Mitigating Broadcast Storm Problems in Vanets

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***Abstract* - For efficient data dissemination over a network, the most commonly used solution is broadcasting the messages by flooding the data over the network. Issues concerned with flooding are redundant rebroadcasting of messages and collision leading to broadcast storm problem. This paper proposes a strategy to overcome the broadcast storm problem in an Vanets using the bounding algorithm. Our analysis and simulation results illustrate better performance by a hybrid approach presented by combining the advantages of distance-based and counter-based schemes in terms of reachability and saving of rebroadcasting which performs efficiently.**

Keywords - Broadcast Storm Problem; Bounding Algorithm; Received Broadcasts; Reach ability

I. INTRODUCTION

In order to implement safety in Vehicular Ad Hoc Networks (VANET), a procedure termed as Broadcasting is used. An efficient data dissemination method to broadcast the data to the vehicles on the road side environment is required to put into practice for these safety applications which include intersection and cooperative collision warning, cooperative assisting driver system, forthcoming vehicle emergencies etc., Few applications like traffic information transferring data, parking lot payment, and traffic management applications fall into the non safety application category. Furthermore, the comfort applications involve optimum route calculation with real time traffic data and administrative applications e.g. in identifying a vehicle Broadcasting is required.

An efficient and reliable solution for data broadcasting is a crucial goal in modern networks. The basic problem stands in acquiring feedback from the destination nodes to avoid network flooding. Reliable data broadcasting is even harder to obtain when we are dealing with wireless networks. These types of networks are highly unreliable, leading standards like IEEE 802.11 [14] to introduce MAC level acknowledgement when dealing with unicast data packets. Obviously, when dealing with broadcasting (or multicasting) any retransmission scheme would cause even more problems due to the access to the medium. A new variation derived from Mobile Ad hoc Network (MANET) is a Vehicular AD Hoc Network (VANET).This is a technology that provides communication among nearby vehicles, as well as between vehicles and nearby fixed Road Side Units (RSUs) by employing moving vehicles as nodes in a network to create a mobile network . The definition of an ad hoc network is given as a collection of nodes dynamically forming a network without any existing infrastructure.

In order to implement VANETS, a set of vehicles are to be equipped with on board units for wireless communications and a set of stationary units along the road known as road side units (RSUs) and thus creating a wide range wireless network for vehicles and RSUs. The demand for Vehicle-to-Vehicle (V2V) communication and Vehicle-to-Roadside (V2R) communication increases continuously with the increase in mobile wireless devices and wireless networks over the recent years. Unlike MANETs, the mobility of vehicles is constrained by predefined roads in VANETs. Based on these two kinds of communications, VANETs can support many applications in safety, entertainment, and vehicle traffic optimization.[1][2].In vehicular mobile environment most suitable solution is flooding in which every incoming packet is sent through every outgoing link except the one it arrived on leading to problem of redundant packets i.e. broadcast storm problem.

The Intelligent Transportation Systems (ITS) considers Vehicular AdHoc Networks (VANETS) as a crucial infrastructure for communication. For the comfort of automotive drivers and enhancement of driving safety, the US government provides a core function which is the Dedicated Short Range Communication (DSRC) in IEEE 802.11p used in their project for vehicular network communication. Future vehicles are likely to be installed with DSRC-based communication devices and to augment safety on roads will work with sensors. The U.S. Federal Communication Commission (FCC) has allocated 75 MHz of spectrum at 5.9GHz to be used exclusively for vehicle communications. The overall bandwidth is divided into seven frequency channels..

II. BROADCASTING IN VANET

Broadcasting in Vehicular Ad Hoc Networks (VANETs) has turned into a dynamic field of research. VANET applications are naturally broadcast-situated and oblige the fundamental communication protocols to be solid and adaptable. Then again, the ordinary broadcast instrument may prompt broadcast storm issue which will intensely influence both the dependability and adaptability of the protocols. In MANET [5] broadcasting occurs during route discovery or route maintenance, such as AODV route request hello messages but in VANET broadcast routing is commonly used in many safety critical ITS applications. The network disconnection problem for VANET is more severe than MANET due to high mobility caused by fast moving vehicles, sparse traffic densities during off-peak hours, and the limited market penetration rates of vehicles with equipped communication devices, especially in the initial stage. This disconnection time (on the order of a few seconds to several minutes) makes MANET protocols such as AODV unsuitable for VANETs. Hence, new network protocols are necessary to improve broadcasting in dense networks and routing decisions in sparse networks.

In dense networks, a pure flooding scheme results in excessive redundancy, contention, and collision rates causing problems in transmissions, referred to as the broadcast storm problem. Such problem is tackled with broadcast suppression techniques. When the traffic density is above a certain value, one of the most serious problems is the choking of the shared medium by an excessive number of the same safety broadcast message by several consecutive cars. In sparse network vehicles may face network disconnections when the transmission range employed cannot reach other vehicles farther in the direction of interest [9]. In such scenarios, protocols should also incorporate a store-carry-forward mechanism to take advantage of the mobility of vehicles to store and relay messages until a new opportunity for dissemination emerges. In such cases routing and broadcasting becomes challenging task.

In [1] the broadcast storm issue in VANET is examined utilizing a case study for a four-lane highway situation which can give 100% reachability in a well-connected system and up to roughly 70% reduction in the broadcast redundancy and packet loss proportion. The proposed plans are disseminated and depend on GPS data (or Received Signal Strength when the vehicle can't get GPS signal), yet do not require former information about network topology.

A performance evaluation of broadcast routing protocols and RSU deployment inside the vehicular networks is discussed in [2].Expanding the number of vehicles inside the system causes an increment in throughput. Besides, including RSUs, the end-to-end postponement is diminished and in the meantime, the system throughput demonstrates a superior result. When more number of RSUs are introduced, it has a negative effect on power consumption in VANET.

Improved broadcast systems lessen the level of redundancy amid a broadcast, in this way minimizing the broadcast storm issue. A broadcast transmission may be lost because of packet corruption, packet collision, or hidden node transmissions. Subsequently, it is conceivable that even proposed hubs may not get a broadcast transmission. This is particularly valid on account of improved broadcast components, where a bundle may be lost and a broadcast may not proliferate due to reduced redundancy. [4].

III. BROADCASTING METHODS

Broadcasting refers to the operation of disseminating a piece of information from one node to other nodes in the network. The challenging issues in broadcasting are suppression of multiple warnings for the same event and determination of appropriate boundaries for message propagation. In order to increase the reliability of sending packets to vehicles in vehicular networks [8], packet flooding in a broadcast is to be reduced. A few broadcasting methods have been mentioned which include counter-based, location based, distance-based, traffic-based and probabilistic-based flooding schemes.

A. Simple Flooding

Broadcast frames the premise of all interchanges in Vehicular ad hoc systems. The least difficult manifestation of broadcast is alluded to as blind flooding. In blind flooding, a node transmits a packet, which is received by every single neighboring node that are inside its transmission range. After getting a broadcast packet, every node figures whether it has transmitted the packet some time recently. If not, then the packet is retransmitted. This procedure considers a broadcast packet to be scattered all through the ad hoc system. Blind flooding ends when all nodes have received and transmitted the packet being broadcast at any rate once. As all nodes indulge in the broadcast, blind flooding results in suffering Broadcast Storm Problem [4]. Blind flooding is extremely expensive and may lead to redundant rebroadcasts, medium contention and packet collision.

B. Probabilistic-based Flooding

Among the various broadcast techniques to overcome the problem of flooding, probability based approach is becoming attractive. When there are more contenders to broadcast, a predetermined probability is assigned to each node which reduces the chances of collision and re-broadcasting. These algorithms adopt different schemes such as *p-persistence, slotted 1-persistence and weighted p-persistence.* In weighted-p

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persistence, the fundamental idea is the usage of probability, instead of delay timer; upon receiving a message each node will retransmit it with a probability „P". This solves the issues of redundant re-broadcasting, congestion and collision. Probability based approaches are simple to implement and does not create any overhead but has the risk of missing some messages. The performance of the algorithm drastically depends on the selection of value for „P" [15].

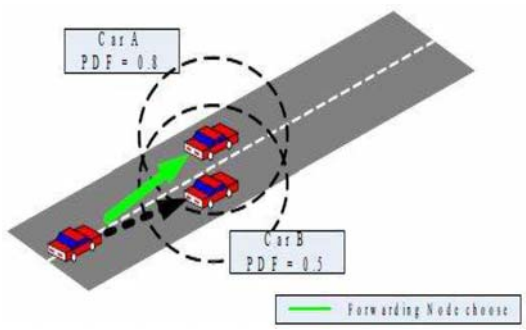

Fig:1 Probabilistic Flooding

In Receipt Estimation Alarm Routing (REAR) [32] protocol, nodes are selected to relay broadcast messages based on their estimated message received value. It is computed based on the received signal strength and packet loss rates. This information is exchanged with the neighbouring nodes using heartbeat messages. Hence, nodes with higher delivery ratios are likely candidates to flood messages in the network. It works on the Manhattan mobility model for urban areas and a highway scenario with bi-directional single lane traffic. Other probability based routing protocols include Position-based Adaptive Broadcast (ABS) [33].

C. Counter based Flooding

In the counter-based scheme, the basic idea is that for a node hearing the same message an increasing number of times from the neighboring nodes decreases the additional coverage benefit from having the node to rebroadcast. Therefore, when a node hears the same message a given amount of times, indicated by threshold C_{TH} , the node is prohibited from rebroadcasting the message. According to [12], a C_{TH} value of 3 or 4 can save a high percentage of retransmission with better reachability than simple flooding.

S1: Initialize counter $c = 1$ when a broadcast message *msg* is heard for the first time.

S2: Wait for a random number (0 ~ 31) of slots. It *msg* is heard again, interrupt the waiting and perform S4. Otherwise, submit *msg* for transmission and wait until the transmission actually starts and proceed to S3.

S3: The message is on the air. The procedure exits.

S4: Increase c by one. If $c < C_{TH}$, go back to S2. Otherwise, if $c = C_{TH}$, proceed to S5.

S5: Cancel the transmission of *msg* if it was submitted in S2. The host is prohibited from rebroadcasting the same message in the future. Then the procedure exits.

The counter-based scheme can be formally represented as follows:

```
procedure cbscheme(msg)
        if (tcount(msg) == 1) then
    procedure cbscheme(msg)
        if (tcount(msg) == 1) then
                wait for a random number (0 ~31) of
                slots send msg
        else
                suspend waiting
                if tcount(msg) < CTH
                   then resume
                   waiting
                else
                   cancel waiting
                   inhibit msg
                rebroadcasting
                endif
        endif
```

D. Area based Flooding

Area based flooding uses the concept of coverage area to adjust the rebroadcast region within the specified geographical area. In this scheme, every vehicle receives multiple packets which may contain overlapping information. Scrutinizing these messages provides additional coverage area. The node that is farther away from the source is preferred for re-broadcast to widen the coverage area.

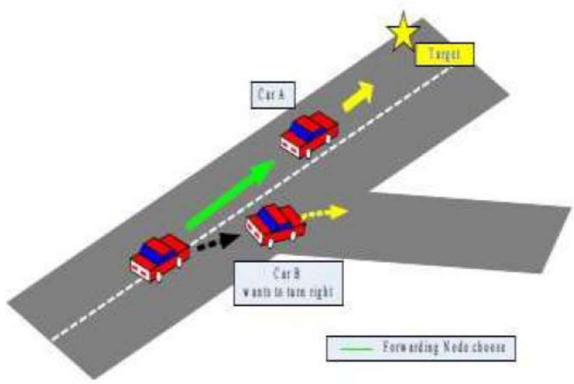

Fig:2 Area Based flooding

It is further divided into two types:

- Location-based flooding
- Distance and Hop based flooding.

D1. Location Based flooding

In location based methods, messages are broadcast based on the geographic area of the vehicles. Each node adds its own location in the header of the message, which is used by the receiving node to calculate the additional coverage area to re-broadcast. The main problem with this approach is the cost of calculating additional coverage areas. Location Based Broadcast (LBB) [20] protocol is designed to meet the communication requirements of highway safety applications. In Location Based Broadcast, sender broadcasts messages to all receivers in its communication range. It is the receiver's responsibility to determine the relevance of message and provide proper response. The decision is made based on the relative position of the sender (in front, behind, left lane etc.), the purpose of the message (brake warning, lane change warning, accident reporting, congestion prediction, etc.) and the highway traffic condition. Urban Multi-Hop Broadcast Protocol (UMB) [21] and Ad hoc Multi -hop Broadcast (AMB) [22] are designed especially for multi- hop broadcast in urban scenarios addressing broadcast storm problem, hidden node problem and reliability issues. Each node during broadcasting, selects the farthest node to forward the message.UMB protocol efficiently broadcasts packets with high delivery ratio using repeaters installed at junctions. Whereas, AMB protocol solves the infrastructure dependence of the UMB Protocol. It is extension of the UMB protocol composed of two parts, namely *directional broadcast* and *intersection broadcast*.

Multi-Hop Vehicular Broadcast (MHVB) [23] is a flooding algorithm, which assumes availability of GPS device for position information. It implements congestion suppression algorithm and adopts backfire algorithm to select the farthest forwarding node to relay the message efficiently. In enhanced MHVB, angle is added as a parameter to the backfire algorithm. V-TRADE/HV- TRADE [24] organizes nodes into groups, where only a small subset of vehicles is selected to re-broadcast the message. These protocols show considerable improvement in performance, but they incur a routing overhead in selecting nodes to do the re-broadcasting. Epidemic routing is introduced as an alternative approach for partially connected ad hoc networks. It exchanges random pair-wise messages among mobile nodes. The epidemic algorithm is flooding based, and it trades system bandwidth and node buffer space for the eventual delivery of a message [25]. It does not rely on end-to-end connectivity. Border node Based Routing (BBR) protocol is designed for partially connected network that has some of the attributes of epidemic protocol, but offers performance comparable to more conventional protocols under fully-connected network conditions. BBR protocol is designed for sending messages either in unicast mode or in broadcast mode[26].

Relative Position Based Message Dissemination (RPB-MD) [27] adopts relative position based addressing model and directional greedy broadcasting routing to forward messages without requiring external location services. RPB-MD achieves high delivery ratio, limited overhead and reasonable delay at different vehicle densities. Beacon-less Routing Algorithm for VANET Environment (BRAVE) [28] is a novel beacon-less protocol, which is designed based on the idea of spatial awareness and beacon-less geographic forwarding. It is selection of next hops, which will lead to successful transmission (ii) forwarding inefficiencies including cycles associated with the beacon messages (iii) failure of message delivery due to disconnected topologies and (iv) data packet reaching local optimum in trajectory based routing schemes. BRAVE performs hop-by-hop data forwarding along a selected street using opportunistic next hop selection method. It uses a reactive scheme for the selection of the next forwarder from those neighbors who have successfully received the message instead of using period beacon messages. In addition, this protocol works in a opportunistic store-carry-and-forward paradigm to cope with uneven network densities and disconnected topologies. BRAVE is fully localized protocol requiring information only from neighbours, which guarantees scalability with respect to the number of vehicles in the network. Da Li *et al* [29] propose a distance based broadcast protocol called Efficient Directional Broadcast (EDB) which is composed of two parts viz. directional broadcast on the road and directional broadcast at the intersection. At the intersection, a directional repeater is installed which is used to forward the message to vehicles on the different road segments incident to the intersection of different directions. It has many advantages including long transmission range, space reuse, low redundancy and collisions.

D2. Distance and Hop based flooding

In distance and hop based methods, messages are broadcast by considering the neighbouring distances and hop count from the transmitting node. The distance between the source and destination is the criteria for deciding whether to re-broadcast to destination or drop the message. Fast Broadcast (FB), a distance based routing protocol, minimizes forwarding hops during transmission of messages. It works in two phases viz. *estimation phase*, in which the transmission range is adjusted using heart beat messages to detect backward nodes and *broadcast phase*, in which the message is transmitted by assigning higher priority to the vehicles that are farther away from the source node. Cut-Through Rebroadcasting (CTR) gives higher priority to re-

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broadcast alarm messages to farther vehicles within the transmission range but operates in a multi-channel environment [16]. Optimized Dissemination of Alarm Message (ODAM) has a defer time to broadcast messages, which is computed based on the distance between source node and receiver node. Broadcast of messages can only occur within risk zone area, determined with a dynamic multicast group based on vehicles proximity to the accident site [17].

Distributed Fair Transmit Power Assignment for Vehicular Ad Hoc Network (D-FPAV) describes a scheme that provides fairness in broadcasting heartbeat messages by dynamically adjusting transmission power of each node based on distance to other neighbouring nodes [18]. Although power control is a well explored research topic for wireless networks, D-FPAV investigates the problem in the context of broadcasting in vehicular networks using realistic vehicle movement traces. *Rex Chen et al* [19] also propose a mechanism to dynamically control the communication range by adjusting the transmission power to mitigate the effects of broadcast storm. They discuss multi-hop broadcasting especially in a *shockwave scenario* which separates the traffic into two streams with different densities and speed. When the first vehicle of the *following stream* meets the last vehicle of the *leading stream,* it senses the danger and immediately sends a broadcast message to all nearby vehicles to caution to reduce the speed.

The distance-based scheme allows the receiving nodes located at a distance greater than a given threshold (D_{TH}) to rebroadcast the message and prevents the others from rebroadcasting. An estimation of the distance can be easily extracted from the signal strength by using a simplified formula for the free space propagation model [13]. Let P_t and P_r be the power level for transmitting and receiving a message, respectively.

$$P_r = (P_t * \lambda^2) / ((4\pi)^2 * d^2) \qquad (1)$$

where λ and d represent the carrier‟s wavelength and the distance between two nodes, respectively. Therefore, the distance-based scheme has no need to provide the nodes with GPS devices unlike the location-based scheme.

S1: When a broadcast message *msg* is heard, set d_{min} to the distance to the broadcasting host. If $d_{min} < D_{TH}$, proceed to S4.

S2: Wait for a random number (0~ 31) of slots. If *msg* is heard again, interrupt the waiting and return to S1. Otherwise, submit *msg* for transmission and wait until the transmission actually starts and proceed to S3.

S3: The message is on the air. The procedure exits. S4: Cancel the transmission of *msg* if it was submitted in S2. The host is prohibited from rebroadcasting the same message in the future. Then the procedure exits.

The procedure *db scheme* is called every time a broadcast message *msg* is received. We suppose to have available a labeling function *tcount(m)* that, given packet *m* returns an integer value which indicates the number of times that it has been received during the previous t_m ms.

```
procedure dbscheme(msg)
 if (tcount(msg) == 1) then
dmin = ds
  if (dmin >= Dth) then
   wait for a random number (0 ~31) of
    slots send msg
  else
    inhibit msg rebroadcasting
  endif
  else
   if waiting to send then
      suspend waiting
        if(dmin>ds) then
          dmin=ds
   endif
   if(dmin < DTH ) then
    cancel waiting
    inhibit msg rebroadcasting
   else
     resume
     waiting endif
    endif
endif
```

where d_S is the distance from the sending node.

E. Neighbor-Knowledge-based Flooding

In this method, most protocols require nodes to share 1-hop or 2-hop neighborhood information with other nodes [8]. This is particularly not suitable in vehicular environments, since such information can quickly become outdated due to the high speed of vehicles. In addition, adding neighborhood information to periodic messages results in high network overhead.

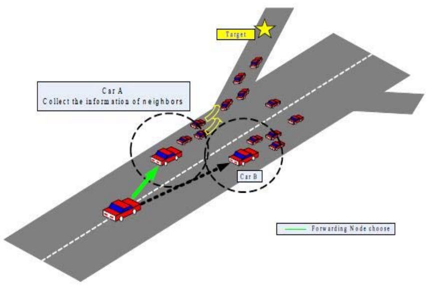

Fig: 3 Neighbour Knowledge Based flooding

It is further divided into the following:

- Cluster based
- Traffic based flooding

E1. Cluster based Flooding

We consider the cluster based protocols, which broadcast messages to a group of vehicles, for example, to a fleet of vehicles with common paths.

The Mobility-centric Data Dissemination algorithm for Vehicular networks (MDDV)[30] combines the idea of opportunistic forwarding, trajectory based forwarding and geographical forwarding. Edge-Aware Epidemic Protocol (EAEP) [31] is a reliable, highly dynamic protocol, which aims to improve bandwidth efficiency. It reduces control packet overhead by eliminating exchange of additional hello packets for message transfer between different clusters and simplifies cluster maintenance. Each vehicle piggybacks its own geographical position to the broadcast messages, which eliminates beacon messages. Upon receiving a new re-broadcast message, EAEP uses transmission count from front nodes and back nodes in a given period of time to calculate the probability for making decision whether nodes will re-broadcast the message or not.

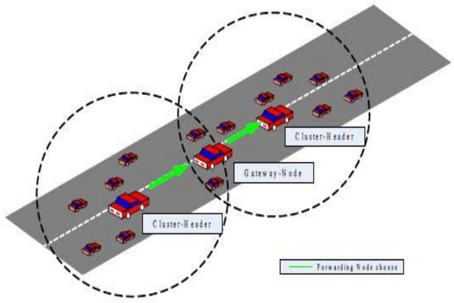

Fig: 4 Cluster based flooding

E2. Traffic based flooding

In traffic based broadcast routing algorithm, a source node broadcasts a packet to all its neighbours and each of those neighbours, in turn, re-broadcast the packet exactly one time. This process continues until all the reachable network nodes have received the packet. The Distributed Vehicular broadcast protocol (DV-CAST) [15] uses local one- hop neighbor topology to make routing decisions. The protocol adjusts the back-off timer based on the local traffic density, and computes connectivity in forward and opposite direction with periodic heartbeat messages. This protocol divides the driving environment into three types of regions depending on the local connectivity as *well-connected, sparsely connected and totally disconnected* neighborhood. In well-connected network, it applies any one of the broadcast suppression schemes using probability: *weighted p - persistence or slotted 1-persistence or p-persistence*[15].

In sparsely connected neighborhood after receiving the broadcast message, vehicles immediately rebroadcast it to vehicles moving in the same direction. In totally disconnected neighborhood vehicles are used to store the message until another vehicle enters into transmission range, otherwise if the time expires it will discard the packet. DV-CAST addresses how to deal with extreme situations such as dense traffic conditions during rush hours and sparse traffic during certain hours of the day. However, this protocol is attributed with high overhead and end-to-end delay during data transfer.

IV. EXISTING ALGORITHMS FOR OVERCOMING BROADCAST STORM IN VANET

While multiple solutions exist to alleviate the broadcast storm problem in a usual MANET environment [6], only few solutions exists to address the problem in VANET. In [11], three variables are utilized to mitigate the broadcast storm problem in VANET.

- Maximum Transmission Power Pt: Each vehicle can use this parameter to reduce the impact of the hidden terminal problem and achieve certain coverage percentage.
- Received Signal Strength (RSS): This can be used instead of the inter distance between the transmitter and the receiver in calculating the probability of retransmission.
- Vehicles Density λs: This is agreed upon from exchanged beacons.

Currently four popular algorithms for broadcast storm suppression have been proposed by different authors.

They are:

1. The Last One (TLO
2. Adaptive Probability Alert Protocol (APAL)
3. Distributed Optimized Time (DOT)
4. Adaptive Broadcast Protocol (ABSM)

A. The Last One (TLO):

Kanitsom Suriyapaibonwattanaet al. in [3] p roposes The Last One (TLO) broadcast method to reduce end-to-end delay and broadcast storm problem. They try to reduce broadcast storm problem by using probability to decide the vehicle that will rebroadcast alert message. When a vehicle receives a broadcast message for the first time, the vehicle will rebroadcast the alert message with a random probability. This method will help to reduce number of rebroadcasting vehicles and thereby the broadcast storm problem. This method could not fully ensure to avoid broadcast storm. It just reduces the chances of its occurrence. But this algorithm suffers when GPS provide incorrect information between 1-20 meters.

B. Adaptive Probability Alert Protocol (APAL)

In [10] KanitsomSuriyapaibonwattana et al. proposed Adaptive Probability Alert Protocol (APAL)

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rebroadcast protocol that use adaptive probability and interval to actuate rebroadcast. It could achieve best quality of erformance compared to all other existing VANET protocols for safety alert message dissemination. The success rate of APAL protocol is high compared to different protocols. Loss of alert message problem cause low success rate. APAL changes interval and transmission probability adaptively to prevent alert message loss and could achieve highest success rate. Moreover it shows robustness of success in spite of increase in number of vehicles, and it remains near to 100%. For all other protocols, the success rate decreases rapidly with the increase in number of vehicles.

C. Distributed Optimized Time (DOT)

In [9] Ramon S. Schwartzthe et al. proposed Distributed Optimized Time (DOT) slot as a suppression scheme for dense networks. It solves scalability issues at each time slot by the presence of beacons, which are messages periodically sent by each vehicle containing information such as the vehicle"s position and speed. The use of periodic beacons or hello messages has been sometimes avoided due to an increased network load.

The common approach to reduce broadcast redundancy and end-to-end delay in VANETs is to give highest priority to the most distant vehicles towards the message direction.

D. Adaptive Broadcast Protocol (ABSM)

In [7] Francisco et al. proposed an adaptive broadcast protocol called ABSM which is suitable for a wide range of mobility conditions. The main problem that a broadcast protocol must face is its adaptability to the very different vehicular arrangements in real scenarios. It should achieve high coverage of the network at the expense of as few retransmissions as possible, regardless on whether the network is extremely dense (e.g., big cities at rush hours) or highly disconnected (e.g., highways at night).

ABSM has turned out to be a very robust and reliable protocol. It extremely reduces the number of transmissions needed to complete a broadcasting task.

V. PROPOSED ALGORITHM

A. Bounding Algorithm

Reliable broadcasting in Vehicular Ad-hoc Networks is one of the keys to success for services and applications on smart transportation system. Broadcasting in VANET is very different from routing in Mobile Ad hoc Network (MANET) due to several reasons such as network topology, mobility patterns, and traffic patterns at different time of the day, etc.

However, the simple broadcasting without a rebroadcasting bounding mechanism at each node may result in an excess of redundancy, channel contention, and collisions. This phenomenon is called the *Broadcast Storm Problem* [12]. Redundancy indicates a situation where a node hears the same messages from more than one neighbors. Channel contention is due to the different nodes which are simultaneously trying to rebroadcast the received messages thus contending for the shared media, increasing the probability of collisions. To address redundancy, the decision whether or not rebroadcast must be controlled at each node receiving the message. For contention and collision, all nodes trying to rebroadcast rely on backoff mechanism with randomly selected slots. Multi-hop relaying is used in a wireless ad hoc network to disseminate information to an area greater than that covered by the transmission range of a node. One of the simplest ways to perform multi-hop relaying is by flooding a packet. In this situation, when a node receives a broadcast message for the first time, the node then re-transmits the message. The node then ignores all subsequent broadcast messages it receives from other nodes, which are also rebroadcasting the message. There are three problems associated with flooding. First, there are a number of redundant rebroadcasts because of flooding. An instance of how serious this problem is when a message is to reach *n* hosts, the packet will be sent *n* times. Second contention occurs, there is a high probability that a message will be received by many hosts in a close proximity and when these hosts try to rebroadcast the message. Each host will severely contend with each other for access to the medium. Third, a large number of collisions can occur because of the lack of RTS/CTS and because of the absence of collision detection.

The counter-based and distance-based schemes can be candidate solutions to efficiently address the well-known broadcast storm problem. Moreover, location-based approach, despite being a better option, is only meaningful when all nodes have GPS devices. In this paper, we propose a re-broadcasting bounding algorithm which is based on both schemes to obtain an increase in reachability while highly reducing the amount of packets re-broadcasted.

According to the distance-based scheme, when a broadcast packet is sent, the receiving nodes re-send it only if the node is located farther than D_{TH}. In this latter situation, a small counter threshold avoids the nodes passing the distance threshold test from rebroadcasting the message though the decreasing reachability. Therefore, a larger counter threshold is used when applying the counter-based scheme to the nodes located above the distance threshold. The bounding algorithm is the following:

S1: Set *dmin* to the distance to the broadcasting host. If this is the first time message *msg* is received initialize counter $c = 1$, otherwise increment c by one.

S2: if $d_{min} < D_{TH}$, proceed to S5. If $c < C_{TH}$, proceed to S3. If $c = C_{TH}$, proceed to S5.

S3: Wait for a random number (0 ~ 31) of slots. If *msg* is heard again, interrupt the waiting and return to S2.Otherwise, submit *msg* for transmission, wait until the transmission actually starts and proceed to S4.

S4: The message is on the air. The procedure exits.

S5: Cancel the transmission of *msg* if it was submitted in S3. The host is prohibited from rebroadcasting the same message in the future. Then the procedure exits.

Suppose two nodes A and B receiving a message broadcast by a sending node S. They are located farther than D_{TH} from node S. If the expiration of node A waiting timer allows it to rebroadcast the message before node B timer expires, and they are respectively located within D_{TH}, node B is also prohibited from rebroadcasting without being affected by the counter threshold. As shown in Figure 5, node S initially broadcasts a message to the nodes within its transmission range. Then, they decide whether or not to rebroadcast the message according to the distance between themselves and node S. While the nodes within D_{TH} from node S are prohibited from rebroadcasting, the others (the nodes in the shaded area as shown in Figure 5) determine their random waiting timers.

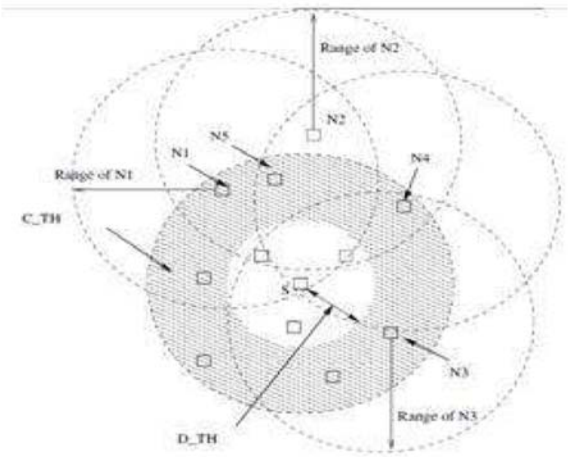

Fig.5 Proposed Algorithm

Suppose that the waiting timer of node N1 expires first. Then, node N5 is also refrained from rebroadcasting because it is located within D_{TH} with respect to node N1. However, node N2 can be given a chance to rebroadcast the message because it is located above the distance threshold from node N1. If the waiting timers of nodes N2 and N3 expire earlier but not simultaneously than that of node N4, in addition to the message sent by node S, when node N4 hears the same message from nodes N2 and N3 before its waiting timer expires, it determines whether or not to rebroadcast according to its counter value. For example, if C_{TH} is set to 3, the node N4 cannot rebroadcast the message. Otherwise, if C_{TH} is greater than 3, the node is allowed to rebroadcast the message.

Or, formally: The bounding algorithm is given as:

```
procedure bounding(msg)
d_min = d_s
if (tcount(msg) == 1) then
   if (dmin < DTH) then
     inhibit msg rebroadcasting
   else
     wait for a random number (0 ~31) of slots
send msg
   endif
else
   if (tcount(msg) < CTH) and (dmin < DTH)
   then wait for a random number (0 ~ 31) of slots
    send msg
   else
    cancel waiting
    inhibit msg rebroadcasting
   endif
endif
```

VI. RESULT AND ANALYSIS

Over the same given distance of about 1000 meters, the distance that is being covered by the 3 different schemes i.e. Counter-based flooding, Distance-based flooding and Bounding-based flooding. The below given graph (Fig.6.1.) shows the total distance that is being covered by the 10 nodes.

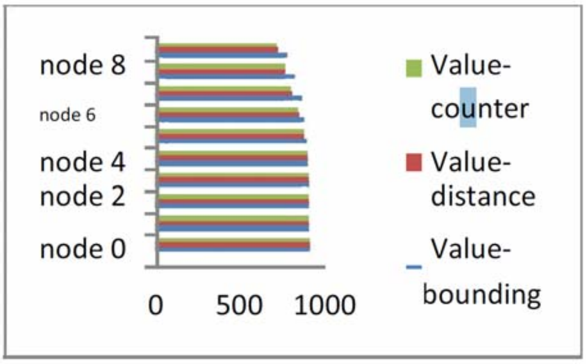

Fig. 6.1. Comparison of the three approaches in terms of distance covered

The main aim of bounding-based flooding is to increase the reachability of a single node. A close analysis of the graph shows that the single node that broadcasts the initial packet to all the other nodes when they are within its distance range thereby eliminating the rebroadcasting of the same packet by various other nodes present in its range. The task of preventing the same packet to be broadcasted by the other nodes is handled by the counte0r-scheme in the algorithm that is proposed. This graph (Fig 6.2.) justifies the elimination of the broadcast storm problem in VANETS.

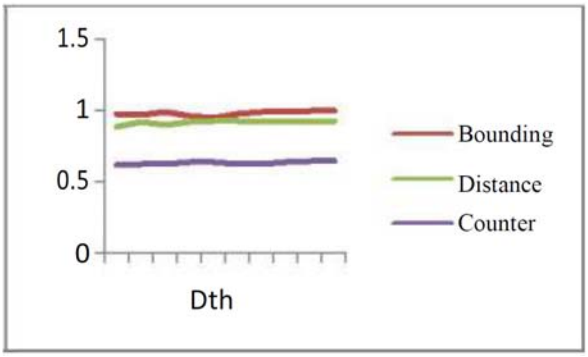

Fig. 6.2. Comparison of the proposed protocol with the Counter-Based approach and Distance-based approach in terms of reachability

The second priority that is given is to reduce the number of the packets that are being sent over a network. The bounding algorithm makes sure it uses the counter scheme which helps in decrease in the number. It clearly has an upper hand over the distance-based scheme as well as the counter-based scheme. This graph justifies the reduction in channel contention by keeping the broadcast packets to as minimal as possible.(Fig.6.3.)

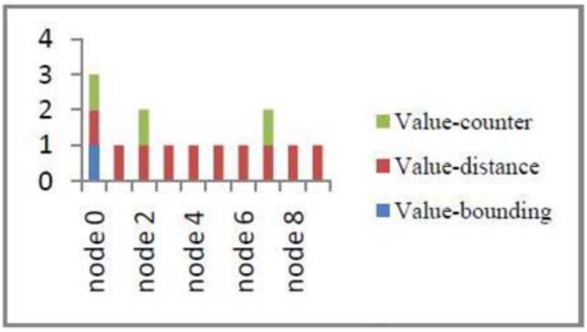

Fig. 6.3. Comparison of the proposed protocol with the Counter-Based approach and Distance-based approach in terms of number of packets sent

On the other hand, the number of broadcasts that are being received have also been reduced as only the node that initializes the data dissemination sends the packet to all the other nodes present. This shows an improvement over both the schemes.(Fig .6.4.)

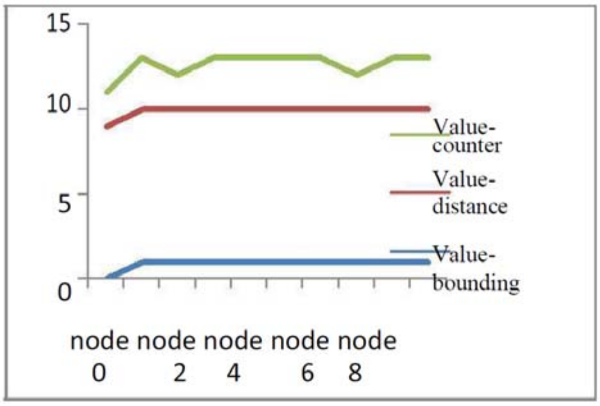

Fig. 6.4. Comparison of the proposed protocol with the Counter-Based approach and Distance-based approach in terms of number of received broadcasts

VII. CONCLUSION AND FUTURE WORK

The simple packet flooding without a careful decision of a controlled rebroadcasting may produce an excessive redundancy of incoming packets, a greater channel contention, and a higher collision rate. This paper presented a bounding algorithm to limit the influence of the problem of broadcast storm in vehicular ad hoc networks.

Many protocols used in VANETs rely on the broadcasting capability, especially when performing a route discovery process. To alleviate the broadcast storm problem various solution are already available. The most promising are the: counter-based, distance-based, and location-based schemes.

Our work is a hybrid approach combining the advantages of distance-based and counter-based schemes in terms of reachability and saving of rebroadcasting without the overhead of equipping all nodes with GPS devices as required by the location-based scheme. We use the counter-based constraint on the nodes located above the threshold to avoid excessive rebroadcasting. Through simulations we showed that our approach can be a candidate solution to satisfy two goals, namely high reachability and low redundancy.

We are more thoroughly evaluating our proposal trying to devise its behavior under many different topologies and mobility patterns. We are also evaluating the implementation and execution cost of the bounding algorithm on standard VANET routing protocols.

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