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Secure and Efficient Mechanism for quick transmission of Safety Critical Information in VANET

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Abstract

Vanet integrates components of Wi-Fi, Bluetooth and other mobile connectivity protocols to facilitate data transfer betweencarsand between roadside equipment andautomobiletraffic. Immediate benefits of vanet are preventing accidents and avoiding traffic jam. If a car spots a dangerous road situation, such as an accident, it transmits the information to cars behind it that might be heading in the direction of the danger. A major research area is how to control such disbursing of data and how to ensure safety delivery of such messages. It should not be transmitted to cars that are driving away from the danger or to cars on the other side of town. This is the kind of problem that need to be addressed when choosing the protocol that will be used. The protocol will need to invisibly ensure the necessary data is transmitted or disseminated with high probability and less delay. We are going to develop an algorithm that modifies an existing protocol, that is well suited for quick transmission of traffic alerts or congestions to every vehicle that passes through an emergency zone.

Index Terms: Active safety, contention, fairness, information dissemination, power control, vehicle-to-vehicle communication.

1 Introduction

Vehicular Ad-Hoc Networks (VANETS), being the real life application of wireless and mobile ad hoc networks. In VANETs (Vehicular Ad-hoc NETworks), RSUs (Road Side Units) and vehicles disseminate safety and non safety messages.In VANET, each vehicle is equipped with the technology that allows the drivers to communicate with each other as well as with roadside infrastructure, e.g., base stations also known as Roadside Units (RSUs), located in some critical sections of the road, such as at every traffic light or any intersection or any stop sign, in order to improve the driving experience and making driving safer. By using those communication devices known as On-Board Units (OBUs),vehicles can communicate with each other as well as with RSUs. VANET is a self-organized network that connecting the vehicles and RSUs, and the RSUs can be connected to a backbone network, so that many other network applications and services, including Internet access, can be provided to the vehicles.Vanet integrates components of Wi-Fi, Bluetooth and other mobile connectivity protocols to facilitate data transfer betweencarsand between roadside equipment andautomobiletraffic. Immediate benefits of vanet are preventing accidents and avoiding traffic jam.

When considering safety-related communication, two types of messages can be identified: 1) periodic and 2) event driven. Periodic exchange of status messages that contain the vehicles position, speed, etc. (also called beacons) can be used by safety applications to detect potentially dangerous situations for the driver (e.g., a highway entrance with poor visibility).On the other hand, when an abnormal condition (e.g., an airbag explosion) or an imminent peril is detected by a vehicle, an event-driven message (also called emergency message) is generated and disseminated through parts of the vehicular network with the highest priority.To counter the issue of channel saturation, we proposed to make use of packet-level interference management based on per- packet transmit power control to give packets relative weights that control the introduced interferences and, implicitly, the ability to capture packets.

In this paper, we analyze vehicle-to-vehicle communication from an active-safety perspective and identify the challenges and required strategies to improve performance through packet-level interference management. With the proposed technology, i.e., the IEEE 802.11p, the load on the wireless medium that results from periodic message exchange should carefully be controlled to prevent deterioration of the quality of reception of safety-related information. To this purpose,a distributed transmission power control strategy called distributed fair power adjustment for vehicular environments (D-FPAV) that controls the beaconing load under a strict fairness criterion that has to be met for safety reasons. D-FPAV also allows a clear prioritization of event-driven over periodic messages. We then turn our attention to a fast and effective dissemination of event-driven emergency messages. We modifies a contention-based strategy called emergency message dissemination for vehicular environments (EMDV) that ensures a fast effective dissemination of alerts in a target geographical area in cooperation with D-FPAV, by incorporating ADEM algorithm. Finally, we evaluate the performance of the protocols in a highway traffic scenario with the use of a significantly extended version of the ns-2 [6] simulator.

The paper is organised as follows: Section II represents recent studies most relevant to this work. Section III formally defines the techniques used, i.e.,the basis of our strategy to maintain the beaconing load under control, i.e., D-FPAV, which is also formally proven to achieve fairness among sending vehicles,the EMDV method to quickly and effec- tively disseminate emergency information within a geographi- cal area using the proposed ADEM algorithm.Section IV defines details of pro- posed methodology and the proposed algorithm ADEM. Section V presents a proposed Implemen- tation Methodology and Section VI gives the con- clusion and remarks.

2 Related Works

The authors of [12] and [13] propose interesting schemes to disseminate the emergency information in a certain direction by making use of contention periods, i.e., after a message trans- mission, all receivers wait for a certain time before forwarding the message. Briesmeister et al. [13] favor the retransmission of receivers located at farther distances from the sender by the selection of shorter waiting times. Biswas et al. [12] select random waiting times and utilize an implicit acknowledgment scheme to cancel retransmissions from nodes closer to the danger (where the message originated).

Our proposal for information dissemination described in Section V makes use of the two latter principles (from [12] and [13]) and further complements them with mechanisms that were aimed at reducing dissemination delay and improving reliability, particularly in high channel load conditions.

3 Fair Congestion Control

A distributed transmit power control method based on a strict fairness criterion, i.e., Distributed Fair Power Adjustment for Vehicular Environments (D-FPAV), to control the load of periodic messages on the channel. Its assumed that two types of messages are used for traffic safety related communication:

1. Periodic messages (beacons) that are sent by all vehicles to inform their neighbors about their current status (i.e., position) and
2. event-driven messages that are sent whenever a hazard has been detected. D-FPAV also allows a clear prioritization of event-driven over periodic messages

The benefits are twofold:

- The bandwidth is made available for higher priority data like dissemination of warnings, and
- Beacons from different vehicles are treated with equal rights, and therefore, the best possible reception under the available bandwidth constraints is ensured.

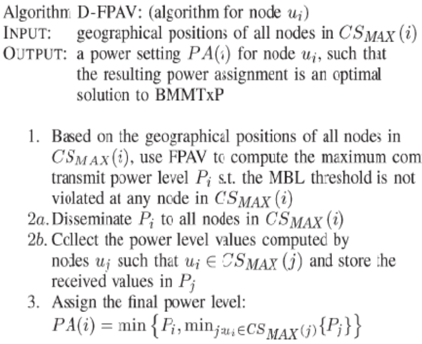
The fairness of the proposed approach is also proved.

D-FPAV algorithm, which makes use of transmit power control to achieve the following design goals.

1. Congestion control: Limit the load on the medium pro- duced by periodic beacon exchange.
2. Fairness: Maximize the minimum transmit power value over all transmission power levels assigned to nodes that form the vehicular network under Constraint 1.
3. Prioritization: Give event-driven emergency messages higher priority compared to the priority of periodic beacons.

D-FPAV is based on the following factors:

1. executing the FPAV algorithm at each node with the information gathered from received beacons;
2. exchanging the locally computed transmit power control values among surrounding vehicles;
3. selecting the minimum power level among the one locally computed and those computed by the surrounding vehicles.



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Algorithm D-FPAV: (algorithm for node $u_i$)
INPUT:   geographical positions of all nodes in $CS_{MAX}(i)$
OUTPUT:  a power setting $PA(i)$ for node $u_i$, such that
         the resulting power assignment is an optimal
         solution to BMMTxP

1.  Based on the geographical positions of all nodes in
    $CS_{MAX}(i)$, use FPAV to compute the maximum common
    transmit power level $P_i$ s.t. the MBL threshold is not
    violated at any node in $CS_{MAX}(i)$
2a. Disseminate $P_i$ to all nodes in $CS_{MAX}(i)$
2b. Collect the power level values computed by
    nodes $u_j$ such that $u_i \in CS_{MAX}(j)$ and store the
    received values in $P_j$
3.  Assign the final power level:
    $PA(i) = \min\{P_i, \min_{j: u_i \in CS_{MAX}(j)}\{P_j\}\}$
```

Figure 1: D-FPAV algorithm

The D-FPAV algorithm is summarized in Fig. 2. A node ui continuously collects information about the status (e.g., current position, velocity, and direction) of all the nodes within its $CS_{MAX}(i)$ range. These nodes are the only ones that node ui can affect when sending its beacon. The communication range is typically smaller than the CS range; thus, a strategy based on multihop information propagation is needed to obtain the information from nodes outside the communication range. Based on the status of all nodes within CS_{MAX} range, node ui makes use of FPAV to compute the maximum common value Pi of the transmit power for all nodes in $CS_{MAX}(i)$ such that the condition on the MBL is not violated (Step 1). Note that this computation is based only on local information (i.e., the status of all the nodes in $CS_{MAX}(i)$), and it might globally be infeasible (i.e., it might violate the con- dition on the MBL at some node). To account for this case, node ui delivers the computed common power level Pi to all nodes in $CS_{MAX}(i)$ (see Step 2a). Meanwhile, node ui collects the same information from the nodes uj such that ui $CS_{MAX}(j)$ (see Step 2b). Knowing the power levels computed by the nodes in its vicinity, node ui can assign the final transmit power level, which is set to the minimum among the value Pi computed by the node itself and the values computed by nodes in the vicinity (see Step 3). Setting the final power level to the minimum possible level is necessary to guarantee the feasibility of the computed PA

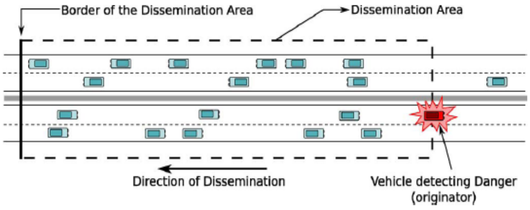

Figure 2: Relevant area for dissemination of emergency information

4 Proposed Methodology

4.1 Dissemination of Emergency Information

A vehicle that detects a hazard issues an event-driven emergency message to warn the drivers that approach the danger. The originating node, according to the corresponding safety application, specifies the relevant area for dissemination of the alert (dissemination area). The alert must be distributed in the complete area, i.e., up to the border of the dissemination area , possibly via multi-hop transmissions, with high reliability and short delay. In this paper, we study the case where roads do not comprise any intersection (or highway entry/exit) and make the reasonable assumption that the communication range of an emergency message is larger than the roads width. The main purpose of dissemination strategy is to select the appropriate nodes to efficiently forward the message in the direction of dissemination to cover the entire dissemination area. The proposed strategy needs to overcome the different challenges that exist in a vehicular environment, such as deal- ing with uncertainties that result from node mobility, fading phenomena, and packet collisions. Furthermore, the wireless channel is also utilized for periodic beacon exchange.

Emergency Message Dissemination for Vehicular Environments (EMDV) strategy for the dissemination of safety-critical information is proposed. EMDV is based on the following three design principles

1. A contention scheme is used after the broadcast transmission of the message to deal with uncertainties in terms of reception failure caused by node mobility, fading phenomena, and collisions.
2. To minimize the delay, the contention strategy is complemented with the selection of one specific forwarder made at transmission time, referred to as the next hop. This step is possible due to the status information acquired from safety beacons. The specific forwarder, in case of correct reception, immediately forwards the message.
3. The reliability of the dissemination process is increased by the following factors:
    - assuming a forwarding range shorter than the communication range
    - a controlled message retransmission scheme within the dissemination area.

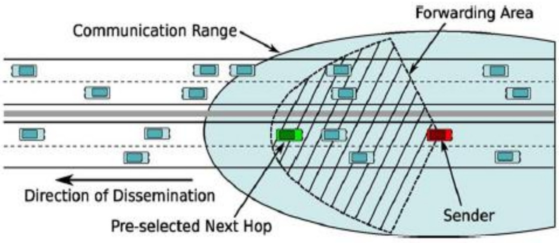

Figure 3: Sender perspective when utilizing the EMDV protocol

Fig.shows a sketch of a sender perspective, which must preselect a next hop among known nodes and then broadcast the message. The forwarding area, which is limited by the forwarding range, identifies the area where potential next forwarders can be located, i.e., both the preselected next hop and the group of nodes that will start the contention period upon the reception of the message. A forwarding range shorter than the communication range is selected to improve the efficiency of the process.To decide which node actually forwards the message, a contention period is started.To favor the speed of the process, each receiving node select a timeout value inversely proportional to the progressed distance in the direction of dissemination with respect to the actual sender. The node(s) whose timeout fires first will rebroadcast the packet. Nodes that stil wait for their timeout to fire land that receive a rebroadcasted packet will cancel their rebroadcast attempts. The advantages of using a contention-based approach for forwarding is that, compared to unicast-based forwarding, the probability that at least one node forwards the message is significantly increased. There is a chance for redundant (duplicate) rebroadcast, however,and when appropriately controlled, these duplicates increase robustness.EMDV works with the following algorithm(ADEM)

4.2 ADEM Algorithm

```
Procedure: PrepareMsg()
Begin
For any Msg do
If no.of.Msg < maxMsg then
Call FindNextHop()
No.of.Msg = No.of.Msg + 1
PrepareContention(sent)
End

Procedure: FindNextHop()
Begin
If no neighbor in senders forwarding area then
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```
    Set NextHop to broadcast address
    Return NextHop
Else
    Set farthest neighbor in senders forwarding area to pre-selected NextHop
End
Procedure : SendMsg()
Begin
If d is the pre-selected NextHop in the forwarding area then
    Check connectivity of d with all vehicles in the forwarding area and direction of dissemination
    Calculate time required by any vehicle, a to reach destination area
    x < findtime(a,d)
    Calculate time required by source s to reach destination area
    y < findtime(s,d)
    If x > y then
        s forwards the packet
    else
        a forwards the packet
End

Procedure: ReceiveMsg()
Begin
If sendernode  pre-selected NextHop then
Begin
    PrepareMsg()
If receivernodepos  dissemination area then
    If sendernodepos  forwarding area then
        no.of.msg = no.of.msg + 1
    else
        PrepareContention()
End
If no.of.Msgs >= maxMsgs then
    CancelContention()
End

Procedure: PrepareContention(sent)
Begin
    Time = maxContentionTime + ChannelAccessTime
    Contend(time);
End
```

ADEM is composed of 5 main procedures. PrepareMsg() procedure is invoked by any node that transmits emergency message This procedure first checks whether the message has already been transmitted for the maximum number of times (maxMsgs) ie no.of.Msg < maxMsg ,If not, the FindNextHop() procedureis invoked . After transmitting the message, the message counter is increased, and inorder to verify at least one neighbor forwards the message, a contention period is started.

The FindNextHop() procedure scans the neighbor table of the sender to check if there is any neighbor in the senders forwarding area with the highest progress in the direction of dissemination. If yes set the farthest neighbor as the NextHop. If no neighbor can be found in the dissemination direction or if the senders forwarding area is at the border of the dissemination area, NextHop is set to broadcastAddress.

In SendMsg() procedure, check the connectivity of all vehicles in the forwarding area with the pre-selected NextHop d. Compare the time taken by source vehicle and any other vehicle to reach the destination, select the vehicle that takes less time.

The ReceiveMsg() procedure is invoked when a node receives an emergency message and first make sure that the node lies inside the dissemination area to proceed. Then, it is checked whether the received message has been sent by a node that is farther in the direction of dissemination and lies inside its own forwardingArea.If the receiving node is indicated as the intended forwarder in the NextHop field, then the message is forwarded with no contention by invoking the PrepareMsg() procedure; otherwise, a contention period is started by invoking the PrepareContention() procedure To account for this case, the contention time is set to maxContentionTime + maxChannelAccessTime when flag = sent.

5 Proposed Implementation Methodology

The proposed implementation methodology evaluate the performance of the two proposed protocols, i.e., D-FPAV and EMDV using ADEM algorithm, with the use of the network simulator ns-2.28[6].

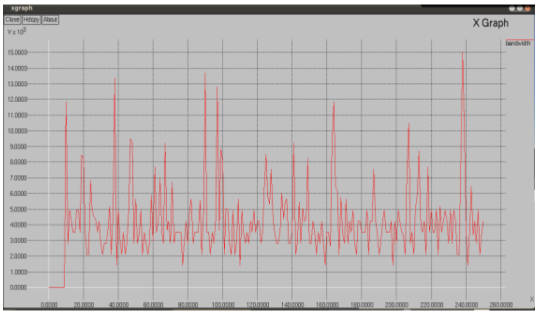

Figure 4: xgraph showing bandwidth

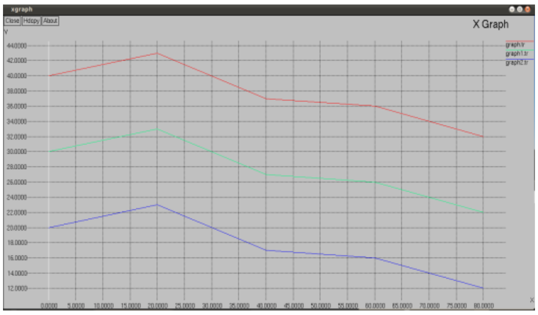

Figure 5: xgraph showing Performance

6 Conclusion

To satisfy the requirements of active-safety communication in vehicular networks also under these stressed conditions, two communication strategies are proposed that can separately be used but show synergistic effects when combined.Synergy is gained when using both protocols together, because D-FPAV can ensure that the channel load, in particular the channel busy time, is kept at a level where EMDV (or other dissemination protocols) can successfully operate. The procedure described in this paper works in two phases.In the first phase A distributed transmission power control strategy called Distributed Fair Power Adjustment for Vehicular environments (D-FPAV) that controls the beaconing loadis described.D-FPAV also allows a clear prioritization of event-driven over periodic messages.Once messeges are prioritized,second phase is dissemination of those prioritized messages.For that,a contention-based strategy for fast and effective dissemination of event-driven emergency messages called Emergency Message Dissemination for Vehicular environments (EMDV)is proposed.EMDV uses the proposed ADEM algorithm. EMDV ensures a fast effective dissemination of alerts in a target geographical area in cooperation with D-FPAV.The proposed suite of protocols provides a comprehensive solution for active-safety communications in IEEE 802.11-based vehicular networks.

The performance of the proposed protocols has been analyzed via simulator ns2.28.The protocol proposed in this paper can be extended to disseminate the emergency message in two opposite directions and to support road junctions, e.g., with smart strategies such as those proposed in [17] or with the use of digital maps, which is left to our future work.

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