A Review on Broadcast Storm Mitigation Techniques in Vehicular Ad hoc Networks

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ABSTRACT

In traffic safety applications for VANETs, some warning messages have to be disseminated in order to increase the number of vehicles receiving the traffic warning information. In those cases, redundancy, contention and packet collisions due to simultaneous forwarding (usually known as "Broadcast storm problem") are prone to occur. So to avoid this, the data should be disseminated efficiently without any loss. This paper focuses on survey of various broadcast storm mitigation techniques developed for efficient data dissemination.

Keywords: Dissemination, VANET, Routing, broadcast storm.

1 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). 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. A portion of the attributes of VANETs which separates it from mobile ad hoc network are frequent changing topology and high mobility, no power constraint, geographical positioning availability, hard delay constraints and modeling mobility and corresponding prediction. Fig.1 underneath clarify the structure of VANET.

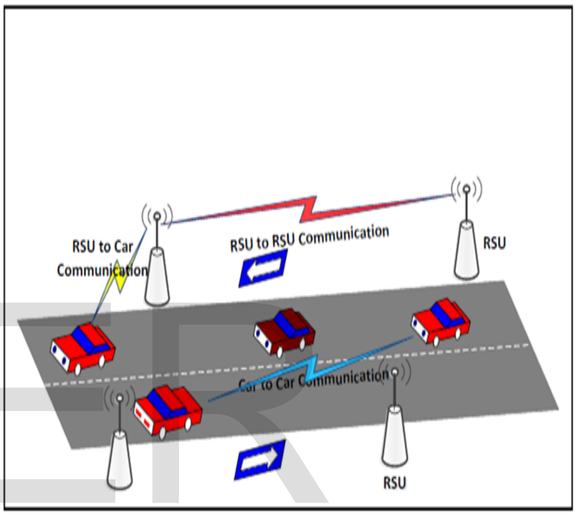

Fig. 1. - Vehicular Ad hoc Network (VANET)

VANETs give us the important idea to enhancing proficiency and security of future transportation. For building VANETs, the fundamental framework necessities are hardware of radios working in unlicensed band and sensors in the vehicles for V2V correspondence, sending of information stations for V2I correspondence gives an approach to web access. Information stations can't be utilized for idleness basic applications e.g. security applications. Correspondence Standards like 2G, 2.5G, 3G, 4G and Wi-Fi is additionally one of the requirements but there is a tradeoff between the 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. Currently, 4G ensures to supports high data rate and high mobility but it is quite expensive. The fundamental test in choosing correspondence standard for VANETs is to pick such a standard, to the point that could bolster both high mobility and high information rate with low cost. VANETs system architecture from the network architecture view 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).

2 RELATED WORK

In VANETs, intermediate vehicles act as message relays for dissemination of messages. For safety and security applications, the flooding of broadcast messages has to be done. If the flooding is not done effectively, broadcast storm problem occurs. The effects of broadcast storm are:

1. Many redundant rebroadcasts
2. Heavy channel contention
3. Long-lasting message collisions

3 THE BROADCAST STORM IN MANETS AND VANETS

Broadcast storm leads to broadcast redundancy, severe contention, packet collisions, inefficient use of bandwidth and processing power and service disruption due to high contention in the channel. Nodes in MANETs discover the routes explicitly by flooding RREQ (Route Request) packet all over the network. The nodes which receive the RREQ packet for the first time, either rebroadcasts the packet, (or) replies to the source, if it has the route to the destination (or) is the destination of the RREQ packet. If the flooding is not done effectively, then the broadcast storm will arise. The technique Expanding Ring Search is used to control the broadcast region to within a few hops away from the source. In this technique, to speed up the discovery process, the nodes cache the routing entry for longer periods and also reply on behalf of the destination node (Gratuitous Route Reply). In Dynamic Source Routing (DSR), the node may be in promiscuous mode so that it can construct a routing table by eavesdropping on other nodes' conversations. All these techniques reduce broadcast redundancy, but may reduce network connectivity and prolong the route discovery process. The drawback of broadcast storm in MANETs is the contention delay which may prolong route acquisition, disrupt ongoing transmissions which are undesirable consequences.

In VANETs, the broadcasting of messages within a certain area used for safety and security related applications as shown in Fig.2. The traffic message should exist in the network for longer period of time. So, the Road Side Unit (RSU) that broadcasts the messages should periodically rebroadcasts that traffic messages to the vehicles to keep alive for longer periods. As the traffic density and frequency at which RSU broadcasts the messages are high, broadcast storm occurs in VANETs. This would in turn lead to wastage of bandwidth, processing time and increased medium access delay. The more serious problem is disruption i.e., other urgent safety messages might get lost (or) delayed during the broadcast storm.

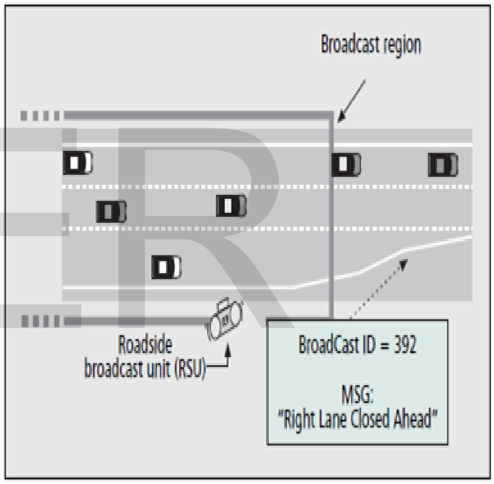

Fig. 2. Traffic Alert System

Several approaches have been developed to address the broadcast storm problem. They are:

4. **The counter-based scheme:** In this scheme each and every node has counter 'c' to keep track of the number of times the broadcast message received. This counter 'c' is compared to a threshold value 'C'. Whenever $c \geq C$, rebroadcasts are inhibited.
5. **The distance-based scheme:** This scheme uses the relative distance 'd' between vehicles to decide whether to rebroadcast the message or not. When the distance 'd' between two vehicles is short, the Additional Coverage (AC) of the new rebroadcast is lower. So, rebroadcasting the warning message is not recommended. But when the 'd' is larger, AC will also be larger and hence rebroadcast takes place.

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6. **The location-based scheme:** It is similar to the distance-based scheme, though requiring more precise locations for the broadcasting vehicles to achieve an accurate geometrical estimation (with convex polygons) of the AC of a warning message. Since vehicles usually have GPS systems on-board, it is possible to estimate the additional coverage more precisely. The main drawback is that high computational cost of calculating the AC, which is related to calculating many intersection areas among several circles.

There are two different scenarios in VANETs they are:

- **Highway Scenarios:** These are one dimensional i.e., traffic messages will be disseminated only in one direction and it is obstacle free environment.
- **Urban Scenarios:** These are multi-dimensional and so the traffic messages will be disseminated in all directions. It has plenty of obstacles. So, there is a chance of signal degradation and would create blind areas where the vehicles will not receive the warning messages unless the intermediate vehicles over pass the obstacle.

4 BROADCAST STORM MITIGATION TECHNIQUES IN HIGHWAY SCENARIOS

4.1 The Simple Broadcast Protocol:

This is the simplest protocol used in safety alert applications for VANETs. Where there is an accident, the warning message will be disseminated to all vehicles approaching towards accident site. When the vehicle receives the broadcast message for the first time, it rebroadcasts the message. Otherwise, the vehicle stop receiving the broadcast message with the same ID from the vehicles. There are two main problems in this scheme. First, there are a lot of redundant rebroadcast messages because of flooding. Thus, when ***n*** hosts for the first time, ***n*** replications will there is a high probability that a message w many hosts located in a close proximity. severely contend with one another for access as show in fig-3, when accident is occur B, C, D, E and F, which are in transmission receive alert message and rebroadcast it. It will then give raise to broadcast storm, and collision will occur to retransmission and further collision.

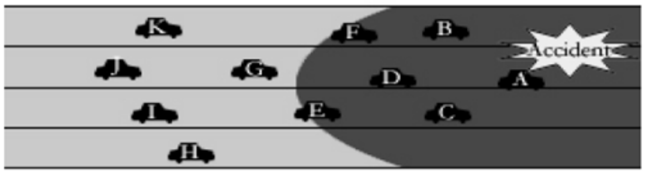

Fig. 3. Situation of an accident and nearby vehicles on the road

4.2 P-Persistence:

This method reduces the broadcast storm problem by using stochastic selection method to decide the vehicle/s that will rebroadcast the warning message [1]. When a vehicle receives the broadcast message for the first time, the vehicle will rebroadcast the warning message with random probability p. So, this method reduces number of rebroadcasting vehicles and there by broadcast storm problem. However, when all nodes that receive broadcast message decide not to rebroadcast then failures to extend the warning message will occur, which will cause the loss of alert message. For example, if all vehicles B, C, D, E and F decide not to rebroadcast the message, no car behind them will receive the warning message. This approach sometimes referred to as Gossip-based flooding.

4.3 Distance based Schemes:

Weighted p-Persistence Broadcasting:.

Rule — After getting a packet from node i, node j checks the packet ID and rebroadcasts with probability pij on the off chance that it gets the packet surprisingly; else, it tosses the packet. The relative separation between nodes i and j is Dij and the normal transmission range by R, the sending probability, pij, can be ascertained on a for every packet premise utilizing the accompanying basic expression:

$$p_{ij} = D_{ij} / R \qquad (1)$$

Note that if node j gets copy packets from different sources inside of the holding up time of WAIT_TIME (e.g., 2 ms) before retransmission, it chooses the littlest pij esteem as its reforwarding probability; that is, every node ought to utilize the relative separation to the closest telecaster so as to guarantee that nodes who are more distant away transmit with higher probability [1]. In the event that node j chooses not to rebroadcast, it

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ought to cradle the message for an extra WAIT TIME+ δms, where δ is the one-bounce transmission and engendering delay, which is commonly not exactly WAIT_TIME. Keeping in mind the end goal to avert message vanish and ensure 100 percent reachability, node j ought to rebroadcast the message with probability 1 after WAIT_TIME + δms on the off chance that it doesn't hear the retransmission from its neighbors. Not at all like the p-tirelessness or tattle based plan, weighted p-industriousness allots higher probability to nodes that are found more remote far from the telecaster given that GPS data is accessible and available from the packet header. This is delineated in Fig-

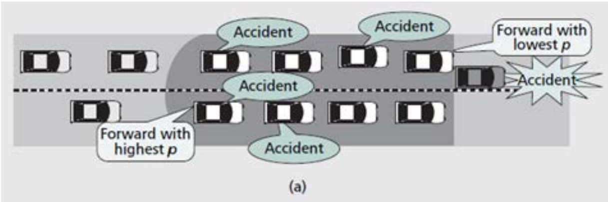

Fig. 4a: Weighted p-Persistence.

Slotted 1-Persistence broadcasting.

Rule — After getting a packet, a node checks the packet ID and rebroadcasts with probability 1 at the doled out time space TSij on the off chance that it gets the packet surprisingly and has not got any copies before its relegated time opening; else, it disposes of the packet.

Given the relative separation between nodes i and j, Dij, the normal transmission range, R, and the foreordained number of spaces Ns, TSij can be computed as:

$$TSij = Sij \times \tau \quad (2)$$

where τ is the estimated one-hop delay, which includes the medium access delay and propagation delay, and Sij is the assigned slot number, which can be expressed as

$$S_{ij} = N_s\,(1- [\min(D_{ij}, R) / R\,]) \quad (3)$$

The time slot approach takes after the same rationale as the weighted p-tirelessness plan, yet as opposed to figuring the reforwarding probability, every node utilizes the GPS data to compute the holding up time to retransmit [1]. For instance, in Fig-4b, the show scope is spatially isolated into four districts, and a shorter holding up time will be appointed to the nodes situated in the most distant locale. Subsequently, when a node gets copy packets from more than one sender, it tackles the littlest Dij esteem. Like the p-perseverance plot, this methodology requires transmission range data with a specific end goal to concede to a specific estimation of slot size or number of slots. Note that Ns is a configuration parameter that ought to be deliberately picked. Despite the fact that Ns ought to hypothetically be an element of the activity thickness (i.e., the denser the movement, the littler the slot size and the bigger the quantity of slots), it is hard for every vehicle to anticipate what the movement thickness is and to land at a solitary estimation of Ns by and by. Thus, network planners can, best case scenario, alter this quality or adaptively change this worth after some time; for instance, the convention ought to utilize five slots amid morning and evening surge hours, and three slots amid non-surge hours

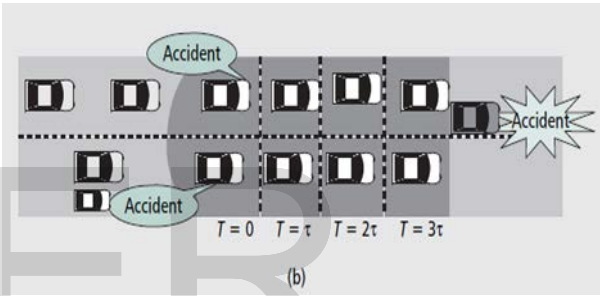

Fig 4b: Slotted 1-Persistence

Slotted p-Persistence broadcasting.

Rule — After accepting a packet, a node checks the packet ID and rebroadcasts with the pre-decided probability p at the alloted time slot TSij, as communicated by Eq. 2, in the event that it gets the packet surprisingly and has not got any copies before its doled out time slot; else, it discards the packet..

Every node in this plan ought to additionally buffer the message for a specific timeframe (e.g., [Ns – 1] × WAIT_TIME + δms) and retransmits with probability 1 if no one in the area rebroadcasts keeping in mind the end goal to keep the message's ceasing to exist [1]. Fig-4c shows the idea of slotted p-determination with four slots. Like the p-industriousness case, the execution of this plan likewise relies on upon the worth decided for the re-sending probabili.

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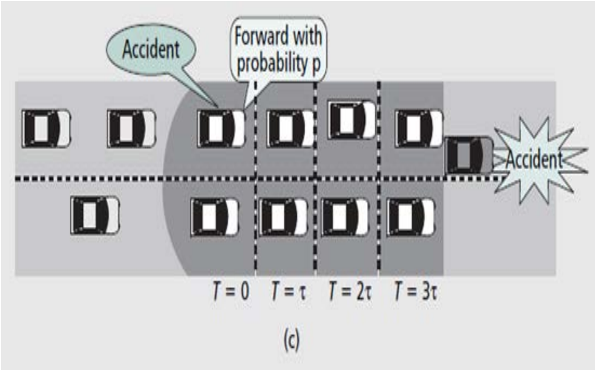

Fig 4c: Slotted p-Persistence

4.4 Received-Signal-Strength-Based Schemes:

Since vehicles will most likely be unable to get GPS signals in a few zones (e.g., burrows, shadowed ranges, urban territories with some tall structures), the proposed show systems can likewise be altered to utilize the packet got signal quality (RSS) information rather than GPS information [1]. We take note of that quick estimation of RSS can just give harsh estimation of the relating separation between the transmitter/beneficiary pair on account of multipath blurring. So as to dispose of the little scale blurring impact and get a closer gauge of the relative separation to the transmitter, every vehicle ought to intermittently test its neighbors so as to monitor the time found the middle value of RSS, which can better speak to the genuine separation of a vehicle from the transmitter. Be that as it may, doing as such might increment activity load in the framework, which may not be attractive. Consequently, without GPS signal and intermittent neighbor examining, every node can, best case scenario, get the RSS of the show packet got from the DSRC gadget driver and figure out if or not to rebroadcast the packet in light of the momentary RSS measured and former information of transmit force and collector affectability. In the accompanying we layout the alterations expected to change the proposed telecast plans depicted before to utilize RSS information.

In the weighted p-persistence scheme each node can compare the RSS of the received packet to the range of RSS, which is given by

$$RSS_{range} = RSS_{max} - RSS_{min} \quad (4)$$

Where the RSSmax and RSSmin relate to the greatest and least conceivable estimations of RSS measured in the considered environment; these qualities can be either gotten tentatively or computed by applying a proper engendering model (e.g., the Friis or two-ray model).

Given that RSSrange is the same for all vehicles, eq-3 can be reformulated as

$$P_{ij} = (RSS_{ij} - RSS_{min}) / RSS_{range} \quad (5)$$

Where RSSij is the RSS of the broadcast packet received at node j.

Similarly, the slotted schemes could be modified to use RSS information instead of relative distance to determine waiting time. Given the number of slots, Eq. 3 can be modified as follows:

$$S_{ij} = N_s - [\ \{\min(RSS_{range}, (RSS_{ij} - RSS_{min}))\times N_s\} / RSS_{range}] \quad (6)$$

The proposed plans are tried against single-path and multilane topologies rather than nonspecific two-dimensional square or torus topologies. The outcomes demonstrate that the proposed slotted 1 tirelessness and slotted p-determination plans can diminish telecast excess and packet misfortune proportion by up to 70 percent while as yet offering satisfactory end-to-end delay for most multi-hop VANET applications (e.g., using a roadside unit to inform drivers about detours, construction).

4.5 The Last One (TLO) Broadcast Method:

It adequately lessens the telecast storm issue. The algorithm is basic and better when contrasted with the above plans. TLO tries to discover the vehicles that are most suitable to rebroadcast ready message.

The supposition considered in this plan is that, every vehicle is furnished with GPS. Along these lines, that each moving vehicle knows the land area of itself and area of vehicles inside of the correspondence range. This information is upgraded at close interims. At whatever point the mischance happens, the deceived vehicle telecast the notice message to all the adjacent vehicles to guarantee wellbeing. The vehicles that gets the ready message won't rebroadcast quickly. The last vehicle of the transmission scope of misled vehicle (source vehicle) will rebroadcast the message while alternate vehicles will sit tight for a limit time interim to take a choice about rebroadcast.

At the point when the limit interim time lapses, if alternate vehicles don't get the same cautioning message from another vehicle behind it i.e., from

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the assigned TLO, the vehicles will choose that there is no transfer vehicle behind them or there is an issue. TLO is run again to locate the following last vehicle. The following assigned TLO node show the ready messages. This procedure is rehashed until a fruitful rebroadcast is finished. In fig-5, progressive TLO are set apart with tick.

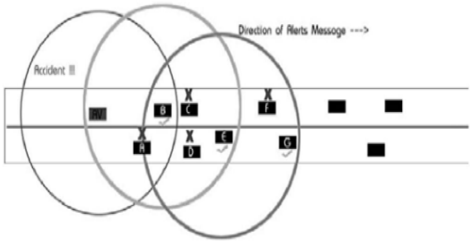

Fig. 5. TLO Broadcast Schemes

This scheme is only effective in a highway scenario because it does not take into account the effect of obstacles (e.g., buildings) in urban radio signal propagation. Moreover, the scheme does not clearly state how a vehicle knows the position of nearby vehicles within its communication range at any given time.

4.6 Adaptive Probability Alert Protocol (APAL):

The TLO scheme was extended by the protocol named Adaptive Probability Alert Protocol (APAL), which uses adaptive wait-windows and adaptive probability to transmit [2]. This scheme shows better performance than the TLO scheme, but it is also only validated in highway scenarios.

4.7 Stochastic Broadcast Scheme:

A stochastic broadcast scheme is proposed to achieve an anonymous and scalable protocol where relay vehicles rebroadcast messages according to a retransmission probability [3]. The performance of the system depends on the vehicle density, and the probabilities must be adapted to different scenarios. However, this scheme is applicable in an obstacle-free environment, thus not considering urban scenarios where the presence of buildings could interfere with the radio signal.

4.8 Cross Layer Broadcast Protocol (CLBP):

The Cross Layer Broadcast Protocol (CLBP) [4] uses a metric based on channel condition, geographical locations and velocities of vehicles to select an appropriate relaying vehicle. This scheme enables reliable warning message transmissions by exchanging Broadcast Request To Send (BRTS) and Broadcast Clear To Send (BCTS) frames. This approach reduces the transmission delay but it is only conceived for one dimensional environments (like highway scenarios), and its performance in urban environments has not been tested.

4.9 A Distributed Vehicular Broadcast Protocol for VANETs (DV-CAST):

The topology of VANETs in urban, suburban, and rural areas can exhibit fully connected, fully disconnected, or sparsely connected behavior, depending on the time of day or the market penetration rate of wireless communication devices. Hence DV-CAST protocol [5] had been proposed that can operate in all traffic scenarios, including extreme scenarios such as dense and sparse traffic regimes. DV-CAST is a distributed broadcast protocol that depends only on local topology information for handling broadcast messages in VANETs.

- **Dense traffic Regime**:

This scenario occurs when traffic density is above a certain value so that the network is fully connected. Because of the shared wireless channel, blindly flooding the traffic messages may lead to frequent contention and collisions. This problem is referred to as the broadcast storm problem. By using efficient broadcast storm mitigation techniques we can mitigate it.

- **Sparse traffic Regime:**

The other scenario, which is very troublesome for conventional routing protocols, is the case where there are very few vehicles on the road. For instance, the traffic density might be so low at certain times of the day (e.g., late night or early morning) that multi hop relaying from a source (the vehicle trying to broadcast) to vehicles coming from behind might not be plausible because the target vehicle might be out of the source vehicle's transmission range. There might be another case that there are no vehicles within the transmission range of the source in the opposite lane either. Under such circumstances, routing and broadcasting becomes a challenging issue. While several routing techniques address the sparsely connected nature of mobile wireless net-

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work, (e.g., epidemic routing, single-copy, multi-copy Spray and Wait).

The DV-CAST protocol mainly relies on Local one hop neighbor information observed by each vehicle via the periodic hello messages. The 3 major components of DV-CAST protocol are

1. Neighbor detection
2. Broadcast Suppression
3. Store-Carry-Forward mechanism

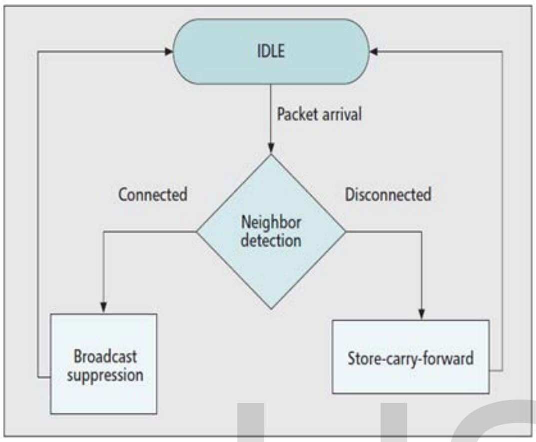

Fig. 6. DV-CAST Protocol Mechanism

If VANET is fully connected i.e., there is at least one vehicle in its one hop then consequently broadcast suppression mechanism should be used to mitigate the broadcast storm problem. If VANET is disconnected it is very difficult to broadcast the warning message hence store-carry-forward mechanism has to be used.

The DV-CAST uses 3 parameters for neighbor detection. They are

1. Destination flag (DFlg), which is used to determine whether the vehicle is the intended recipient of the traffic message or not.
2. Message direction connectivity (MDC), which is used to determine whether the vehicle is the last vehicle in the group/cluster (or whether there is any next-hop neighbor moving in the same direction that will be responsible for reforwarding the message).
3. Opposite direction connectivity (ODC), which is used to determine whether the vehicle is connected to at least one vehicle in the opposite direction or not.

MDC	ODC	DFlg	Scenario	Actions taken by DV-CAST Protocol
1	0/1	1	Well connected	Broadcast suppression
1	0/1	0	Well connected	Help relay the packet by doing broadcast suppression
0	1	1	Sparsely connected	Rebroadcast and assume that the ODN will help relay or rebroadcast
0	1	0	Sparsely connected	Rebroadcast, and help carry and forward the packet to the first new neighbor in the opposite direction or in the message direction encountered
0	0	0/1	Totally disconnected	Wait and forward the packet to the first neighbor in the opposite direction or in the message direction encountered

Fig. 7. Summary of DV-CAST Protocol Operation.

Even though the performance of the proposed DV-CAST protocol in terms of reliability, efficiency, and scalability is excellent, it is not suitable for real urban scenarios

5 FACTORS THAT DISTINGUISH THE PROTOCOL DESIGN FOR THE URBAN SCENARIOS FROM THE DESIGN FOR HIGHWAY SCENARIOS

5.1 Low penetration rates in the next ten years:

The partial and even low penetration rate of DSRC technology in wireless communication devices during the initial deployment stage could worsen the disconnected network problem even in dense urban areas. So, the broadcast protocol in urban regions that does not depend on existing infrastructure has to be addressed first in this problem.

5.2 Omni directional message direction and region of interest (ROI):

To determine the appropriate Region of Interest (ROI) for a VANET application, one has to consider whether all the vehicles in a particular geographical location that travel in a particular direction must be interested in the broadcast message. This implies that the ROI of any application should be determined not only by the geographical location of the vehicles but also by the route itinerary of individual vehicles. Obtaining such sort of information could be cumbersome because of several privacy issues.

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Note that ROI and dissemination direction of the message may vary based on application and cannot be uniquely determined.

5.3 Direction change at intersections in 2D urban scenarios:

At road intersections the direction of the vehicle changes. Due to these direction changes of vehicles, it is not clear that which vehicle is responsible for storing, carrying, and forwarding the traffic message. In highway scenarios, the temporal relay node is always the farthest vehicle traveling in the direction opposite to the message direction (such a vehicle has the smallest rehealing time, i.e., time to encounter new vehicles). But in the urban scenarios, the farthest vehicle criterion might be inadequate, as it will relay the message only to a sub region of a city. Hence, the traditional store-carry-forward (SCF) mechanism (i.e., the selection of SCF-agent vehicles) used in highway scenarios is not applicable for urban scenarios.

5.4 Multiple "enter" and "exit'' points to the ROI:

Fig-8 shows another major difference between highway and urban scenarios. In highway scenarios there is only one "entry'' and one "exit'' location in the Region of Interest (ROI) (as indicated with green and blue arrows, respectively). But in the urban scenarios, the ROI has several locations where vehicles can enter and exit. As a result, Vehicles that enter into the already covered area may not receive the message if they arrive at a later time, after the time the message passes through the area.

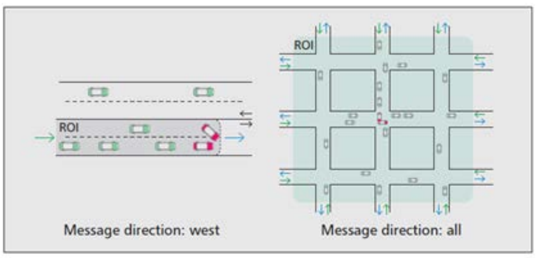

Fig. 8. Region of interest and direction of the messages in two scenarios: highway (left) and urban (right). Green and blue arrows indicate the entry and exit points of the ROI, respectively.

5.5 Connectivity of a vehicle depends on its location:

The transmission connectivity of the vehicles at intersections may cover more "road area'' than that of vehicles between intersections (i.e., non-intersection vehicles). Hence, the intersection vehicles have better connectivity, i.e., they have a higher number of neighbors. Thus, an urban routing protocol should utilize this non-uniform transmission connectivity characteristic which is unique to the urban environment when compared to highway scenario.

6 FEATURES OF BROADCAST ROUTING PROTOCOLS FOR URBAN VANETS

6.1 More than one vehicle should be responsible for the SCF task:

In urban scenarios, due to the multi directionality of message direction and the ROI, if there is only one vehicle responsible for the SCF task, the message will be temporally relayed to the region through which that vehicle passes before it leaves the ROI (i.e., only a sub region of a given ROI will be covered). So, to relay messages in all directions, SCF task should be assigned to more than one vehicle. This mechanism is indispensable during the initial deployment stage of DSRC where only a small fraction of wireless communication devices in the vehicles are DSRC equipped.

6.2 SCF-assigned vehicles should "forward'' the message more than once:

Because of the possible changes in vehicles' direction and the ROI in urban areas has several entry and exit points, there may be a chance that a vehicle will encounter same neighbors again and again at different instants of time. Thus, vehicles assigned as "agents'' for SCF should continue to carry and forward the message even though they have already relayed their messages to the new neighbors which leads to lot of rebroadcasts; some of which may create redundancy. In order to avoid such unnecessary rebroadcasts, the routing protocol should restrict the message rebroadcasts as opposed to blindly rebroadcasting the message whenever SCF-agent vehicles meet new neighbors.

One solution to avoid redundant rebroadcast is to use message acknowledgment in periodic hello messages. For example, an additional 4- byte field (called message id field) should be added to the message header which stores id of messages that a vehicle has recently received. With this acknowledgment mechanism, an SCF assigned vehicle can decide whether it should rebroadcast the message upon receiving hello messages from its neighbors.

6.3 Intersection-based broadcast storm suppression mechanism:

Vehicles at intersections have more neighbors as they have better network connectivity than non-intersection vehicles, especially in a network with high traffic density. Message rebroadcasts from the intersection vehicles thus reach more vehicles within a shorter time, as compared to the case where the same numbers of messages are rebroadcasted from the non-intersection vehicles. Intersection-based broadcast storm suppression technique will be more effective than other non-intersection-based schemes.

7 BROADCAST STORM MITIGATION TECHNIQUES IN URBAN SCENARIOS

Most existing solutions to the broadcast storm problem were performed only in the obstacle-free environment i.e., highway scenarios which are not applicable to real urban scenarios where plenty of obstacles cause signal interference, creating blind areas where vehicles will not receive the warning message unless intermediate vehicles help to overpass the obstacle. This effect is shown in Fig-9 which includes an example of traffic message propagation in a real city scenario obtained from Google Maps. If vehicle A is trying to broadcast a warning message, a basic radio propagation model will consider in such a way that all vehicles within its transmission range (vehicles B and C) would receive the warning message sent by vehicle A. However, because of obstacles like buildings, there will be a blind area (dark area in the figure) that will hinder vehicle C from receiving the message if vehicle B decides not to rebroadcast it.

Fig. 9. Traffic message dissemination in an urban scenario extracted from Google Maps.

The effect of obstacles in warning message dissemination has been addressed by other proposed schemes, specifically designed for traffic message propagation in urban areas. They are

7.1 Urban Multi-hop Broadcast Protocol (UMB):

It is proposed by Korkmaz et al. is a medium access layer (MAC) layer solution for disseminating messages to all vehicles [6]. In this protocol, each vehicle contends for the channel. They transmit a variable-length black-burst over the shared channel; the vehicles with the longest burst end up forwarding the traffic message. Vehicles at intersections also create additional directional message broadcasts to other road directions.

7.2 Street Cast Protocol:

Yi et al. have proposed the Street Cast protocol [7], which is also a MAC layer protocol that consists of three components:

- Relay node selection (Road Side Units (RSU) at intersections chooses the appropriate relay vehicles)
- Multicast request-to-send (MRTS) handshaking, which is used to mitigate collisions and the hidden terminal problem
- Adaptive beacon control, which is used to mitigate the broadcast storm problem caused by hello messages at a denser intersection.

Both UMB and StreetCast protocols assume that the network is always well connected; no solutions for disconnected networks have been investigated.

7.3 Direction-Aware Function-Driven Feedback Augmented Store and Forward Diffusion scheme (DFD-FSFD):

Upon receiving the broadcast message, each vehicle calculates a forwarding probability based on the proposed traffic message propagation function that encodes information about target areas and preferred routes to the target. In the case where the network is disconnected, vehicles store and periodically rebroadcast the message.

7.4 Acknowledged Parameter less Broadcast in Static to Highly Mobile protocol (Ack PBSM):

It is proposed by F. J. Ros et al. in this protocol uses the connecting dominating set (CDS) concept for broadcasting messages in well-connected networks. Message reception acknowledgment, piggybacked in periodic hello messages, is used for relaying the message in a disconnected network. In this scheme, vehicles, upon receiving the messages, have to wait for the new hello message in order to calculate their wait time. Hence, the message latency depends on the hello message interval, which might cause additional delay when the hello interval is large.

7.5 Urban Vehicular Broadcast Protocol (UV-CAST):

This protocol is applicable in both well connected and disconnected network regimes in urban scenarios. It is fully distributed, lightweight, and zero-infrastructure support broadcast protocol. This protocol utilizes both direct relays through multi-hop transmissions (i.e., spatial relay) and indirect packet relays through the "store-carry-forward'' mechanism (i.e., temporal relay). The protocol has been evaluated extensively in both ideal Manhattan-like and real city scenarios. The UV-CAST (Urban Vehicular broadcast) protocol [8] allows reducing the broadcast storm problem while solving disconnected network problems in urban VANETs. It defines a region of interest for each VANET application, and the propagation is adapted to maximize the number of informed vehicles in this region. The drawbacks in this protocol are: despite showing good results in a scenario obtained from the city of Pittsburgh, this scheme is not compared with other protocols that could produce similar results. In addition, the density of vehicles studied is relatively low and the performance of this protocol when there are more than 50 vehicles/km2 has not studied.

7.6 Relative Position Based- Message Dissemination Protocol (RPB-MD):

The RPB-MD protocol (Liu and Chigan, 2012) is a message dissemination (MD) approach with a relative position based (RPB) addressing model that defines the intended receivers in the zone of relevance. Simulation results show high delivery ratio and low data overhead, still the drawbacks are as follows: the scenario used is a single bidirectional highway, and the Radio Propagation Model selected is the deterministic Two-Ray Ground. Hence, we consider that this proposal should be revised to ensure that results are comparable to real ones obtained from existing urban scenarios.

7.7 Enhanced Message Dissemination Based on Roadmaps in real maps (eMDR):

This scheme improves the dissemination and reduces the warning notification time by making use of the topology of the area where the propagation takes place. But the techniques proposed earlier use only the basic metrics such as the distance or the relative angles between vehicles. This scheme includes additional knowledge about the roadmap to determine the appropriate set of relaying vehicles. There are two types of messages in this scheme- warning messages i.e., safety related and time critical messages and beacon (normal messages) i.e., non-critical information such as their positions and speed. Normal messages have lower priority than warning messages.

In this scheme [9] vehicle will rebroadcast the warning message only when the relative distance between the sender vehicle and the receiver is higher than a distance threshold D, or the receiver is in a different street than sender. We consider that two vehicles are in a different street when: (i) both are indeed in different roads, or (ii) the receiver, in spite of being in the same street, is near to an intersection. Hence, warnings can be rebroadcasted to vehicles which are traveling on other streets, overcoming the radio signal interference due to the presence of buildings.

Note: If the message is a beacon, it is simply discarded since we are not interested in the dissemination of beacons.

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Fig-10 shows an example in a real map scenario. When vehicle A broadcasts a warning message, it is only received by neighboring vehicles B, C, and D because buildings acts as obstacles and prevents further transmission of message to other vehicles. In this situation, if we use distance or location-based schemes, vehicles B, C, and D will rebroadcast the message only if distances d1, d2 and d3, respectively, are large enough (i.e., the distance is larger than the distance threshold D), or its additional coverage areas are wide enough (i.e., the AC is larger than the coverage threshold A). Supposing that only vehicle B meets this condition in our scenario, the warning message could still not be propagated to the rest of vehicles (i.e., E, F, and G).

eMDR scheme improves this situation as follows. In eMDR, vehicle D will rebroadcast the warning message since vehicle D is in a different street than vehicle A. The warning message will then arrive to all the nearby vehicles (in our scenario) in only three hops. In modern Intelligent Transportation Systems (ITS), vehicles are equipped with on-board GPS systems containing integrated street maps. Hence, location and street information can readily be used by eMDR to ease the dissemination of warning messages. When the additional coverage area is wide enough, vehicles will rebroadcast the received warning message. However, when the additional coverage area is low, vehicles will rebroadcast warning messages only if they are in a different street. Note that distance and location-based schemes can be excessively restrictive, especially when buildings interfere with radio signal propagation. Without eMDR, warning messages will not arrive to vehicles E, F and G due to the presence of buildings.

Fig. 10. The enhanced Message Dissemination based on Roadmaps scheme: example scenario taken from the city of Valencia in Spain.

eMDR algorithm produces more reception overhead than Location based and UV-CAST schemes, but this is only noticeable in the New York roadmap (where the increase is about 15%), whereas the differences are almost negligible in the other scenarios. Therefore, the eMDR scheme introduces little overhead compared to other more restrictive schemes, which is compensated by the improvement in terms of warning notification time and vehicles informed.

The proposed eMDR scheme is specially suitable in situations where there are few vehicles able to forward messages, which can be due to either the low vehicle density or the low market penetration rate of wireless devices.

Efficient Data Dissemination Protocol.

This algorithm tackles the broadcast storm problem by effective data dissemination. Parameters used in this algorithm are:

- $vehicle_i$ represents a vehicle present in the scenario;
- T_{war} is the interval between two consecutive warning messages;
- P_{war} indicates the priority index of the warning messages;
- P_{bea} indicates the priority index of the normal messages.
- warning represents a warning message generated by a warning mode vehicle;
- beacon represents a normal message generated by a normal mode vehicle;
- msg indicates each message sent or received by each vehicle;
- ID indicates the message id;
- T_{bea} is the interval between two consecutive normal messages;
- D_{ROI} is the distance that is under our region of interest;
- msg.X, msg.Y, msg.Z are the coordinates of the warning mode message vehicle at that instant of critical event.
- D_{RFE} is the distance of the receiving vehicle from the event and is calculated using the GPS coordinates of the receiver and that of the coordinates in the packet.

Send module().

Pwar=High;

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```
Pbea=Low;
DROI= Fixed (say 1 km radius);
ID=0;
while(1) do
{
if (vehiclei is in warning mode) then
{
create message msg;
set msg.priority = Pwar;
set msg.seq_num = ID++;
set msg.X = Xs;/*X coordinate of vehiclei*/
set msg.Y = Ys;/*Y coordinate of vehiclei */
set msg.Z = Zs;/*Z coordinate of vehiclei */
broadcast warning message(msg);
sleep(Twar);
}
else
{
create message msg;
set msg.priority = Pbea;
broadcast beacon (msg);
sleep (Tbea);
}
}
```

Receive module().

```
for (every received message ) do
{
if( msg is a warning and msg.seq_num received
for the first time)
{
if (DRFE< DROI)
{
rebroadcast (msg);
else
discard (msg); /*do not broadcast messages if
conditions are not met*/
}
}
else
discard (msg); /*duplicated warnings and beacons
are
not broadcasted*/
}
```

When vehiclei broadcasts a message it is received by all the neighbours of vehiclei. When this message has been received for the first time the neighboring vehicles rebroadcast it to their neighbours. The repetition period of this process depends on the type of message i.e. whether it is a normal message or a warning message. The vehiclei keeps broadcasting this warning message periodically every Twar seconds for a preset time. Every time a vehicle receives a message it tests whether this message was previously received, if it has been already received then that message is not disseminated else it will be rebroadcasted. This mechanism is possible with the help of the sequence number of the message stored by the vehicle. When a message is received for the first time and the distance of the receiver from the event is less than our region of interest then the message is rebroadcasted. This mechanism makes sure that the limiting condition for the broadcast of message exists and thus prevents dissemination of the message beyond our region of interest and helps in reducing the broadcast storm problem.

8 SIMULATION USING MOVE & SUMO MOBILITY MODELS

This paper utilizes MOVE tool for the purpose of simulation as it is capable of handling both the mobility simulation and network simulation, MOVE contains SUMO an NS2 to handle those tasks. SUMO generates the TCL files required by NS2 for network simulation [10]-[14]. This is achieved by giving appropriate map and mobility models to SUMO.

Using these simulators, road networks for both urban and highway scenarios has been created and simulated as well.
Here, a network in urban scenario had constructed using MOVE and simulated using SUMO.

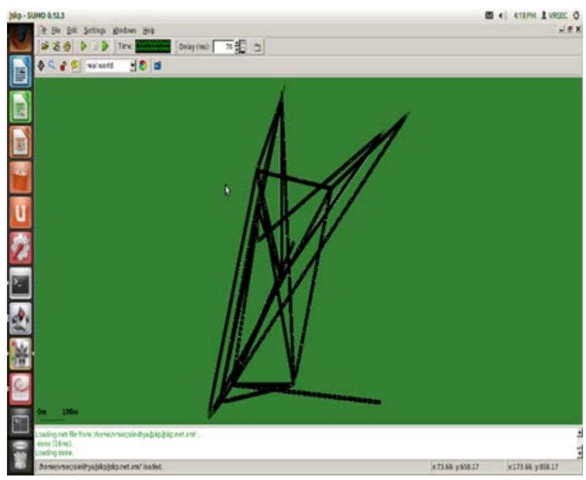

Fig. 11. Created road network using MOVE

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Fig. 12. On zooming the road network

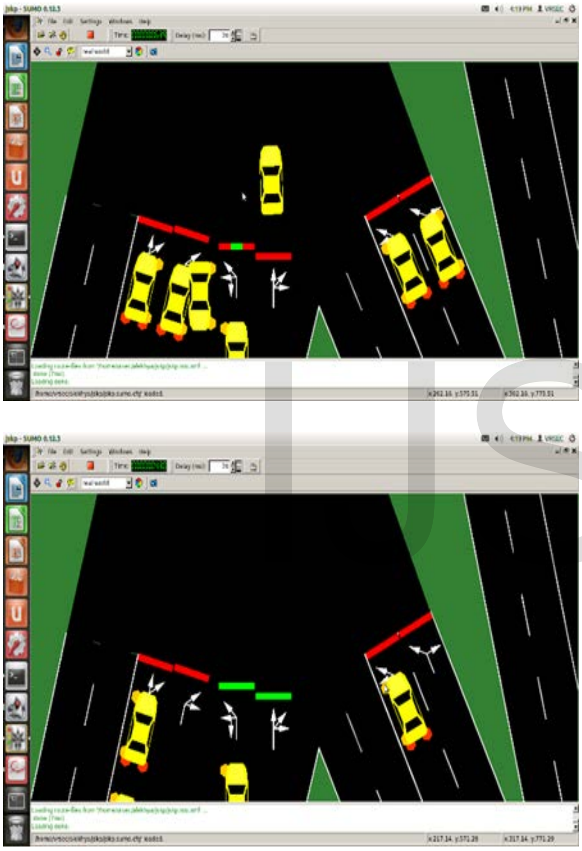

Fig. 13. Vehicle Movement

9 CONCLUSION AND FUTURE WORK

To warn drivers about critical road conditions efficient warning message dissemination is of utmost important for safety related applications in VANETs. The warning message should be broadcasted to all the vehicles from the victimized vehicle. If this broadcasting is done inefficiently broadcast storm problem would arise which results in increased channel contention and packet collisions due to simultaneous message transmissions. The proposed models of data dissemination reduces the number of total broadcasted messages by limiting the region of interest it also makes sure that the messages are not broadcasted through the entire network thus tackling the broadcast storm problem.
This article presents all the distance-based and location-based schemes, the Function Driven Probabilistic Diffusion algorithm, and the UV-CAST protocol in terms of warning notification time and percentage of informed vehicles, while exhibiting a reduced overhead. This article also depicts the factors that distinguish highway scenarios from urban scenarios and also presented the techniques to mitigate the broadcast storm problem in highway and urban scenarios as well.

This work controls the distance of propagation using network diameter and thus reduces the number of vehicles receiving the warning messages. In the case of dense networks this may cause the warning to spread to a very short distance. Future work may involve using distance calculated from node position to accurately limit the distance of propagation.

By applying efficient above discussed broadcast storm mitigation algorithm for the above simulated road network and can reduce broadcast storm.

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