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A Review on Vehicle to Vehicle Communication Protocols in VANETs

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Abstract— Vehicular Ad hoc Networks is a form or type of mobile ad-hoc network to provide communication among nearby vehicles and nearby fixed equipments or roadside units for improving efficiency and safety of transportation. Even though it possesses characteristics of high node mobility and fast topology changes but still it can provide wide variety of services, ranging from safety related warning message system for improved navigation mechanism as well as information and entertainment applications. In this paper, we have studied various mechanisms or techniques along their comparison and limitation which were used to handle the communication challenges like congestion, delay, collision, redundancy while propagating emergency warning messages in Vehicular Ad hoc Networks (VANeTs), as it is the case where if these communication challenges are not controlled may result in traffic accidents leading to human loss.

Keywords— VANETs, Emergency Warning Messages, Abnormal Vehicles.

I. INTRODUCTION

The Vehicular Ad hoc Network (VANET) is a technology having the art of integrating ad hoc network, wireless LAN and cellular technology to achieve intelligent Inter-Vehicle Communications (IVC) also known as Vehicle-to-Vehicle(V2V or C2C) communications and Roadside-to-Vehicle Communications (RVC or R2V) [1]. Vehicular Ad hoc Network (VANET) is a type of Mobile Ad hoc Network in which communicating nodes are vehicles and roadside communication equipments. In VANETs nodes can communicate with each other without the use of central access-points, means that vehicular nodes are treated as *"computers on wheels"* or *"computer networks on wheels"*. The FCC (Federation of Communication Consortium) allocated a frequency spectrum for V2V and V2R or R2V wireless communication in 1999. The commission then established Dedicated Short Range Communication(DSRC) services in 2003 using frequency band of 5.850—5.925 GHz. Some of the characteristics of VANETs which differentiates it from other mobile ad hoc network are frequent changing topology and high mobility, no power constraint, geographical positioning availability, hard delay constraints and modelling mobility and corresponding prediction. Fig.1 below explains the structure of VANET.

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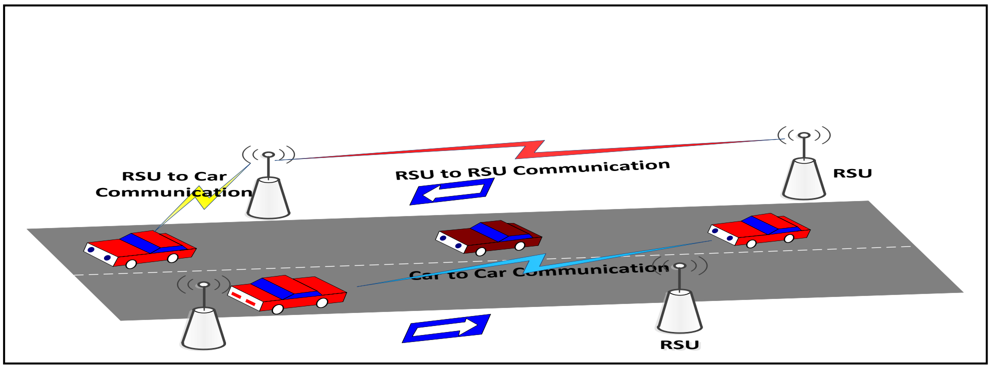

VANETs provide us the valuable concept for improving efficiency and safety of future transportation. For building VANETs, the basic infrastructure requirements are equipment of radios working in unlicensed band and sensors in the vehicles for V2V communication, deployment of info stations (access-points) for V2I communication provides a way for internet access [2]. Info stations cannot be used for latency critical applications e.g. safety applications. Communication Standards like 2G, 2.5G, 3G, 4G and Wi-Fi is also one of the basic infrastructure requirements but there is trade-off between data rate and data mobility for communication standards e.g. the Wi-Fi supports high data rate carrying capacity but low or no mobility support. Now a day's 4G promises to supports high data rate and high mobility but it costs more. So, the main challenge in choosing communication standard for VANETs is to choose such a standard that could support both high mobility and high data rate with low cost. VANETs system architecture from the network architecture view [1] includes related protocols in *Physical Layer(*deals with the frequency spectra used by different IVC apart from issues such as the antenna and modulation), *MAC Layer (*used for avoiding transmission collision and onboard infotainment services in VANET), *Network Layer* (provides multi-hop communication based on geographic addressing and routing and executes functions like congestion control) and *application Layer (*there are various application classes based on the vehicle's role). Major challenges in the field of VANET research are IVC Security, Position Verification Approaches, Scalability problem and MAC protocols, Availability of DSRC spectrum (5.9 GHz) and its channelization, Congestion Control & Performance Surveillance application of IVC through vehicular Sensor Networks.

The introduction of IEEE 802.11 along with advanced wireless ad-hoc networks and location-based routing algorithms makes vehicle-to-vehicle communication viable. Applications for inter-vehicle communication include intelligent cruise control, lane access and emergency warning systems among others. Vehicular systems employ wireless ad-hoc Networks and GPS to determine and maintain the inter-vehicular separation necessary to ensure the one hop and multi hop communications needed to maintain spacing between vehicles. Location based routing algorithms are flexible and efficient enough with regards inter-vehicular communication so, they form the basis of any VANET [3].

The rest of the paper is divided into four sections. Section II defines the scope of VANETs along with the problem which is to be resolved. Section III explains various mechanisms used to eliminate delay, redundancy and collision while transmitting EWMs/security alerts. Section IV includes comparison of these mechanisms and at last section V defines conclusion of this paper.

II. PROBLEM DEFINITION

Traffic accidents have been taking thousands of lives each year, outnumbering any deadly diseases or natural disasters. Studies [4] show that about 60% roadway collisions could be avoided if the operator of the vehicle was provided warning at least one-half second prior to a collision. So, based on these statistic figures, researchers and scientists switch to computerize and automate the vehicular transportation system so as to reduce the road accidents which in estimation takes lives of about 1.2 million people per year worldwide [5], and injures about forty times of this number, as the human driver suffers from following problems:

- *Line-of-sight limitation of the brake lights*: Typically, a driver can only see the brake light from the vehicle directly in front.
- *Large processing/forwarding delay for emergency events*: Driver reaction time typically ranges from 0.7 seconds to 1.5 seconds which results in large delay in propagating the emergency warning [6].

So, VANET is one of the solutions to remove these problems but that too needs a mechanism so as to avoid collision, achieve congestion control and low latency in delivering of emergency warning messages.A vehicle to vehicle communication for cooperative collision warning provides such facilities to a large extend but the wireless communication used is unreliable due to channel fading, packet collisions, and communication obstacles, can prevent messages from being correctly delivered in time. The main problems while propagating Emergency Warning Messages (EWMs) in Vehicular Ad hoc Networks are:

1) *Presence of Redundancy in EWMs while propagating them in VANETs.*
2) *Delay in propagating and delivering of EWMs.*
3) *Collision of data traffic whenever there in congestion in vehicular traffic.*
4) *Broadcast Storm.*

The *sole reason* behind all these challenging problems includes *Packet loss* or the *Communicating Nodes may be Out-of-Range.* So, in order to remove or control these challenging problems, there is a need for effective mechanism that could:

1) Control the redundancy of EWMs to an optimum acceptable level.
2) Provide an efficient EWM dissemination scheme for controlling delay and collision in VANETs.
3) Handle message forwarder node failure in VANETs.
4) Provide an efficient data dissemination scheme to choose the warning message forwarder.

III. LITERATURE REVIEW

Since, the evolution of VANETs various techniques and concepts have been used in order to overcome the above depicted problems while propagating security alerts or emergency warning messages. These techniques and concepts are as:

A. Simple Broadcast [7]

It is the simplest protocol used in propagation of safety alert messages mainly during accidents to all the vehicles moving towards the accident site. According to this protocol when a vehicle receives a broadcast message for the first time, it retransmits the message, after that ignores all subsequent broadcast messages with same ID from other vehicles.

The main features against using this protocol is that because of flooding there are too many redundant rebroadcast messages and also every host in the close proximity will contend for the access to the medium.

B. p-Persistence [7]

This mechanism uses the probabilistic method to decide the vehicle(s) that will rebroadcast the alert message so as to remove the problem of broadcast storm. This means that once a vehicle has received the message for the first time it will rebroadcast the alert message with random probability *p*.

However, there are high chances of loss of message due to the reason when none of the nodes that receive message decide not to rebroadcast.

C. Weighted p-Persistence [8]

In this case, distance between the sender and receivers along with transmission range of node are used as weighted factors to determine the forwarding rebroadcast probability which is calculated on per packet basis.

The main issue of this technique is that there is high probability of collision as multiple vehicles simultaneously decided to rebroadcast though with different probabilities.

D. Slotted 1-persistence [8]

This technique is based on the concept of division of transmission band into sub-bands and assigns different sub-bands for transmission to different distance ranges from the transmitting node. Each sub-range will be assigned its own *WAIT TIME* to rebroadcast the message. Once a node receives an alert message from a neighbouring node for the first time, it retransmits with probability 1 after expiration of *WAIT TIME*, otherwise it discards the packets. This approach uses same logic as weighted p-persistence but it uses the GPS information to calculate the waiting time to retransmit.

This approach falls behind in scenarios when there is more than one vehicle in the farthest slot ready to transmit messages simultaneously, this leads to collision of packets.

E. Slotted p-persistence [8]

This is the improvement over 1-persistance protocol. In this case, the node upon receiving the packet checks packet ID and rebroadcasts with a pre-determined probability p at the assigned time slot, if it receives it for the first time and has not received any duplicates before its assigned time slot expires. Otherwise it discards the packet. In order to prevent the message die out each node buffers the message for a certain period of time.

But here also the performance depends on value chosen for reforwarding probability p, which is chosen randomly.

F. TLO [9]

This approach finds the vehicle most suitable to rebroadcast alert message when there is an accident or any other event by choosing the farther most vehicle in the transmission range from the victimized or abnormal vehicle with the help of TLO algorithm as the node for retransmission. All other vehicles will wait for a threshold time interval in order to take decision about rebroadcast. When the threshold waiting time expires and other vehicles do not receive the same alert message again, there is a problem in rebroadcasting.TLO is run again to find the next candidate as last node. This is repeated until a successful rebroadcast is done. This protocol is somewhat different in its approach from the above ones to control VANET performance parameters.

But this protocol doesn't guarantee retransmission by the last node as it may not receive the main message which it has to retransmit also it is suited to 1D scenarios only.

G. VCWC Protocol [10]

A vehicle to vehicle communication for cooperative collision warning as proposed by *Xue Yang et al* is known as Collision Warning Communication (VCWC) protocol which supports the following application challenges:

- Stringent delay requirements immediately after the emergency
- Differentiation of emergency events and elimination of redundant EWMs
- Support of multiple co-existing Abnormal Vehicles Avs over a longer period

It uses Active approach i.e. when a vehicle on the road acts abnormally, e.g. deceleration exceeding a certain threshold, dramatic change of moving direction, major mechanical failure, etc. It becomes an abnormal vehicle (AV), Only when an abnormal event occurs, the correspondingly AV actively generates Emergency Warning Messages(EWMs),which include the geographical location, speed, acceleration and moving direction of the AV, to warn other surrounding. The protocol consists of *Message differentiation mechanism* by implementing 802.11e EDCF (Enhanced Distributed Coordinated Function), supporting multiple priorities of data to be transferred. Another component of VCWC Protocol is *Congestion Control policies (CCP)* for reducing emergency warning delivery delay, determined by both waiting time and retransmission delay. The last component consists of *Rate Decreasing Algorithm (RDA)* a multiplicative rate decreasing algorithm as described in [7] is used in order to remove trade-off between (re)transmitting EWMs too fast or too slowly. This algorithm describes that the EWM transmission rate is decreased by a factor of a after every L transmitted EWMs. The results as observed by Xue Yang et al shows that value of $a=2$ is adequate in achieving low EWM delivery delay for a wide range of co-existing Avs. Apart from this CCP also consists of *state transition mechanism* to ensure EWM coverage for the endangered regions and to eliminate redundant EWMs.

This protocol is to a large extend successful in achieving its main motive both in 1D and 2D scenarios but the delay is still gradually increasing for transmission of EWMs with the increased number of co-existing vehicles which in turn makes the transmission rate dependent on initial probability of accessing the VANET communication medium.

H. APAL Broadcast Protocol [11]

Adaptive Probability Alert (APAL) protocol is originally derived from VCWC Protocol as the equation which depicts VCWC protocol for the (re)transmission rate [10] is adapted to certain specific observed range of the parameters or variables for achieving better retransmission rate (i.e. minimum delay, redundancy and collision of packets) of alerts or EWMs for inter-vehicle communication.

APAL doesn't need the location information about the every vehicle. According to this approach, the vehicles which receive an alert message adaptively decide whether to rebroadcast it or not which in turn depends on certain conditions like random waiting time (traffic intensity dependent) interval after a node receives a EWM for the first time. Suppose the node doesn't receive any duplicate message until expiration of this waiting time it will broadcast it with initial probability in the range of 0.7—0.9.otherwise the vehicle refrains from rebroadcasting and counts the duplicate messages for updating its next retransmission probability and waiting time. After every successful retransmission, the vehicle reduces (updates) the transmission probability to half without changing waiting time, otherwise the retransmission probability is updated to twice of the previous one (Clipped to 1) and waiting time is reduced to half. In this protocol maximum limit is put on both life time and duplicate number of the message alerts or EWMs.

This protocol still possesses some challenging issues as that of VCWC protocol like redundancy still exist (although less in magnitude than previous ones which results in delay) which is of no use in the limited range of wireless VANET.

I. Data Aggregation [12]

Data aggregation for adaptive delay control proposed by *Bo Yu et al* is a methodology or technique for merging information from various sources into a set of organised and refined information to reduce redundant data and to improve communication efficiency. Data aggregation is based on action reward concept. For reducing redundancy adaptive delay control scheme is used which dynamically changes the forwarding speed of nearby reports so that they have better chance to meet each other and aggregate together [12].This scheme is based on *distributed learning algorithm* (i.e. learning from local neighbours about adapting delay) so as to aggregate the nearby reports from neighbouring vehicles.

However, the noted feature of this scheme it takes much processing time for calculating adaptive delay at each node so as to remove redundancy of message alerts/reports due to complex mechanism of distributive learning algorithm, which hinders it from achieving its main goal of reducing delay.

J. Receiver Consensus (ReC) Protocol [13]

According to this approach, it is the receiving node which will decide for selection of nodes as message forwarder. This scheme proposed by *Junliang Liu et. al*. It consists of two components:

- *Acknowledgement-based Neighbour Elimination* which Guarantees reliability while reducing the number of retransmissions considerably. For each warning message, each node divides its neighbour nodes into three sets (with respect to message according to their reception status: R_m (affirmatively received, nodes that attach ACK in their beacons), P_m (potentially received), and N_m (not received, nodes without ACK in their beacons). Potentially received is a transient status before receiving ACK. Receiver node computes each neighbour's distance to the sender. Neighbours inside the communication range of the sender, i.e. whose distance to sender are less than sender's communication radius, are marked as potentially received and moved into set P_m.
- *Location-based Ranking* – (enables fast propagation at every hop without unnecessary waiting time): The ideal location for the next hop forwarder is *the centroid* O of all nodes in N_m (*the point having average coordinate values of —not received neighbours*).

ReC protocol is totally dependent on GPS for locating centroid of nearby neighbouring nodes, as it is found GPS is 66% accurate in locating nodes in the transmission range of 15m .So, this along with the limited redundancy control are the factors which are hindering it from achieving efficient VANET performance.

IV. COMPARISON OF EXISTING SOLUTIONS

All the existing solutions presented in Section III has one or the other limiting factor for achieving efficient transmission of EWMs.The simple broadcast protocol suffers from broadcast storm problem. All the persistence based techniques are probability based and results in packet loss and collision of packets/EWMs. Data aggregation technique leads to large processing time which in turn results in large delay. ReC protocol is dependent on GPS for centroid prediction which too is inaccurate and it also control the redundancy of EWMs to a little. TLO Algorithm does not guarantee transmission of EWMs results in message/packet loss The VCWC and APAL protocols to a large extend results in efficient transmission of EWMs but depends on initial conditions in the prevailing environment. These two protocols need little modification so as to come up with a scheme which will be better in transmission of EWMs/alerts.

Table I below shows the comparison of performance of various existing solutions along with the mechanism used and their corresponding limitations.

V. CONCLUSION

In this paper, we have analysed various schemes or techniques for efficient transmission of emergency warning messages in VANETs so as to counter affect the challenging problems like collision, delay and redundancy etc. We compared these existing solutions for their performance degradation and also identify drawbacks of each of these solutions. So, we can say that this paper can be used as reference by researchers which are trying to build a technique for efficient transmission of emergency warning messages in VANETs. Currently, we are working on developing an effective V2V Communication protocol having capability of coping up with the communication challenges of collision, delay and redundancy while transmitting emergency warning messages in VANETs.

TABLE I

COMPARISON OF VARIOUS EXISTING PROTOCOLS FOR TRANSMISSION OF EWMS IN VANETS

Existing Protocol or Scheme name	**Mechanism**	**GPS Equipped**	**Broadcast Problem**	**Message Loss**	**Message Redundancy**	**Overall Performance Degradation**
Simple Broadcast	Broadcasting	No	High	Low	High	Very High
p-persistence	Probabilistic broadcasting	No	Medium	High	Medium	High (Magnitude of Co-existing AVs dependent)
Weighted p-Persistence	Weighted Probabilistic broadcasting	Yes	Medium	Low	Medium	High (Magnitude of Co-existing AVs dependent)
Slotted p-Persistence	Probabilistic with division of channel capacity broadcasting	Yes	Medium	High	Medium	High (Magnitude of Co-existing AVs dependent)
TLO	Choosing farthest node from AV as message forwarder	No	Low	High	Low	Medium
VCWC Protocol	Rate Decreasing Algorithm	Yes	Low	Low	Medium	Low
APAL Broadcast Protocol	Rate Decreasing Algorithm with slight modification	May be	Low	Low	Medium	Low
ReC Protocol	Receiver oriented message forwarding (centroid method)	Yes	Low	Low	Medium	Medium (GPS Dependent)
Data Aggregation Protocol	Aggregation of redundant data by applying adaptive delay	Yes	Low	Low	Medium	Medium (High delay due to large processing time)

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