Mobility Aware Broadcast Routing Mechanism in VANET

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Abstract— From several past decades message (information) dissemination using broadcasting has been emerging subject of research in vehicular ad-hoc network (VANET) field. Broadcasting is the most popular technique for emergency information message transmission from one vehicle to another vehicle by means of inter-vehicular communication. VANETs does not have physical backbone to transmitting the message but the concept of virtual backbone in mobile ad-hoc network is applicable to VANET environment. Virtual backbone can be created by constructing dominating set using any vehicle selection strategy and then applying selective vehicles to broadcast information message. Even though reducing the size of broadcasting node there still problem of broadcast storm and flooding problem in the VENET network. This paper proposes to reduce the problem of broadcast storming problem in VANET environment using probabilistic selection approach by selecting a single node from dominating set there by reducing rebroadcast node and applying dynamic broadcasting interval to enhance reliability of VANTE. We implement and compare our proposed scheme with standard existing approach of connected dominating set(CDS) as well as navigation route based minimum dominating set algorithm(NRMDS). Comparing simulation results to standard approaches shows that proposed scheme has a significant batter performance in terms of packet delivery ratio, end-to-end delay as well as reducing network overhead.

Key words: Connected Dominatng Set; Virtual Backbone; Probabilistic Broadcasting; Routing in VANET; Emergency Message Dissemination; Inter-Vehicle Communication

I. INTRODUCTION

Around the world due to on road accidents a lots of people are die or injured every day. The on road safety in vehicle is the main motivation behind implementation of vehicular ad-hoc network. The problem is to implement the information message dissemination among the vehicles while on the move or on the road by means of locating the vehicle and sending/receiving with some equipment like transceiver which will results in on road safety and control.

VANET technology provides communication in between vehicle, usually known as Inter-Vehicle Communication (IVC) and Vehicle-to-Vehicle Communication (V2V). Communication between vehicles may take place using road side units (RSU) which is fixed along road side, and this type of communication is known as Vehicle-to-Infrastructure Communications(V2I) [1]. Each vehicle is equipped with the wireless communication so that the can send, receive real time information message about road conditions, traffic in same and other lane, and other important information with other relay node.

Major problem in the VANETs is information dissemination. In contrast to the other networks VANETs some unique and attractive feature like higher computational capability, unlimited transmission power and predictable mobility [1]. In VANTEs the information dissemination has broadcast-oriented nature [2]. The basic method to disseminate the information in VANET is broadcasting. Broadcasting has some significant befits like vehicle can send information to other vehicle without knowing destination address and without some specific route. Which will ultimately eliminates topology management, route discovery and address resolution which is tough in complex and highly dynamic network. Due to highly dynamic nature in VANET, it became vast field of research in information routing.

Flooding is the simplest technique to broadcasting in which every receiver is allowed to re-broadcast the message. Though, flooding technique has too many disadvantages in terms of performance. Flooding increases congestion and packet collision whenever number of nodes increases, which also increases delay due to information retransmission [3] [4]. To resolve the problem of flooding rather than selecting all of nodes to rebroadcast the message i.e. relay nodes, approach of selected nodes to re-broadcast the message will reduce the number of retransmission as well as packet collision can also be significantly decreased, there by improvement in scalability of broadcasting. Selecting a relay nodes is also major research problem in VANET. Many techniques are proposed to selection of relay nodes in [2].

In this paper we create a virtual backbone and applying selection strategy for relay node will results in some dominating sets of nodes. These selected node can be act as a rely node for further retransmission of messages in network. Dominating Set technique is one of the major used strategy for selective approach of relay nodes. Still this technique is not efficient too reduce the problem of flooding. Further optimization in these method can be placed by filtering node using further probabilistic criteria like distance from source vehicle and selecting only those nodes as a relay nodes that fulfill that criteria from the dominating set of nodes [5] [6] [7] [8]. In [5] it is mentioned that, while applying the probabilistic approach to VANET it is possible that packet may not always reachable to the distance vehicles due to reason that some vehicle decide not to forward message. To address this problem broadcast interval can be adjust dynamically by means of increasing coverage and reachability.

To examine our mobility aware broadcast routing scheme we had prepared simulation scenario in ns-2 [19]. The mobility pattern data are generated in MOVE [17] and SUMO [18] tool and it is than integrated with ns2 for traffic generation purpose. We had compared our strategy with CDS [9] and navigation route based minimum dominating sets (NRMDS) [7] strategies. The simulation analysis shows that our new strategy performance improvement in terms of delivery rate and end-to-end delay within the same environment.

Further sections in this paper organized as: Section II describes related background on probabilistic broadcasting and dominating set approach followed by Section III which describes our proposed scheme, followed by Performance Evaluation described Section IV and in Section V Conclusion And Future Work

II. BACKGROUND AND RELATED WORK

Broadcasting in VANTEs research field has been one of the key issue. Broadcasting of information message using flooding technique in VANET environment cause broadcast storm problem due to packet retransmission of multiple node at the same time. Thus packets lose ratio also increases. In [3] it is mentioned that the problem of packet collision can be addressed by reducing the number of rebroadcasting nodes.

In [9] CDS algorithm which works on the base of dominating set theory we can achieve reduced number of relay node by selecting only those nodes which are included in the dominating set. In this method for creating as subnetwork of dominating set, network is assumed as a graph. VANET has no central management so the construction of dominating set must be distributed. Also considering other parameters like dynamic and frequent changes in topology central management is not possible. In multi-hop broadcasting technique, every node needs minimum two-hop neighbor knowledge in order to decide whether the node is in dominating set or not. Thus by reducing rebroadcasting nodes to a small sub set and which will results in less packet collision. Efficiency and performance of dominating set based broadcasting is highly depends upon selection process of dominating set. Assuming a network as a graph G and S is the set of vehicles i.e. vertices in terms of graph in graph G. Graph g is said to be as a connected dominating set if every vertex not in S is adjacent to some vertex in S and thus the subgraph created by S in connected [9] [10].

Even though reducing the number of rely nodes by dominating set the broadcast storm problem is still significant and in [8] it is mentioned that problem of broadcast storm can be addressed by selecting vehicle which furthest from source vehicle as a rebroadcasting vehicle. Thus [8] uses probabilistic approach. The higher probability is given to the vehicle with furthest distance. In this method vehicle uses neighbor information in order to select best rebroadcast node that is furthest away from source vehicle by looking up own position in neighbor as well as counts the number of vehicles behind itself. The vehicle with furthest distance will also wait for $(n-1)*\tau$ time, τ is WAIT_TIME function. If vehicle itself not overhear same message within this τ time than it will rebroadcast the message.

TLO (The Last One) [11] attempt to improve performance of broadcasting by reducing broadcast storm and End-to-End delay parameter. TLO uses beacon packets in close interval to update information of vehicles within the communication range. In [11] it is mentioned that, if distance and relative velocity of in-range vehicle changes slowly than longer update intervals can be used. When any event occurrence takes place at that time all vehicle within communication range will receive an alert message and keep the message. The vehicles which has received an alert message will use TLO algorithm to find the last one vehicle from the place of event, and that particular vehicle will only rebroadcast the message. All other vehicle have to wait until threshold time to decide whether to rebroadcast message or not. If other vehicle does not receive same message within threshold interval than the vehicles behind the TLO vehicle will run TLO again to find new TLO and that new TLO vehicle now act as a rebroadcasting node.

fficient Directional Broadcast (EDB) [12] uses information from directional antenna in which it is assumed that each vehicle is placed with two directional antenna with 30° beam-width. Before retransmission of message, EDB assigns different waiting time to each vehicle within transmission range, to reduce retransmission of packets. In addition EDB also account distance parameter to assign rebroadcast probability. The vehicle which is farther away from transmitter will be assigned a higher rebroadcast priority. EDB also attempts to increase reliability by keeping rebroadcast the message periodically if no other vehicle forward the message within interval of $maxWT$. ACK packet is transmitted after waiting time expires. To inform other vehicles that they not need to rebroadcast the message. After sending ACK packet can start rebroadcasting the message.

Multi-hop Vehicular Broadcast (MHBV) [13] protocol is delay based broadcasting protocol. In this protocol also based on the distance between transmitter and it self, waiting time is assigned to the vehicles before retransmitting the message. Vehicle with furthest distance from transmitter will assigned shorter waiting time. MHBV detects traffic congestion information and thereby attempts to adjust beacon packet broadcast interval dynamically. If any vehicle detects neighbor number of vehicle is exceed threshold value and own speed is less than some threshold speed than it decides the traffic is congested. If traffic is congested, than periodic broadcast interval will be increased.

In Auto-Cast [5] vehicle detects number of neighbor to assign rebroadcast probability. Rebroadcast probability increases as the number of neighbor decreases. Auto-Cast also attempts to increase coverage and reachability by rebroadcasting message periodically as well as adjusting rebroadcasting interval dynamically using function $t = N_h/\alpha$. Where, N_h is number of neighbor and α is constant specifies desired packet rate.

Collision Ratio Control Protocol (CRCP) [14] and Abiding Geocast [15] protocols are also adaptive broadcast interval broadcasting techniques in which broadcast intervals are adjusted dynamically. In [14] it is aimed to adjust broadcasting interval dynamically based on proposed rate of packet collision. As the network density increases the packet collisions also increases. To achieve packets collision at desired level vehicles needs to adaptively change their broadcast interval. This protocol is aimed to maintain collision ratio at directed level. If observed Collison ratio is greater than pre-defined threshold level, than the broadcast interval is doubled else shorten by one second. In [15] broadcasting interval is adjusted dynamically by determining speed, relative distance, transmission range and emergency site information. As the distance between active relay node and emergency site increases, the rebroadcast interval also increases as well as if vehicle speed decreases the rebroadcast interval also increases.

III. PROPOSED SCHEME

Our proposed scheme is starts with exchanging beacon message that exchange information about vehicles like position, speed and direction with vehicles in communication range. So, in our experiment setup we assume that navigation system is equipped in each vehicle. With the help of the navigation system vehicles can get information about position, direction and speed of the car.

Vehicles within communication range of car can communicate in ad-hoc way so, we also assume that vehicles are equipped with wireless communication system device. Any vehicle that are directly connected is known as a neighbor and they can exchange information directly.

In our proposed scheme we will select optimized selection of message rebroadcasting node from dominating set with probabilistic approach and also set message rebroadcasting interval dynamically method to maintain and control collision in VANETs. Next we see detailed description of our proposed scheme step by step.

In [9] it is mentioned that to create a dominating set we need neighbor information. The neighbor information will be achieved using beacon messages by broadcasting it periodically within some time interval.

B_pkt(my_position(), max_range, distance)

Where, *B_pkt()* is beacon packet identifier, *my_position()* parameter will send vehicle's own current position and *distance* parameter will calculate and send distance between sender and receiver.

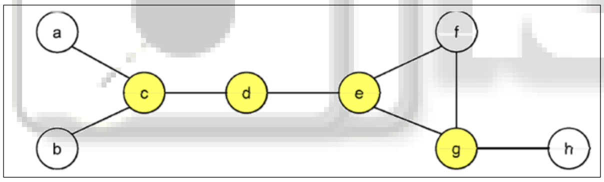

Fig. 1: Representation of VANET as a Graph [9]

To select rebroadcasting node in our new proposed method, first step is to create dominating set of VANET. We will first create dominating set by initiating the marking process to select only those nodes which have exist only two unconnected neighbors and after creating dominating set we call that set as a sub graph [9] [10]. Before starting marking process vehicles exchange their neighbor information using beacon packets with the vehicle within communication range *r*. Initially every vehicles *v* in *V* are unmarked. After exchanging neighbor information the process of construction of dominating set starts by marking process. Vehicle in communication range is marked by m_v if vehicle has minimum two unconnected neighbors.

Graph	Vehicles	Edges	Mark	Neighbour
$G = (V, E)$	V	E	m_v	$N(V)$

Table 1: Graph Network Notations

Every marked vehicles are included in set of marked node *V'*, known as a dominating set [9]. As shown in Figure 1. VANET is represents as VANET as a graph. The node with minimum two unconnected neighbors are also marked with yellow color.

The Process of Dominating Set Construction as follow:

1) Initialization – All v in V is Unmarked
2) Every v exchanges its neighbour information N(v) in transmission range r using periodic beacon message.
3) Calculate neighbour set N(v) = {u | {v,u}∈ E} of v
4) Mark every node m_v if there exists minimum two unconnected neighbours.
5) Every marked m_v is included in V ' (Set of vertices marked) Begin selection from V'

We will now consider only that created dominating set for further selection process and select only one vehicle as a relay node from dominating set, based on the distance and waiting time probability parameter criteria, by assigning probability function to each node. By assigning probability we also intended to improve good congestion control. Probability of each node in dominating set.

The node with highest probability will be selected as a next relay node i.e. rebroadcasting responsibility will only assigned to the node with highest probability. The node with shortest waiting will give highest priority and the node with furthest distance from source node will give shortest waiting time. We use distance based strategy to select rebroadcasting node, by selecting furthest vehicle from source as a highest probable node [8] [11] [12] [13] [16]. Waiting time calculation is function between distance and transmission range parameter, this can be fulfil by getting GPS location of neighbor nodes. We will calculate waiting time using function in [4] [12] and modifying it as

$$WT(n\_id) = \left(1 - \frac{d}{max\_range}\right) * WT_{th} \qquad (1)$$

Where, d is the distance from source vehicle, max_range is the maximum transmission range of source vehicle, WT_{th} is threshold waiting time.

$$WT_{th} = rand(1 - 100ms) \qquad (2)$$

WT_{th} is the calculated using random function and its range is limited to 1-100ms for best performance in our experiment. After waiting time expires, the vehicle with shortest waiting time can rebroadcast the message. Other vehicle will drop the packet after overhearing the same message. If other vehicle does not receive the same message during their waiting time period, the next vehicle with shortest time will rebroadcast the message.

Vehicles in VANET can get number of neighbor surrounding in their communication range. By getting density information we can decide whether traffic is congested or not, so we can optimize message broadcast rate and its interval by congestion information. We use threshold limit of speed and density for deciding whether traffic is congested or not [5] [13] [14] [15]. If traffic is congested than density is also increase and so collision will also increase. To maintain collision ratio broadcasting interval should be optimized. In traditional and existing method there are fixed broadcasting interval to exchange information among the nodes. Using the traffic information and neighbor speed information we will adjust broadcast interval dynamically. If both of parameter's value is respectively greater and less than threshold value that broadcast interval should be increased else interval should be shorten. If neighbor list is greater than threshold X and vehicle's own speed is less than threshold speed S_{max} than we can decide that traffic is congested so, broadcasting interval should be increased and adjusted to *1s* else should be shorten to *0.8s*. Function for deciding threshold values of speed and neighbor is depends upon past information of vehicle itself. Summarizing the process flow for proposed scheme as:

1) Find dominating set of VANET.
2) Mark node, if node having minimum two unconnected neighbor.
   – Enter all marked nodes with in subgraph.
3) Calculate waiting time
   – Assign minimum waiting time to the vehicle that is furthest from source vehicle than the nearest one.
   – Assign threshold waiting time to nodes.
4) Assign message forwarding probability
   – Assign highest probability to vehicle whose waiting time is shortest.
5) Congestion detection
   – Calculate vehicle density, if it is more than threshold value and its own speed less than threshold speed than traffic congested.
6) Adjusting rebroadcasting interval dynamically
   – If traffic is congested the broadcast interval will be increased and if traffic in not congested than broadcast interval will be decreased.

A. *Proposed Algorithm:*

```
Start
//Beacon packet interval
intvB = 0.8s
//Broadcast beacon packet
beacon_packet(B_pkt) → getNeighbourInfo();
        B1_pkt(my_position(), max_range, distance)
//Compute CDS
if neighbour_list of neighbour_node ≥ 2
foreach node within 'max_range select 'net_id'
  Repeat
        Step for each neighbor node within 'max_range'
end
add selected n_id(s) to CDS_list
//At the time of event occurrence
start CDS_timer(n_id):
Broadcast_event_message(CDS_list);
getDistance(n_id →  CDS_list)
//Send beacon packet
Beacon_packet(B2_pkt) to each n_id → CDS_list
      B2_pkt(event_id, declared_max_range, my_n_id,
            my_position(), distance, wait_time())
//Calculate waiting time of each n_id in CDS_list
```

$$WT(n\_id) = \left(1 - \frac{d}{max\_range}\right) * WT_{th}$$

```
//Broadcast event message
event_message(event_id, CDS_list, my_position(),
distance);
//Select node 'n_id' with shortest waiting time as a
forwarding node.
foreach n_id  → CDS_list
        if (wt(n_id) < wt(c_n_id))
                        select forwarding_node →
(n_id)
        else forwarding_node →  (c_n_id)
endif
end
Start waiting_timer(wt)
foreach n_id → CDS_list
        if event_message getDuplicate();→ n_id
                        //Discard the message
                        drop_pkt();
                else broadcast_message();
                //after time out occur.
        endif
// Adjusting rebroadcasting interval dynamically
getNeighboutList() & getNeighbourSpeed()
        if(NeighbourList(n_id) > threshold X)
                if(n_id speed < threshold_speed Smax)
                traffic is congested → adjust intvB = 1s
        else set to intvB = 0.8s
        endif
        endif
end
end
```

IV. PERFORMANCE EVALUATION

For performance evaluation and simulation of our proposed algorithm we use ns-2 [19]. MOVE [17] known as "Rapid Generation of Realistic Simulation for VANET" tool is used for Route configuration and for mobility pattern generation we used SUMO [18] tool. For traffic generation we have integrated a SUMO files to ns-2 and performed simulation in standard environment with [9] [7] to compare and analyze results of our proposed algorithm.

A. *Simulation Setup:*

We used 1000 X 700 meter area and designed road network with two-lane bidirectional and two intersection on each road configuration and each intersection has traffic light to control the movement.

We have simulated our proposed algorithm with sparse to dense city traffic scenario i.e. light to heavy traffic scenario, more precisely we performed simulation for vehicle ranging from 30, 40, 50, 60, 70, 80, 90 and 100. Vehicle on each roads varies from 10-100/km/lane and speed of each vehicle also varies from 22~55 km/h as we has considered city traffic scenario. Vehicle probability at each junction is varies from 25% ~ 75%. Data in TABLE II shows parameter and its values of simulation setup.

Parameter	Value
Simulation Time	500sec.
Vehicle Traffic Rate	10 – 100 vehicles/km/lane
No. of Lane and Road Type	2 – Bidirectional Road
Minimum ~ Maximum. Speed	~ (22 – 55) km/h (City Traffic)
Field Area (City)	1000 X 700 meter
Vehicle Probability (Per Junction)	~ (25% - 75%)
Beacon Broadcast Interval	0.8s
Transmission Range	250m

Table 2: Simulation Parameters and Values

B. *Performance Metrics:*

We use different performance metrics to compare and measure our proposed algorithm.

1) Average packet delivery rate: It is the ratio between the total number of packets successfully received by vehicle to the total number of pacaket sent by vehicles in the network. For example, if 80 vehicles has received packets out of total 100 vehicles. Than the delivery rate is 80% i.e. 80 / 100]
2) Packet loss: It is the fraction of sent data packets not received at their destination.
3) End-to-End delay: End-to-End delay is the deifferent between the time at which receiver received the packet and receiver recerive the packet.

C. Simulation Results:

For the packet delivery ratio metrics we compare our proposed scheme with NRMDS and CDS based algorithm used for VANET. Other performance metrics are compared with CDS algorithm.

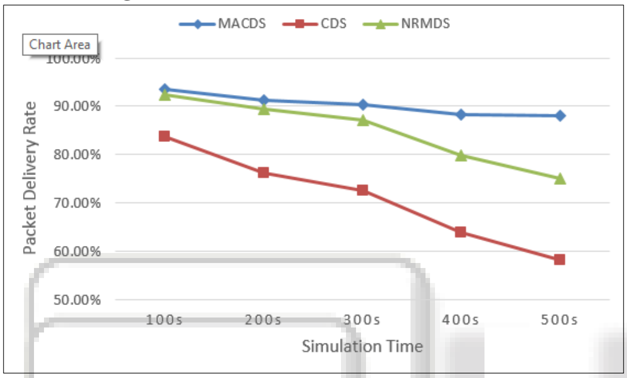

Fig. 2: Average Packet Delivery Rate vs. Simulation Time

1) Average Packet Delivery Rate:

In Figure 2 comparison of delivery rate with respect to time between [7], [9] and our proposed algorithm (MACDS) is shown. We can analyze that the delivery rate of our proposed algorithm and NRMDS algorithm initially has the same result until *200s* but after that time we can see significant performance improvement in our proposed algorithm that show that our proposed algorithm has noticeable improvement over other two algorithm in terms of average packet delivery rate metric.

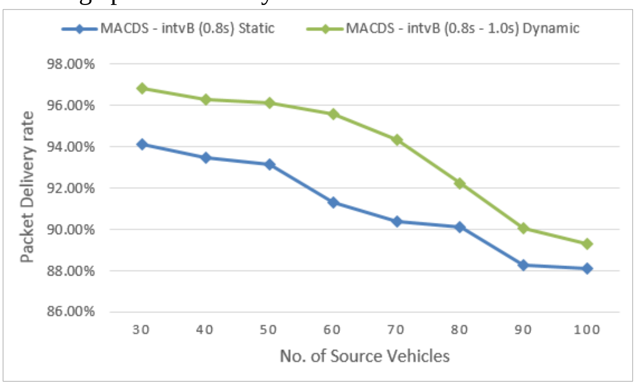

Fig. 3: PDR with Static and Dynamic Broadcast Interval

2) Packet Delivery Rate with Dynamic Broadcast Interval:

In Figure 3 packet delivery ratio comparison with static and dynamic broadcast interval is shown for our proposed algorithm. In sparse network scenario, dynamic broadcasting adjusting state performance is better that static method but as network becomes denser the performance near to static broadcast method. Though it still has significant improvement in dense network too. Thus our proposed algorithm gaining more reachability and reliability improvement.

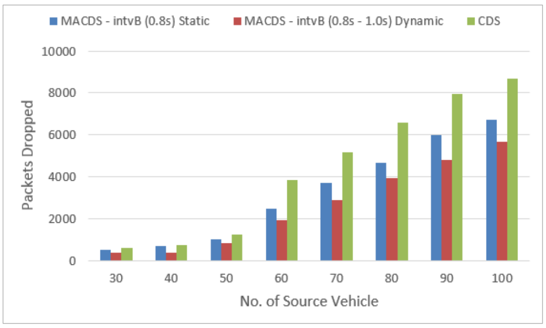

Fig. 4: Packet Loss (Packets Dropped) vs. No. of Source Nodes

3) Packet Loss:

Figure 4 shows a graph of comparison between proposed algorithm with static and dynamic broadcast interval and CDS algorithm for packet loss metric. Packet loss is also known as packets dropped. As we can see in graph, packets dropped in our proposed algorithm with different density vehicle has significance improvement which will ultimately cause less packet collisions in network and thus reliable communication can be achieved.

4) End-To-End Delay:

End-to-End delay metric performance comparison is shown in Figure 5. In sparse network scenario we do not get significant change in end-to-end delay parameter for our proposed algorithm and CDS algorithm. But as network becomes dense we get performance improvement for end-to-end delay. We can see that our proposed algorithm has less end-to-end delay compared to CDS algorithm which improves efficiency of algorithm.

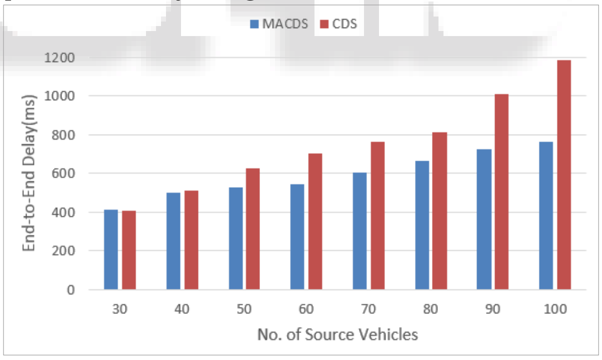

Fig. 5: End-to-End Delay vs. No. of Source Nodes

V. CONCLUSION AND FUTURE WORK

In this paper we proposed mobility aware broadcast mechanism that works on optimized relay node selection strategy. We choose a single node as a rebroadcasting node to forward the message from the dominating set of nodes based on distance parameter. We assign waiting time to each nodes included in the dominating set and shortest time will be assigned to the furthest vehicle from source node. The vehicle with shortest time will be assigned as a rebroadcasting node.

The method attempts to improve and reachability and reliability performance metrics in VANET by adjusting rebroadcasting interval dynamically. This is achieved by speed and density information of vehicle.

Apart from the features of this method, it also has some disadvantages which can be thought as a future implementation and enhancement. The performance improvement can be more achieved by resolving some issue as, one, this method does not account that if new vehicles which enters in dominating set area after event occurrence will be not get easily acknowledge about the event until it included in some dominating set successfully. Two, the dominating set overlapping may occur in network i.e. signal vehicle in any network may be included in more than two dominating set. This causes bad effect on scalability metric in algorithm. Third, vehicle direction also not considered so, it event occurred in opposite direction to the vehicle running, so message may be delivered to the vehicles that are not necessarily needed that information. So, this cause network overhead problem and number of packets may be generated and transmitted that necessary required.

Overall, the algorithm has an efficient packet delivery ratio than basic dominating set broadcasting method. Packet collision and congestion control can also be achieved well in this algorithm. So, it will be good to use this algorithm if it is desired to control packet collision, reduce broadcast storm problem and want to get good reachability and reliability performance metrics.

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