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Research Article

Intelligent Communication Pattern for Effective Congestion Control in VANET

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Abstract

Recent advances in hardware, software, and communication technologies are enabling the design and implementation of a whole range of different types of networks that are being deployed in various environments. One such network that has received a lot of interest in the last couple of years is the Vehicular Ad-Hoc Network (VANET). VANET has become an active area of research, standardization, and development because it has tremendous potential to improve vehicle and road safety, traffic efficiency, and convenience as well as comfort to both drivers and passengers. Dynamic nature of network due to moving vehicle creates complications in design of appropriate comprehensive communication system. In this article we are proposing an effective communication pattern for VANET which efficiently handles the vehicle to vehicle communication and also avoids flooding problem.

Keywords: *VANET, Traffic efficiency, Road safety, Effective communication pattern.*

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1. Introduction

Up to now, a number of research projects have been carried out to investigate the vision of communicating vehicles. In projects like FleetNet1 and CarTALK, researchers designed protocols, algorithms, and systems to test the general feasibility of wireless communication between vehicles[Elmar Schoch, Frank Kargl, & Michael Weber 2008]. As the first-generation projects in both the United States and Europe finished their work some time ago, vehicular networks are now being both extended and consolidated at the same time. In a number of more recent research projects such as Network-on Wheels and the European projects SafeSpot, CVIS, and Coopers, both the automotive industry and academia are addressing the topic and approaching the vision in a less experimental way than did previous initiatives. This intention is also corroborated by the fact that new consortia like the Car-to-Car Communications Consortium (C2C-CC) and Vehicle Infrastructure Integration (VII) have started the process of standardizing systems and protocols. For instance, as a basis for wireless communication, the U.S. FCC has allocated 75 MHz of bandwidth for dedicated short-range communication (DSRC) [Elmar Schoch, Frank Kargl, & Michael Weber 2008], which is now used by the emerging IEEE 802.11p standard.

Starting with the idea of making driving safer by intervehicle communication, the concept of vehicular networks or vehicular ad hoc networks (VANETs) has been extended to a large collection of various applications that can profit from wireless communication between vehicles[Elmar Schoch, Frank Kargl, & Michael Weber 2008]. Nowadays, vehicles are not only envisioned to communicate between each other, but also to get information from and send data to infrastructural units. These stationary parts of the vehicular network range from traffic lights and dynamic traffic signs to access points at home, gas stations, and elsewhere. In addition, although active safety applications still represent the central idea, traffic efficiency applications as well as entertainment and business applications have also been proposed. In summary, the diverging requirements of all these applications make the design of a comprehensive communication system a very complex topic[Elmar Schoch, Frank Kargl, & Michael Weber 2008].

In this paper we are proposing an effective communication pattern. After analyzing the structure proposals made so far we are proposing a pattern which helps in preventing flooding problem as well as ensures effective V2V communication. The message generation is not on periodic basis, they are generated in case of event occurrence and affected vehicle broadcasts the messages continuously.

2. Node Velocity

One of the most important aspects of mobility in VANETs is the potential node velocity. Nodes either denote vehicles or roadside units (RSUs) in this case. Node velocity may range from zero for stationary RSUs or when vehicles are stuck in a traffic jam to over 200 km/h on highways [Elmar Schoch, Frank Kargl, & Michael Weber 2008].

In particular, these two extremes each pose a special challenge to the communication system. In case of very high node velocities, the mutual wireless communication window is very short due to a relatively small transmission range of several hundred meters. For example, if two cars are driving in opposite directions at 90 km/h each, and if

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*Corresponding author: **Snehalata Mundhe** we assume a theoretical wireless transmission range of 300 m, communication is only possible for 12 s. At the same time, moderate relative velocities of vehicles driving in the same direction lead to less topology dynamics among those vehicles. These node velocity characteristics have implications on all communication layers. In case of high relative velocity, the transceivers have to cope with physical phenomena like the Doppler effect. Because the link layer cannot predict when a connection will be disrupted, link failures will occur frequently. For routing or multihop message dissemination, the short encounters between vehicles and general movement lead to a highly unstable topology, rendering topology-based routing practically useless for applications, high node velocities have the effect that e.g., context awareness gets difficult because the immediate context changes very fast [Elmar Schoch, Frank Kargl, & Michael Weber 2008].

At the other extreme, with almost no mobility, the network topology is much more stable. However, slow movement in the vehicular domain usually also means a very high vehicle density, which results in high interference, medium access problems, and so on. For such reasons, very scalable communication solutions are required [Elmar Schoch, Frank Kargl, & Michael Weber 2008].

3. Movement Patterns

Vehicles do not move around arbitrarily, but use predefined roads, usually in two directions. Unpredictable changes in the direction of vehicles usually only occur at intersections of roads [Elmar Schoch, Frank Kargl, & Michael Weber 2008]. We distinguish three types of roads:

1) Dense city road network: Inside cities, the road density is relatively high. There are lots of smaller roads, but also bigger, arterial roads. Many intersections cut road segments into small pieces. Often, buildings right beside the roads limit wireless communication.
2) Rural roads: These roads usually have much larger segments, which means that intersections are more rare than in cities. Traffic conditions often do not allow the formation of a connected network, because too few vehicles are on the road. The overall direction of rural roads changes more frequently than the direction of highways.
3) Highways: Highways typically form a multilane road, which has very large segments and well defined exits and on-ramps. Movements are quasi one-dimensional, and highways usually keep their direction toward another city.

These movement scenarios pose special challenges, particularly for routing. In contrast to cities where the traffic is very unordered, vehicles on a highway form the other extreme, because almost only one dimension is left[Elmar Schoch, Frank Kargl, & Michael Weber 2008].

4. Node Density

Apart from speed and movement pattern, node density is the third key property of vehicular mobility. As already briefly discussed, it is not hard to imagine that the number of other vehicles in mutual radio range may vary from zero to dozens or even hundreds. If we assume a traffic jam on a highway with four lanes, one vehicle every 20 m and a radio range of 300 m, every node theoretically has 120 vehicles in its transmission range [Elmar Schoch, Frank Kargl, & Michael Weber 2008].

In case of very low density, immediate message forwarding becomes impossible. In this case more sophisticated information dissemination is necessary, which can store and forward selected information when vehicles encounter each other. In this case the same message may be repeated by the same vehicle multiple times. In high-density situations the opposite must be achieved. Here, a message should be repeated only by selected nodes, because otherwise this may lead to an overloaded channel [Elmar Schoch, Frank Kargl, & Michael Weber 2008].

In addition, node density is not only correlated to the type of road, but also to time. In the daytime the density on highways or in cities is high enough for immediate forwarding, as long as the routing can deal with fragmentation. However, during the night, few vehicles are around on these kind of roads either [Elmar Schoch, Frank Kargl, & Michael Weber 2008].

5. Proposed Intelligent Communication Pattern

IEEE 802.11p is a suitable communication system that is likely to be deployed in VANETs. In proposed intelligent communication pattern properties of geobroadcasting are used. Unidirectional communication is achieved by accepting if message from front and discarding the message from behind and from other lane. The properties of Geobroadcast communication pattern are explained as below.

5.1Geobroadcast

Purpose: Immediate distribution of information in a larger area, for example, to inform approaching vehicles about a sudden event or abnormal road condition that needs attention by drivers [Elmar Schoch, Frank Kargl, & Michael Weber 2008]).

Communication Mechanism: The sender of the message determines a destination region for the message to be sent and attaches it to the message. Then the message is sent via link layer broadcast to all immediate neighbors in transmission range. Every receiver located within the specified destination region forwards the unchanged message via broadcast (geographically restricted flooding, Fig.1). For better scalability in a situation with high node density, the forwarding scheme may also be optimized to reduce redundancy, as in Gossiping [Elmar Schoch, Frank Kargl, & Michael Weber 2008].

Trigger: Geobroadcast messages are typically sent upon a certain external event, or, in other words, Geobroadcast messages are not sent continuously, although messages with the same content may be repeated from time to time (e.g., in case of a work zone warning) [Elmar Schoch, Frank Kargl, & Michael Weber 2008].

Direction: Geobroadcast messages are unidirectional.

Data: Messages contain data that is set by the sender. For example, in case of an accident, the crashed vehicle detects this situation using local sensors and can then send an appropriate warning message[Elmar Schoch, Frank Kargl, & Michael Weber 2008].

Quality of Service: Due to their event-based nature, Geobroadcast messages often require very low latency of messages to inform addressed vehicles as fast as possible. On the other hand, some applications like the aforementioned work zone warning have relaxed requirements here, so messages should indicate their priority to adapt forwarding accordingly. In addition, certain applications like accident warning may need best possible delivery success to inform all addressed vehicles [Elmar Schoch, Frank Kargl, & Michael Weber 2008].

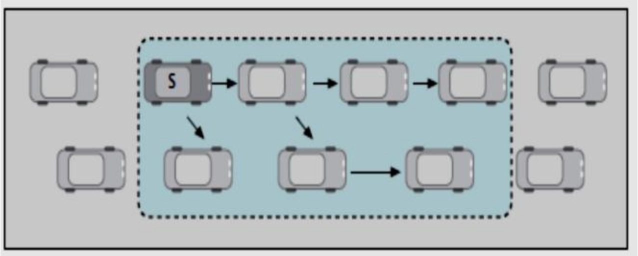

Fig. 1 Geobroadcast

6. Case Study

It is assumed that all the vehicles are equipped with radio communicating device.

6.1 Accidental Condition

The road is assumed to be divided into three lanes. The outer lanes are for heavy and small vehicles traffic and the middle lane is for overtaking. It is assumed that vehicle is blocked on the road due to accident. In post accident condition according to proposed method the blocked vehicle creates the message of warning i.e. message of accident. This message will be broadcasted to all the nodes coming in the range. Nodes can be either vehicle or roadside unit. The message received by the immediate short range vehicle is converted into action such as diversion, and this vehicle will add this decision field in broadcasted message and updated message will be broadcasted further. The accident message is also received by the tower and it starts broadcasting its own decision message i.e. message of slow down so that the traffic congestion creation can be avoided. the tower broadcasts these messages to all the vehicles coming in the range. Thus vehicles are receiving two messages from vehicle and from tower. Due to tower message the vehicles are coming slowly and vehicles get sufficient time to act according to decision and thus avoids congestion creation. Thus we can break situation into two parts i.e. 1) Post Accidental Condition handled by affected vehicle, and 2) Immediate Vehicle In Short Range. The following flowchart describes the proposed communication pattern pattern clearly

6.2 Message broadcasting by affected vehicle

In this case the message broadcasting is initiated in case of incident. After accident the affected vehicle itself initiates the message broadcasting. The affected vehicle sends the warning message i.e. message of accident happened based on which next incoming vehicle can take intelligent decision to control the congestion. The affected vehicle transmits this message to all the vehicles coming in its range. Every vehicle coming in the range will get the message of accident and that vehicle after receiving the message will take the intelligent decision such as diversion which helps in controlling congestion problem. In similar way this message is also received by the road side towers. After receiving this message they transmit their decision message ex. slow down message. This message is long range message which alerts the vehicles about the incident and they reduce their speed which gives them sufficient time to take smart decisions.

Flow Chart

Post-Accident Condition

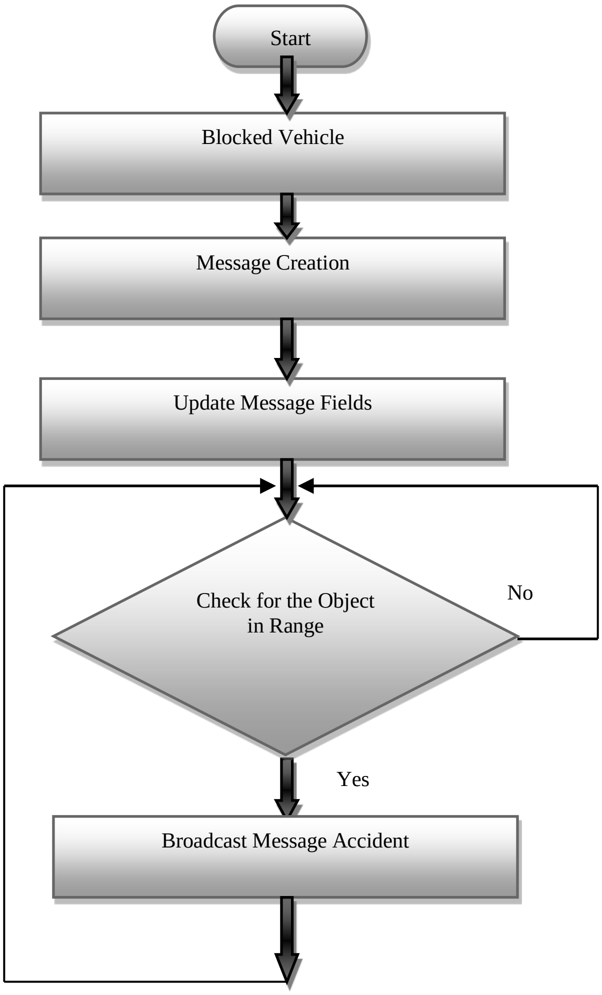

Fig. 2 Message broadcasting by affected vehicle

Vehicle in Short Range

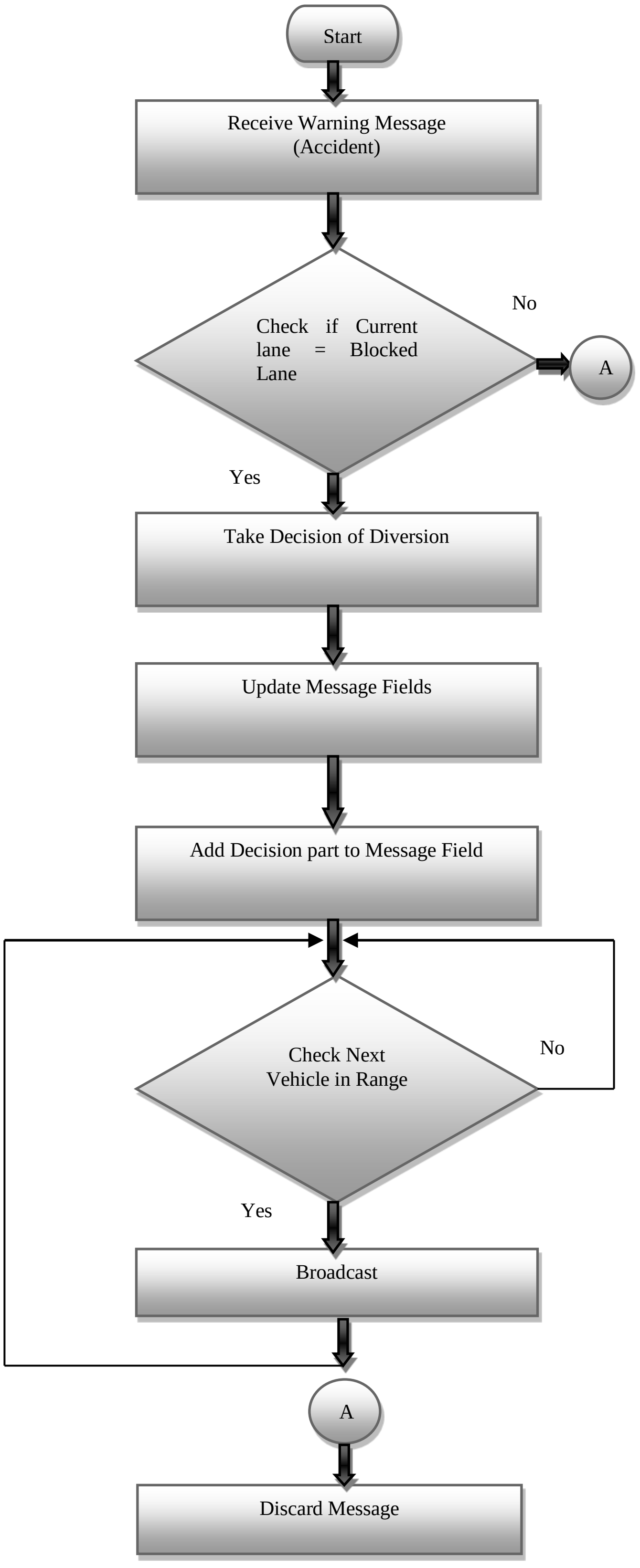

Fig. 3 Message broadcasting by Vehicle in short range

Following table shows the fields of broadcasted message.

Field structure of a Message

Table 1 Field structure of Message

Field Name	Description	Ex
Vehicle Id	Vehicle Identifier	695286
Speed	Speed Status of vehicle	0.0
Lane Id	Lane identifier	0
Status	Status of Lane	Blocked
Warning	Warning message broadcasted by affected Vehicle	Accident
Decision	Decision message broadcasted by Road side unit	Slowdown

6.3 Message broadcasting by Vehicle in short range

When immediate vehicle in short range receives the message of accident, it first compares the current lane and the lane of accident. If both are same i.e. means that the vehicle is in blocked lane and needs to change the lane. Thus vehicle in short range takes the decision of diversion and accordingly updates the message fields and also adds the decision message of diversion with the message. This message is further forwarded by the same vehicle to all the vehicles which are coming in its range. After diverting in the another lane this vehicle stops broadcasting.

If the current lane is not equal to the affected lane, it clearly indicates that this vehicle is not in affected lane and doesn't require to take any decision. Thus vehicle simply discards the message if not present in affected lane. Following table shows the fields of broadcasted message.

Table 2 Field structure of Message

Field Name	Description	Ex
Vehicle Id	Vehicle Identifier	995828
Speed	Speed of vehicle	2.0
Lane Id	Lane identifier	1
Status	Status of Lane	Blocked
Decision	Decision message broadcasted by affected Vehicle	Divert
Decision	Decision message broadcasted by Road side unit	Slowdown

From above message forwarding technique it is very clear that no periodic messages are broadcasted. Messages are broadcasted only in case of event occurrence, thus limiting the number of messages getting broadcasted to limit the problem of flooding.

Also only affected vehicle transmits continues messages and other vehicles broadcasts only when they are in the same lane . As soon as they change the lane broadcasting is stopped and with this each vehicle gets only one chance for message transmission, thus flooding problem is getting avoided. Following is a picture of how congestion problem is controlled on road by applying proposed intelligent communication pattern. Following picture gives an idea about the simulation. JAVA is used for creating the virtual traffic scenario. The scenario is as shown in the diagram. It contains a curved road which is divided into three lanes, two outer lanes for heavy and small traffic respectively and middle lane is for overtaking. A ramp is connected as shown in diagram. The further we are showing the accidental case in which the vehicle is blocked on the road and by using the VANET how we can control the traffic congestion.

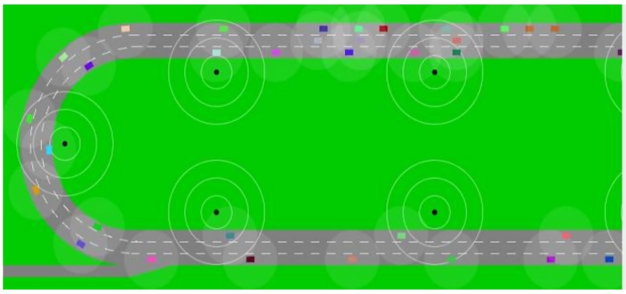

Fig. 4 VANET Simulation

Following picture shows how congestion problem is controlled on road by applying proposed intelligent communication pattern.

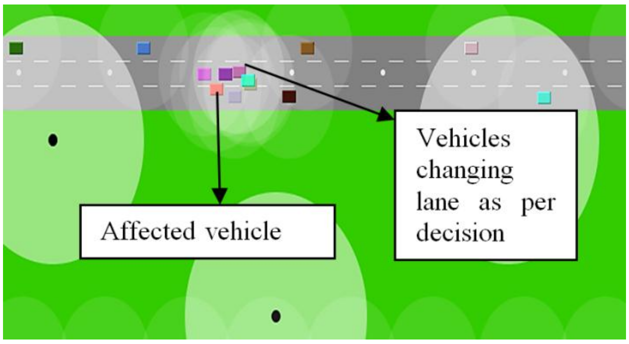

Fig. 5 Congestion Control Achieved

7. Results

The result of above mentioned intelligent communication pattern is avoidance of flooding. As only in case of event the messages are broadcasted already messages are limited and further every vehicle is broadcasting the message only once except affected one as it is continuously broadcasting the message, the further control on flooding is achieved. Following graph will give a clear idea how flooding is reduced by using proposed intelligent communication pattern.

For ten cars the number of messages broadcasted without applying the proposed algorithm is counted and similarly the number of messages broadcasted after applying the proposed algorithm is counted, and the graph of same values is plotted. From graph one can understand that flooding is avoided effectively. The data used to plot the graph is given in following table.

Data for graph

In graph Y-axis is message count and X-axis is number of vehicles. Graph clearly indicates that without applying algorithm the number of messages broadcasted is very high resulting in flooding and with proposed algorithm the total no of messages is very less almost one message per vehicle resulting in reduction in flooding.

Table 3 Message count with and without algorithm

Cars	Without AG	With AG
1	1	1
2	1	1
3	2	1
4	3	1
5	5	1
6	8	1
7	13	1
8	21	1
9	34	1
10	55	1

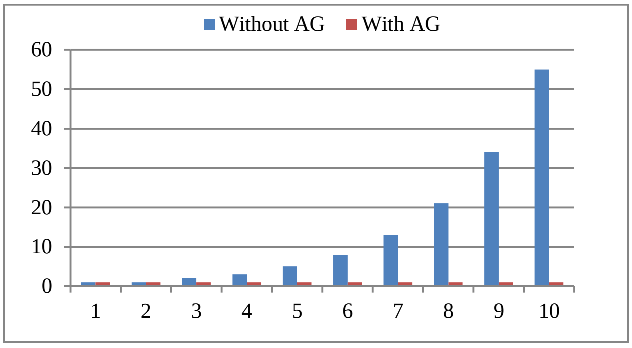

Fig. 6 Flooding control

Conclusion

We presented an intelligent communication pattern for traffic congestion control using VANETs that preserves driver privacy, and does not require any external infrastructure but uses vehicles themselves, an abundant resource in today's highways, as gatherers and distributors of information. We showed the effectiveness of the system by using case study through the use of a flexible framework for simulation and visualization designed and developed to aid in the research of VANETs and other types of networks. We showed how intelligent communication pattern controls existing traffic congestion problem and also solves the problem of message flooding by starting the broadcasting in case of even only and also by limiting the number of messages broadcasted by the vehicles.

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