. MPR controls retransmitting at the sender. This protocol has knowledge about 1-hop and 2-hop neighbors. Because of high mobility of VANETs it is not a proper assumption in real world. Therefore total overhead introduced by this protocol may be high.

In Distance based method, each vehicle calculates the distance between itself and its neighbors. A vehicle with maximum distance to the source will choose as a relay node. Disadvantage of distance based method is same as area based method.

Fast Broadcast (FB) and Cut-through Rebroadcasting (CTR) are distance based protocol that minimizes forwarding hops when delivering a message [8]. It contain two major components the estimation and broadcast phase. In the estimation phase the protocol adjusts the transmission range in the broadcast phase it gives higher priority to vehicles that are farther away from the source node. CTR gives high priority to rebroadcast alarm messages to farther vehicles within transmission range but operating in a multichannel environment. Three broadcast suppression techniques, slotted 1-persistence, slotted p-persistence and weighted p-persistence and schemes have been proposed [9, 10].

Slotted 1-Persistence Broadcasting Rule — whenever a node receives a packet, it checks the packet ID. If it receives this packet for the first time and it is not a duplicate packet, rebroadcast with probability 1 at time slot TS_{AB} else it discard it.

Slotted P-Persistence Broadcasting Rule — while a node receives a packet, it checks the ID of the packet and checks it for duplication. If it is not a duplicate message, the node forward it with pre-determined probability at time slot TS_{AB} else the packet will discard. Weighted p-Persistence Broadcasting Rule — While a packet receive from node A , node B checks it's ID and if it is the first time receive this packet, rebroadcast it with P_{AB} else node B discard the packet.

Waiting time based method is based on calculating a waiting time for each vehicle instead of immediately broadcasting a packet. The simplest protocol in this category is Simple Flooding with Random (SFR). This protocol is a modification of flooding. Instead of rebroadcasting the message immediately, SFR waits for a random time before rebroadcasting.

In Urban Multihop Broadcast (UMB) and Ad hoc Multihop Broadcast (AMB) [11] suppression technique is utilized based on the road location or vehicle position. In these methods message contains the position of its sender. The vehicle that received the broadcasting message calculates a waiting time or delay time depends on the distance between itself and the source. To reduce the multihop messaging UMB and AMB select vehicle farthest away from information source as relay node. Efficiency of these protocols depends on network density.

Network density is an important factor affects the performance of broadcasting protocol. In this paper we propose a new distributed broadcasting protocol considering distance and local density. Our proposed scheme operates effectively at different network flows.

III. Dynamic Broadcasting Algorithm

Flooding suffers from the problem of redundant message forwarding. The same message is forwarded multiple times by every node. This mechanism waste resources and can cause contention and collision in transmission medium. In dense network, multiple nodes share similar area because of their transmission range. But in sparse network there is much less shared coverage (Fig. 1), therefore some nodes may not receive packets [12].

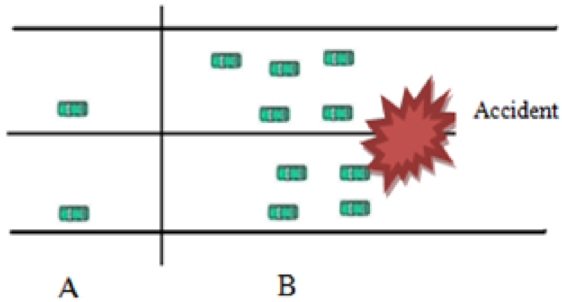

Fig. 1. A) Sparse area and B) Dense area

Each vehicle should determine a neighbor list. For this purpose, our protocol uses a periodic hello packet beaconing. To choose an optimal forwarder node under different traffic flow it is necessary to calculate waiting time based on number of neighbors and distance between the sender and other vehicles.

In this Step, vehicles with one neighbor in their list immediately broadcast the message. The other nodes (nodes with more than one neighbor in their list) calculate the waiting time independently considering the number of neighbors and distance base on the following formula.

$$Wt = (1 - \frac{d_{ij}}{R})^{nn} Wt_{\max}$$

The notation of waiting time formula as follow:

nn: Number of Neighbors in message direction

d_{ij}: The Distance of Vehicle *i* to vehicle *j*

R: Transmission Range

Wt_{max}: Maximum Waiting Time

Value of maximum waiting time should be carefully chosen. If Tmax is too low many vehicles rebroadcast before they could receive any duplicate messages and if Tmax is too high, the delay will be increase. Waiting time is set to 200 ms for our study. After calculating of waiting time by vehicles, each node waits for Wt until expiration. When timer expires and vehicle i do not receive any duplicate message vehicle i rebroadcast. Other node discards the message to prevent duplication.

When density of the network is high, distance between vehicles decreased therefore probability of having two or more neighbor with same distance from source increase. According to our proposed formula farthest vehicles with more number of neighbors rebroadcast the packets as quickly as possible while closed vehicles or those with low number of neighbors have to wait and receive more duplicate packets. Thus it will avoid unnecessary retransmission if possible.

IV. Performance Evaluation

We have use OMNET++ [13] to conduct experiments to evaluate behavior of the proposed dynamic probabilistic algorithm. We compare our algorithms against a simple flooding and random waiting time based. The performance metrics for comparison include the Reachability and network overhead.

- Reachability is The number of nodes in the network receiving the broadcast package divided by the total number of nodes that are reachable (directly or indirectly)
- Network Overhead: Number of duplicate packets received at the network layer.

TABLE I: Parameter Setting

Packet life time	10 s
Packet size of a broadcast message	512 bytes
Simulation time	20 s
Number of simulation run	10
Transmission range	250m
Vehicle density	10,20,30,40,50

The simulation results represent the performance of each algorithm across node density. Parameters setting for simulations are configures as indicated in Table I. All protocols use IEEE 802.11 with collision MAC and their bandwidth are 2 Mbps. The following two metrics are considered for performance evaluation.

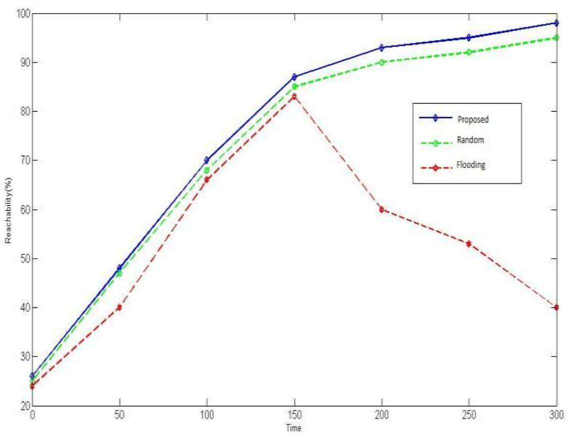

Fig. 2. Reachability

As shown in this Fig. 2, the reachability of our scheme remains almost close to 100% even as the number of nodes increased. Fig. 3 shows average network overhead for a single broadcast observed by each vehicle. Network overhead of proposed protocol scale well specially in heavy traffic. For the normal traffic flows each vehicle observes only few additional overhead packets.

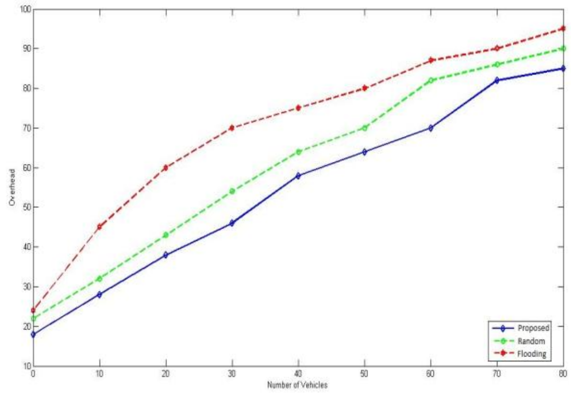

Fig. 3. Overhead

V. Conclusion

In this paper, we proposed a dynamic broadcasting scheme for Vehicular Ad hoc Networks. This proposed approach dynamically sets waiting time of rebroadcasting according to number of neighbors and distance. We compare simulation results of our protocol with flooding and random waiting time.

References

[1] L. M. M. M. Bani-Yassein, M. Ould-Khaoua, and S. Papanastasiou, "Performance analysis of adjusted probabilistic broadcasting in mobile ad hoc networks," *International Journal of Wireless Information Networks*, pp. 127-140, 2006.

[2] B. Wiliams and T. Camp, "Comparison of broadcasting technique for mobile ad hoc networks," in *Proc. the ACM International Symposium on Mobile Ad hoc Networking and computing*, 2006.

[3] S. Ni, Y. Tseng, Y. Chen, and J. Sheu, "The broadcast storm problem in a mobile Ad Hoc network," in *Proc. ACM MobiCom '99*, 1999, pp. 151-162.

[4] J. Cartigny and D. Simplot, "Border node retransmission based probabilistic broadcast protocols in ad hoc Networks," *Telecommunication systems*, pp. 184-204, 2003.

[5] A. Vinel, V. Vishnevsky, and Y. Koucheryavy, "A simple analytical model for the periodic broadcasting in vehicular ad -hoc networks," presented at IEEE Globecom Workshops, November 30, 2008.

[6] Q. Zhang and D. P. Agrawal, "Dynamic probabilistic broadcasting in mobile ad hoc network," in *Proc. the Vehicular Technology Conference*, pp. 184-24, 2003.

[7] A. Qayyum, and A. Laouiti, and L. Viennot, "Multipoint relaying technique for flooding broadcast messages in mobile wireless networks," in *Proc. HICSS: Hawai Int. Conference on System Sciences*, 2002.

[8] P. Akkhara, Y. Sekiva, and Y. Wakahara, "Fast dissemination of alarm messages based on multi-channel cut-through rebroadcasting for safe driving," *Intelligent Automation and Computer Engineering, Lecture Notes in Electrical Engineering*, vol. 52.

[9] N. Wisitpongphan, O. K. Tonguz *et al.*, "Broadcast storm mitigation techniques in vehicular ad hoc networks," *IEEE Wireless Communications*, vol. 14, no. 6, pp. 84-94.

[10] O. Tonguz, N. Wisitpongphan *et al.*, "Broadcasting in VANETs," Mobile Networking for Vehicular Environments, Move, Anchorage, AK, United State, Institute of Elec and Elc Engineering computer Society, 2007.

[11] G. Korkmaz, E. Ekicici, F. Özgüner, and U. Özgüner, "Urban Multi-hop broadcast protocol for inter-vehicle communication systems," in *Proc. the 1st ACM Int. Workshop on Vehicular Ad hoc Networks VANET'*, NY, USA, 2004, pp. 76-85.

[12] S. Najafzadeh, N. Ithnin, S. A. Razak, and R. Karimi, "Analytical Model for Sparse and Dense Vehicular Ad hoc Networks," in *Proc. The first International Conference on Computer Science and Information Technology*, Banglore, India, 2011.

[13] OMNeT++ Network Simulation Framework. [Online]. Available: http://www.omnetpp.org

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