

Sender-designated Alert Message Propagation in VANET

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ABSTRACT

In this paper, we propose a sender-designated alert message propagation mechanism, named vehicle multi-hop protocol (VMP), which permits fast and reliable alert message propagation in VANET. The core of the VMP is that every vehicle is to maintain multiple candidate forwarders to broadcast the alert message before detecting a danger on the road. The simulation shows that the VMP can achieve better performance than the simple flooding in terms of network overload and end-to-end delay.

Categories and Subject Descriptors

C.2.2 Network Protocols, Routing protocol – *routing protocols for V2V communications.*

General Terms

Algorithms, Performance, Experimentation

Keywords

VANET, multi-hop broadcasting, alert message, V2V, V2I

1. INTRODUCTION

Recently much research has been devoted to the active safety applications based on inter-vehicle communication. In this paper, we mainly focus on the alert message propagation mechanism in VANETs (Vehicular Ad-hoc Networks). When a dangerous condition is detected, the dissemination of an alert message is started. This safety message may be propagated along the road by a forwarder (so called alert message propagation) until a termination condition is satisfied (e.g., hop count is 0).

There are several approaches for alert message propagation in VANETs [1]-[5]. These mechanisms require the selection of forwarders and a broadcast transmission for fast delivery of alert

messages. The first approach is simple flooding. When the node detects a danger, an alert message is generated and broadcasted to all incoming neighbor nodes as soon as possible. The all neighbor nodes receiving the alert message become a forwarder and rebroadcast that message if it is not duplicated. The simple flooding has a good point that it can be easily implemented and there are many forwarders than any other approaches so the message will be delivered with high reliability. On the other hand, it can significantly generate large network traffic overload causing the broadcast storm problem.

The second approach is contention-based forwarding [2][5]. The significant difference of this method, when compared to the simple flooding, is that a forwarder is determined by contention among receivers receiving the alert message. Some mechanisms favor the retransmission of receivers located at further distances from the sender by selecting shorter waiting times. The drawback of this approach is that several forwarders may decide to retransmit the message at the same time due to coarse positioning information and MAC layer contention, leading to collisions and/or bandwidth wasting.

In this paper, we propose a sender-designated alert message propagation mechanism, named Vehicle Multi-hop Protocol (VMP), which permits fast and reliable alert message propagation in VANET. The core mechanism of VMP is that all vehicles will maintain multiple candidate forwarders to broadcast the alert message before detecting a danger. While detecting a danger, the node prepares an alert message that contains information of multiple forwarders. This information includes the selected forwarder identifier, offset timer and hop count. The forwarder with the smallest offset timer has the highest priority to retransmit the received alert message. This strategy can solve the traffic load problem brought by simple flooding and multiple simultaneous rebroadcasting of contention-based forwarding. The simulation shows that the VMP can achieve better performance than the simple flooding in aspects of network overload and end-to-end delay.

The remaining part of this paper is organized as follows. In Section 2 we present the vehicle communication based applications and their characteristics. In Section 3 the VMP

Mechanism is explained in detail. The VMP performance simulation results are presented in Section 4. Finally, conclusions are given in Section 5.

2. Vehicle Communication Applications

The vehicle communications can be classified as two types: vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I), and vehicle communication related applications can be categorized into two major classes: safety-oriented applications and non-safety oriented applications. Non-safety applications mainly use V2I communications to share traffic information among on-board units (OBU) in vehicle, road side units (RSU) on the road and centralized traffic control system. In contrast, safety applications use V2V communication to monitor active neighbor situations and notify their neighbors the incoming danger via ad-hoc networking among vehicles. The V2V/V2I applications of interest are shown in Table 1.

Table 1. Application characteristics

	Trigger Condition	Delay	Hop Count	Cooperative Mode
Danger Notification	Event	< 100 ms	> 1 hop	V2V
Cooperative Collision Warning	Periodic/Event	< 100 ms	> 1 hop	V2V
Work Zone Warning	Periodic	< 1 sec	= 1hop	V2I

As shown in Table 1, each application has its own specific requirements: application trigger condition, delay, hop count and cooperative mode. Application trigger condition specifies how the applications are triggered, which is either periodic or event-driven. The periodic message such as beacons is used to monitor the updated information about the state of all surrounding vehicles. The event-driven message is used to deliver a danger message to all vehicles in a certain geographical area allowing drivers to have enough reaction time. The delay specifies the promptness of alert message to avoid a hazard situation. The hop count determines the propagation of a message. Whenever a message arrives at a forwarder, its hop count is decremented and the message is terminated when its hop count becomes zero.

From Table 1, we can know that safety applications have unique characteristics of V2V communication mode, alert message dissemination with maximum promptness and multi-hop delivery. In the CCW (cooperative collision warning) need periodic broadcast its own situation to all neighbor moving in the same lane. So we propose the VMP mechanism to adapt these characteristics. In the remaining part, we discuss VMP mechanism and simulation results in detail.

3. VMP Mechanism

3.1 Operation

Figure 1 shows the operation of the proposed VMP mechanism. When v1 notices a danger on the road, it broadcasts an alert message. The alert message contains two forwarder's IDs (v4, v5) and two offset timers (10 ms, 0 ms). When v2 and v3 which are non-forwarders receive the alert message, they do some actions (braking or slowing) to avoid a danger and don't rebroadcast the message. When v4 receives the safety message, it sets the

rebroadcast timer of 10ms. When v5 receives the safety message, it relay the alert message with a forwarder ID (v8) and a new offset timer(0ms) because the v5 has the smallest offset timer(0 ms). If v4 don't receive any re-broadcasted message within the rebroadcast timeout (10ms), it relay the alert message with the new forwarder and rebroadcasts it to the neighbor's nodes.

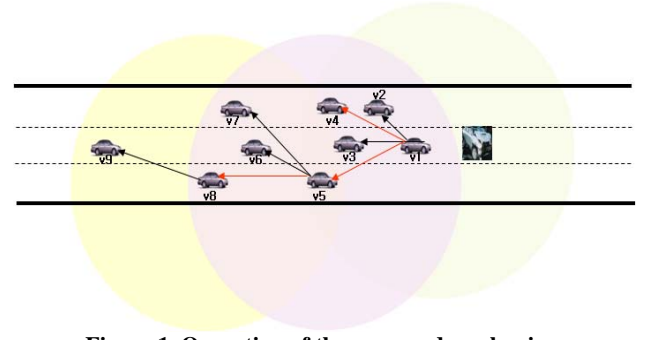


Figure 1. Operation of the proposed mechanism

3.2 Main Procedures

The VMP mechanism is composed of three procedures as shown in Figure 2: beaconing hello (BH), forwarder selection (FS) and delayed forwarding (DF).

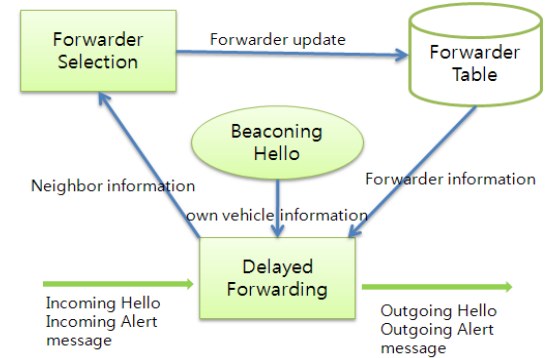


Figure 2. Main procedures of VMP

3.2.1 BH procedure

The main purpose of the BH procedure is to control and manipulate a hello message. A hello message is periodically generated and broadcasted to all neighbor vehicles. Each hello message contains vehicle information such as position, direction and speed .which is acquired from the GPS receiver. The BH procedure parses the received hello messages and hands over to FS procedure.

3.2.2 FS procedure

The FS procedure is to select and maintain multiple forwarders for each vehicle. Forwarder selection strategy is to select multiple vehicles located at further distances from the source among vehicles with same direction by using the greedy forwarding and the directional forwarding. The main purpose of the multiple forwarders is to compensate the positioning error of GPS and message loss due to hidden terminal problem and collision.

3.2.3 DF procedure

The VMP mechanism maintains a list of multiple candidate forwarders to increase reliability of alert message delivery. When detecting a danger, the DF procedure composes the information (offset timer, forwarder's ID and hop count) of multiple forwarders before transmitting an alert message. The offset timer represents the priority of a forwarder. We use the delayed forwarding technique, buffering the received message in some time and rebroadcast it when the time is expired. With the result that the shorter offset timer, has the higher priority.

4. Simulations

In order to assess the applicability of the observations for the VMP protocol in VANET's environment, this section describes the simulation scenarios and simulation setup we used, and finally we evaluate the performance of the VMP protocol and discuss the simulation results.

4.1 Highway Scenarios

Scenario 1 shows that three groups of vehicles travel at the same direction on the highway composed of 2 lanes. The distance between first group and second group is 320m and the distance between second group and third group is 220m. The first alert messages are generated at 10 second (start time) by the foremost 2 cars (red solid line) of group 1 which detect the danger. The alert message is generated in 10packets/second and duration time is 10 seconds. The result is the number of total alert messages generated is 200. Obviously we can find the alert message relay from group 1 to group 2 occurs just only through the last 2 cars of group 1 because of its transmission range (330m) in Table 2.

Scenario 2 shows that two groups of vehicles travel in the opposite directions. It is more likely to real situation. The highway is composed of 4 lanes: the upper 2 lanes for group 1 and the under 2 lanes for group 2. In this scenario, the foremost 2 cars of group 2 generate alert messages and the packet interval time is 100 ms and 20 ms respectively.

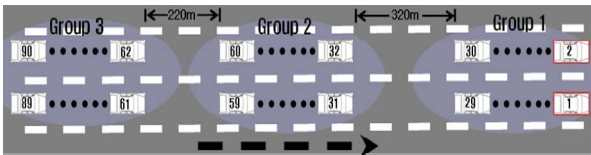


Figure 3. Scenario 1

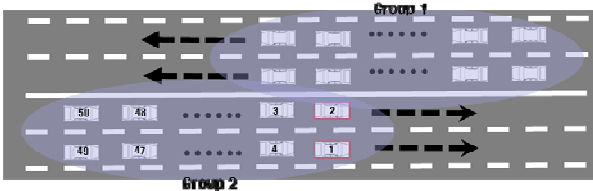


Figure 4. Scenario 2

4.2 Simulation setup

To analyze the performance of proposed VMP protocol, we implemented it in Qualnet 4.0[12]. Each vehicle is assumed to be equipped with IEEE 802.11a devices, with a homogeneous

transmission range of 330 meters. Table 2, 3 lists the relevant parameters used in the simulations.

Table 2. Simulation setup

parameter	Value
Transmission range	330m
Data rate	6Mbps
PHY layer	802.11a OFDM
MAC layer	802.11 DCF
network layer	Simple flooding/VMP
transport layer	UDP
application	Modified MCBR(Multicast CBR)

Table 3. VMP setup

parameter	Value
Hello interval	1 second
Forwarder number	2 nodes
Delayed forwarding	First : 1 ms Second : 5 ms

4.3 Simulation results

We compare the proposed VMP protocol with traditional simple flooding. In each simulation, vehicle's maximum speed and inter-vehicle distance are varied. Figure 5 shows the number of the alert messages transmitted by each node during simulation time (10 seconds). In case of simple flooding, all vehicles in group 1 transmit an alert message after receiving the alert message from the foremost vehicles (1, 2) in scenario 1. So all vehicles within the same group have the same number of the packets transmission. Group 2 and 3 have much less packets sent than group 1 because group 2 has received fewer alert messages from group 1. In case of VMP, the forwarder nodes (31, 61, and 81) have the same number of packets sent because only forwarder nodes can send an alert message.

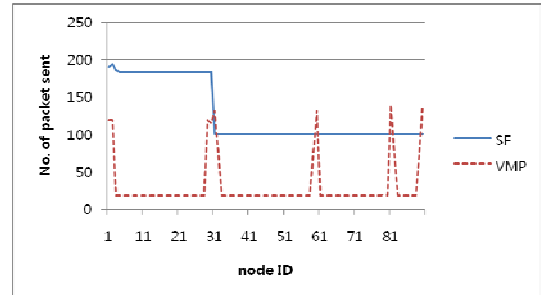


Figure 5. number of broadcast packet sent (scenario 1)

Figure 6 shows the end-to-end delay of two mechanisms. Simulation results show that the VMP protocol has lower end-to-end delay, when compared to simple flooding. Unlike the simple flooding, the VMP protocol specifies multiple forwarders to re-broadcasting. This scheme can efficiently suppress the re-broadcasting the alter message compared with the simple flooding, and less contention happened in MAC layer results in the smaller end-to-end delay.

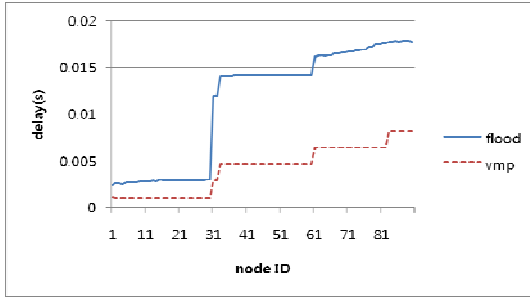


Figure 6. End-to-end delay (scenario 1)

Figure 7 shows the number of total packet received successfully at each car in scenario 1. We observe that the VMP outperforms the simple flooding. These results explained clearly that the reason of large number of packets loss is the broadcast storm problem. The simple flooding has lost large number of packets due to packet collision. In contrast, VMP has small impact of packet collision because only designated forwarders can send an alert message.

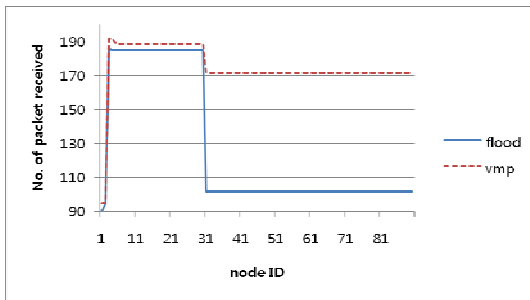


Figure 7. number of packet received (scenario 1)

Figure 8 and 9 show the end-to-end delay of alert packets in scenario 2. From the results, we know that the simple flooding has much more delay time than the VMP as alert message traffic density increases. Also the delay of the VMP protocol is almost as same as MAC layer delay however the traffic loads increased and the hello message overhead.

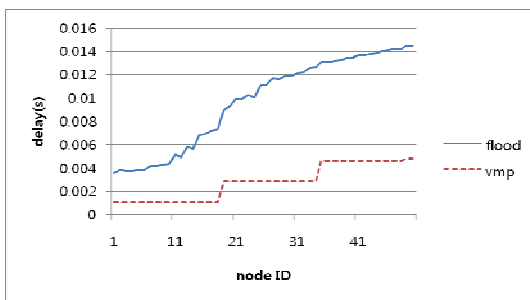


Figure 8. End-to-end delay (scenario 2, 100ms)

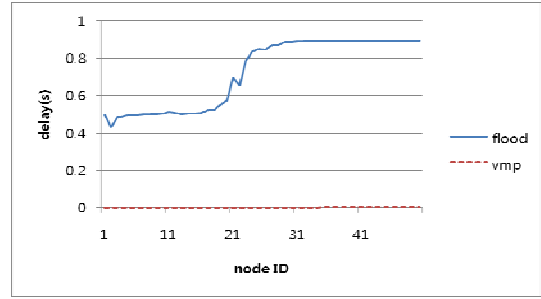


Figure 9. End-to-end delay (scenario 2, 20ms)

Figure 10 shows the number of total packet received at each successfully at each vehicle in scenario 2. We observe that VMP protocol significantly outperforms the simple flooding in the heavy traffic conditions. Otherwise both VMP protocol and simple flooding show a similar efficiency in light traffic conditions.

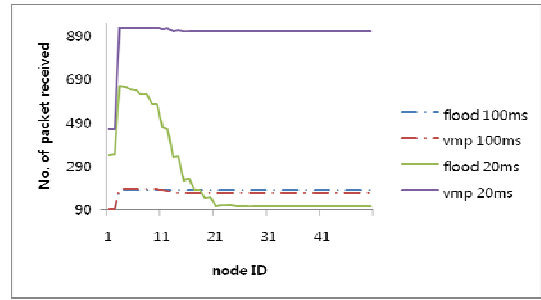


Figure 10. number of packet received (scenario 2)

5. Conclusion

In this paper, we have proposed a novel alert message propagation scheme, based on predefining multiple forwarders by sender. Proposed VMP protocol requires all vehicles maintaining multiple candidate forwarders to relay the alert message by sending hello message periodically. It provide the ability to allow fast dissemination of alert message and can compensate the coarse positioning of GPS and decrease the packet loss rate due to MAC layer contention problems. From the simulation results, we have also shown that the VMP can achieve better performance than the simple flooding in terms of network overload and end-to-end delay.

6. ACKNOWLEDGMENTS

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