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EMDAI: An Emergency Message Diffusion for Accident Information in Vehicular Ad Hoc Networks

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Abstract- ***A Vehicular Ad Hoc Networks (VANETs) brings the breakthrough in industries. In highways the road safety and travel comfort are accomplished through vehicle-to-vehicle and vehicle-to-roadside unit communications. A major issue in safety application is to diffuse emergency message to all the other vehicles immediately without redundancy. There are number of works have been proposed to disseminate the emergency message, but those works suffer from delay and bandwidth consumption due to redundancy. This paper considers vehicle-to-vehicle communication for emergency message diffusion without the assistance of roadside units. In this paper, an Emergency Message Diffusion for Accident Information (EMDAI) approach is proposed for the efficient communication of emergency message. The EMDAI approach ensures the broadcasting of Short Range Message (SRM) and Long Range Message (LRM) to all the vehicles with minimum delay. A Non-Redundant Acyclic Group (NAG) technique is introduced to form a group to avoid the broadcast storm problem. In addition, the proposed EMDAI approach provides assistance to the ambulance to reach the Point of Incidence (PoI) in a short span of time. The performance analysis is done on reliability, channel occupancy, delay, message transmission per involved vehicle and traffic clearance delay. The results prove that the proposed EMDAI approach outperforms the existing protocol.***

Keywords: Vehicular Ad Hoc Networks, Emergency Message Diffusion, Accident Information, Ambulance Assistance and Broadcast Storm Problem.

I. INTRODUCTION

A Vehicular Ad Hoc Network (VANET) is a specific form of mobile ad hoc networks, spontaneously forms a connection among moving vehicles that are equipped with wireless interfaces. These wireless interfaces could be achieved using similar or different radio interface technologies, employing short-range to medium-range communication system. The emergency message can be propagated through vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I). The vehicles can be of small, medium and heavy vehicles and these vehicles have different capabilities with respect to speed and purpose. The infrastructure could be of roadside units

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cellular networks, internet clouds and satellites. The applications of VANETs [1][2] are broadly classified as safety applications and user applications. A safety application has three major scenarios such as accidents, intersections and road congestions. User applications are mainly to provide roadside information, advertisements and entertainment.

A VANET operates in a self-organized manner without any fixed infrastructure this leads to two major routing issues such as broadcast storm problem and network disconnection problem. The broadcast storm problem occurs when the vehicles send information by flooding [3][4]. For safety applications, VANETs need broadcast protocols to disseminate information proficiently and consistently within a given region. Generally, VANETs are linear in nature, and the vehicles are exceedingly mobile with probably predictable movements. Due to high mobility of the vehicles, connectivity is a real dispute. Routing protocols for VANETs must deal with the partitioning and merging of networks. In VANETs, to improve the performance of the network the concept of mobility can be considered. This nature offers the possibility of optimizing the existing routing protocols or there is provision for even designing new routing protocols.

Nowadays, vehicles travel at a high speed on highways, which increase the occurrence of accidents. There is a necessity to broadcast safety messages to avoid further collisions and also to provide medical assistance to save the lives of people. Broadcasting is considered to be the most suitable communication mechanism to diffuse safety messages in VANETs and this could be achieved through flooding. However, flooding introduces the redundant message retransmission and broadcast storm problems [5]. A plethora of selective retransmission protocols are proposed to overcome these issues in an optimal and efficient manner. The selective retransmission protocols [6][7][8][9] overcome redundant message retransmission by selected relay vehicles within its proximity. Most of the existing selective retransmission protocols are focuses the performance metrics of reliability and delay and few protocols consider the metrics of channel occupancy and message transmission per involved vehicle. None of these protocols provides complete solution. In addition, mostly all the existing protocols were implemented in two different infrastructures such as highways and urban.

There is a need of efficient broadcast protocol which addresses all the issues that need to be focused.

In this paper, an Emergency Message Diffusion for Accident Information (EMDAI) approach has been proposed for broadcasting emergency message to all the upcoming vehicles to avoid further collisions. In addition, the proposed approach assists the ambulance to reach the PoI with minimal delay. The EMDAI adopts Non-Redundant Acyclic Group (NAG) to overcome broadcast storming problem. The EMDAI approach has been implemented using two different channels as discussed in [10] for two different messages SRM and LRM. The SRM will reach the vehicles that are in the proximity of 100m whereas the LRM will reach the vehicles in the range between 100m to 200m from PoI. In this work, the traffic scenarios of national highways are considered with respect to day and night.

The following sections present organization of the work in a detailed manner with necessary explanations, algorithms results and discussions. Section 2 describes the background study. Section 3 discusses the related works pertaining to the proposed work. Section 4 represents the design and execution of the EMDAI system model. Section 5 illustrates the system performance metrics with respect to different scenarios. The conclusion is presented in the Section 6.

II. BACKGROUND STUDY

A. Connected Dominating Group

The most common technique to forward a message without redundancy is Connected Dominating Group (*CDG*) [11].

Let *G (V, E)* be the graph induced by the network topology, so that *V* is the set of nodes in the network and *E* is the link between them. Then a subset $V_{CDS} \subseteq V$ is said to be dominating if each node in *V* either belongs to V_{CDS} or has at least one neighbor which belongs V_{CDS}

The steps to form *CDG* as follows:

(i) Initialize every element $v \in V$ as unconnected *(U).*

(ii) $\forall\ v \in V$, find its neighbor $N(v) = w$.

(iii) For every v $\exists$ a neighbor w such that the neighbor of w does not exist in $N(v)$.

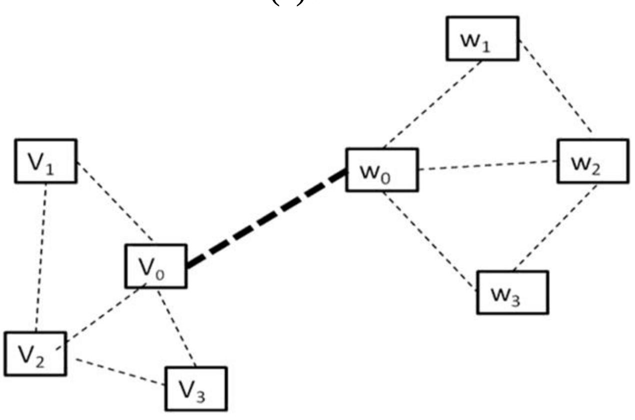

Fig. 1 Connected Dominating Group

In the example of Fig. 1 $N(v_0) = \{v_1, v_2, v_3, w_0\}$, $N(v_1) = \{v_0, v_2\}$, $N(v_2) = \{v_0, v_1, v_3\}$, $N(v_3) = \{v_0, v_2\}$, $N(w_0) = \{w_1, w_2, w_3, v_0\}$, $N(w_1) = \{w_0, w_2\}$, $N(w_2) = \{w_0, w_1, w_3\}$, $N(w3) = \{w_0, w_2\}$. After step2 $N(v_0) \cap N(v_1) \neq NULL$ (Neighbor of v_0 and v_1 are connected), the same way for every V_i find the intersection with its neighbors. If the intersection is *NULL* then the nodes are connected. Otherwise, the nodes are unconnected, for eg. $N(v_0) \cap N(w_0) = NULL$. This implies that the nodes v_0 and w_0 are *CDG*. In the same way all the unconnected nodes in the graph forms a *CDG*.

B. Dedicated Short Range Communications

Dedicated Short Range Communications (DSRC) [10] is a short to medium range communications service that supports communal safety and personal operations in road-side to vehicle and vehicle-to-vehicle communication environments. Due to road constraints its mobility is highly regular and predictable in normal conditions. In this protocol, the *75 MHz* frequency band allocated by federal communication commission has seven *10 MHz* channels to minimize the inter-symbol interference over long distance with high mobility. The second and third channels are allocated for medium range services and can be bounded to *20 MHz* channel. The fifth and sixth channels are for short-range services. *IEEE 802.11p* standard has been used for *MAC* layer and orthogonal frequency division multiplexing physical layer of *IEEE 802.11a. IEEE 802.11*p achieves data rates of 3 Mbps up to *1 km* and *27 Mbps* within *200m.*

III. RELATED WORKS

Broadcasting is the most suitable communication mechanism to transmit emergency information in VANETs. Broadcasting allows the vehicles to retransmit the accident information to all the vehicles in their proximity.

However, it introduces redundancy because all the vehicles which receive emergency information involve in further communication. This brings down the efficiency of the communication system due to overhead and delay. There exists a plethora of broadcast protocols in the past for emergency message transmission and these protocols suffer from retransmission and overhead. This section focuses the most common broadcast techniques that have been designed for VANETs.

Fusun and Umit [12] proposed an Urban Multi-Hop Broadcast Protocol for Inter-Vehicle Communication to address broadcast storm, hidden node and reliability problems of multi-hop broadcast in urban areas. This protocol forwards and acknowledges the broadcast packet to only one vehicle by dividing the road portion inside the transmission range into segments and choosing the vehicle in the utmost non-empty segment. New directional transmissions are initiated by the repeaters when there is an intersection in the path of the information transmission.

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In this protocol the repeaters retransmit the same message more than once which leads to considerable overhead. Tatsuaki et al. [13] proposed a flooding protocol to disseminate the safety information along with velocity and position. This work is implemented the congestion detection algorithm to suppress unnecessary packets and backfire algorithm to forward packets efficiently by selecting the adequate receiver nodes based on the distance. This protocol suffers from scalability issues. Yu and Cho [14] proposed a selective flooding method based on the time which benefits selective rebroadcasting the emergency message among the vehicles. This protocol also considers the priority for forwarding the messages. There will be a delay in selecting the vehicle for rebroadcasting the emergency message.

Vegni et al. [15] proposed a novel approach to reduce the broadcast storm problem by opportunistically selecting neighboring nodes. In this work, the cluster head is elected based on zone of interest whenever the vehicle approaches it will be forwarded to the cluster heads in order to limit the broadcast. The increase in the mobility of the vehicles leads to frequent change of cluster heads in a small time interval. This may cause overhead and delay in the emergency message dissemination. Muthamizh et al. [16] proposed a Spanning Tree-Based Broadcasting protocol to reduce end-to-end delays by reducing duplicate messages. The vehicle computes a spanning tree within its transmission range when a vehicle receives a broadcast message. The vehicle becomes the source and decides the rebroadcasting vehicle through Prim's algorithm. In spanning tree algorithm, the vehicle in the root node may suffer from message delivery delay when there is more number of vehicles in the traffic.

Nakorn and Rojviboonchai [17] proposed a density-aware reliable broadcasting protocol which performs periodic beaconing to receive density information from its 1-hop neighbor and uses the information for broadcast decision making.

The overhead of the involved vehicle will be high because each vehicle stores the rebroadcasting message. Di et al. [18] proposes a multicast routing for maximum distance separation code and local topology information from the forwarding set to achieve robust communication. Also it achieves maximum flow and minimum cut data dissemination using carry-and-forward scheme which solves the disconnection problem in sparse VANETs. Qianhong et al. [19] proposed a privacy preserving system that ensures content reliability in vehicle to vehicle communications. The system has prior and posterior countermeasures to the content speed and traffic contest. The authentication and verification of messages are done through batch process technique to bring down the overhead due to this there may be delay in message dissemination. Panagiotis et al. [20] proposed an algorithm which collects location, speed, and acceleration for all coupled vehicles to forecast the future path. In addition, an emergency electronic break light application uses this algorithm to meet the importance of using communication in road users. Francisco Javier et al [21] proposed an efficient and appropriate technique for extensive range of vehicular ad hoc networks. Every vehicle decides whether it belongs to a connected dominating set which uses a smaller waiting time for retransmission. It provides high consistency and content competency for insecure applications. The retransmission timeout delay is to limit the size of the acknowledgment list in beacon messages. Jaehoon et al. [22] proposed a data forwarding scheme utilizing the vehicles trajectory information for light traffic networks. It preserves the privacy in data forwarding. It computes the expected data delivery delay at individual vehicles using trajectory information and traffic statistics. Qing et al. [23] proposed a location based broadcast communication protocol to meet the highway safety and communication requirements. It considers the channel occupancy to reduce the probability of failure in highway traffic during message transmission. Nekovee [24] proposed an epidemic algorithm for information dissemination without additional control data. Yung-Cheng and Nen-Fu [25] proposed an information reduction scheme to represent local traffic information through mobility adaptive cluster. This simplifies individual high speed movements and reduce information broadcast. In addition, it implements vehicle adaptive cluster-to-cluster multi-hop forwarding scheme to increase the efficiency of multi-hop propagation by selecting optimal relay node in the cluster. Francisco and Perdo [26] proposed an optimal data forwarding technique in minimum no. of transmissions. It adopts the polynomial-time approximation algorithm to overcome the issues in data dissemination. Zhuang et al. [27] presented a time and location critical methodology for urgent information dissemination where vehicles near the accident region receive authenticated, complete information to initiate necessary action without delay. The vehicles still away have to be informed and take location aware decisions referred of GEO by Mani et al.[28] with the support of reverse traffic.

IV. EMDAI – THE PROPOSED APPROACH

A. System Model

The proposed work assumes a vehicular ad hoc network in which the set of vehicles are passing through two lanes in an opposite direction. The common scenario for proposed work is presented in Fig. 2. The emergency information can be disseminated to all the other vehicles without redundancy through NAG. The assumptions for common scenario have two lanes in each direction in national highways. There are vehicles v_1, v_2, v_4 and v_5 moves in one direction and the vehicles v_3, v_6 and v_7 moves in another direction. The *PoI* represents Point of Incidence where the accident has happened.

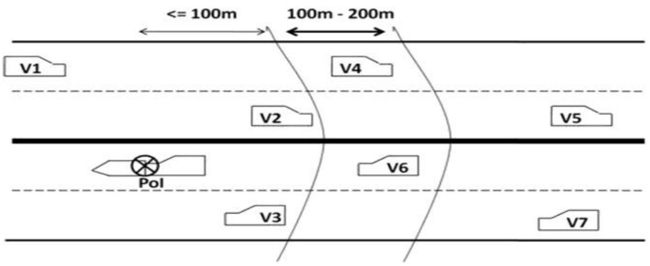

Fig. 2 Traffic Common Scenario

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B. Non-Redundant Acyclic Group

To disseminate the emergency message efficiently a Non-Redundant Acyclic Group technique has been introduced in the proposed work to form an acyclic group.

Let *G (V, E)* be the graph induced by the network topology, so that *V* is the set of nodes in the network and *E* is the link between them. Then a subset $V_{NAG_P} \subseteq V_{NAG} \subseteq V$ is said to be dominating if each node in *V* either belongs to V_{NAG_P} or has at least one neighbor which belongs to V_{NAG_P}

The steps to form NAG_P as follows:

(i) Initialize every element $v \in V$ as unconnected and not received the emergency message *(U).*

(ii) $\forall\ v \in V$, find its neighbor $N(v) = w$. Such that w also not received the emergency message.

(iii) For every v $\exists$ a neighbor w such that the neighbor of w does not exist in $N(v)$.

(iv) Thus the nodes v and w forms a NAG such that the neighbors of v and w are disconnected and not received the emergency message.

(v) Prioritize $v \in V_{NAG}$ such that the velocity of v >= velocity of other vehicles in V_{NAG} irrespective of the vehicle direction otherwise prefer v such that the velocity of v < velocity of other vehicles in V_{NAG} only in the same direction.

(vi) Now, the nodes v and w forms a NAG_P such that the neighbors of v and w are disconnected and not received the emergency message.

C. System Description

All vehicle floods the beacons with discrete interval of time. The vehicle which receives the beacon checks the status of the received emergency message to avoid redundancy. If the status bit is set the emergency message has been received already otherwise, NAG has been formed with the respective vehicle. When a vehicle met with an accident immediately it generates two kinds of messages namely *SRM* and *LRM*. The range for *SRM* message is less than or equal to *100m*. The *SRM* are instantly sent to the vehicles that are existing in the short ranges. The *SRM* is mainly for emergency alert that will be sent to the one-hop neighbor of *PoI* at every time interval t_1. Upon receiving the *SRM* message the one-hop neighbor intern has to forward to its one-hop neighbor with its velocity and also it sends an *ACK* utmost once to *PoI*. The purpose of sending the velocity is to avoid further collisions. Based on the number of *ACKs* the density of the vehicles can be calculated and also it gives provision to reduce the number of *SRM* message by increasing the time interval t_1.

The *LRM* is to give warning for the vehicles which comes in long distance from *PoI* to take necessary precautions. The range of the *LRM* message is between *100m* to *200m* from *PoI*. This message is being sent in particular time interval t_2 along with the density of the vehicles nearby *PoI*. The number of vehicles may be more beyond *100m* range. Due to this reason, there is a need to have an efficient routing mechanism to forward the *LRM* without redundancy and with minimal delay to all the vehicles. In the proposed work the concept of *NAG* has been adopted in order to route the *LRM* efficiently to all the designated vehicles.

a. Vehicles Available on Both Directions in the Proximity of PoI

The Fig. 3 shows that the scenario with the vehicles which moves on both directions and located in the proximity of *PoI*. Once a vehicle met an accident the SRM will be generated and transmitted to the vehicles v_1, v_2 and v_3 that are in the proximity of *100m* for every time interval t_1. The vehicles v_1, v_2 and v_3 intern forward the *SRM* to its one-hop neighbors with its velocity. For example, Fig. 3 shows that the vehicle v_2 is a one-hop neighbor of *PoI* will forward the *SRM* to its one-hop neighbor's v_4 and v_7. The one-hop neighbors of *PoI v1, v2* and *v3* give *ACK* packets to *PoI* as soon as it receives the *SRM* only once. The *LRM* generated by *PoI* will be sent to the vehicles between the ranges of *100m - 200m* along with the density of the vehicles. In the scenario the vehicles v_4 and v_7 will receive the *LRM* for every time interval of t_2. To forward the *LRM* to the other vehicles without redundancy the concept of *NAG* has been implemented. In the scenario, the vehicles v_4, v_6 and v_4, v_9 are not connected directly. Based on the concept of *NAG* the vehicle v_7 acts as an intermediate vehicle to forward the *LRM* to v_6 and v_9. In the same way v_7, v_5 and v_7, v_8 are not connected directly, the vehicle v_6 acts as an intermediate vehicle to forward the LRM to v_5 and v_8. The vehicles v_6 and v_7 forms the *NAG*.

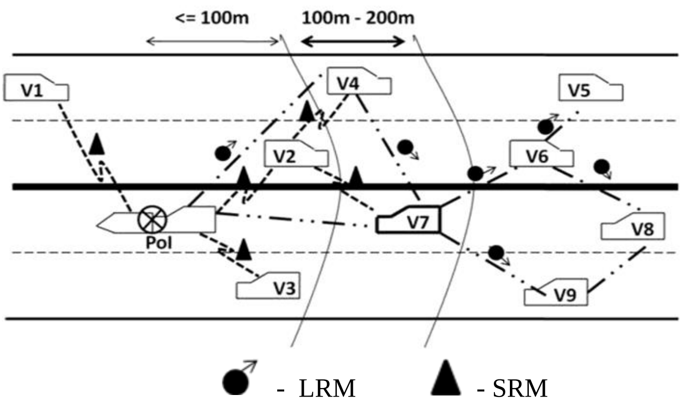

Fig. 3 Scenario for Vehicles in Both Directions

b. No Vehicles in Opposite Directions in the Proximity of PoI

The scenario shown in the Fig. 4, the vehicles move only towards *PoI*. Once a vehicle met an accident the *SRM* will be generated immediately and it will be sent to the vehicle v_3 that is in the range of *100m* for every time interval t_1. There is only one vehicle v_7 in the range of *100m-200m. A*s discussed in Section A the vehicle v_7 receives *SRM* and *LRM* for every time intervals t_1 and t_2 respectively. The vehicle v_9 is not directly connected to v_7 where v_8 is in the proximity of both

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the vehicles v_7 and v_9. Hence the vehicle v_8 acts as an intermediate to forward the *LRM*. From this scenario, it observed that the delay to deliver the *LRM* message to every vehicle in the lane is more when compared to the earlier scenario as discussed in Section A. Because the velocity of those vehicles will speed up the message delivery if suppose there are vehicles in the opposite direction.

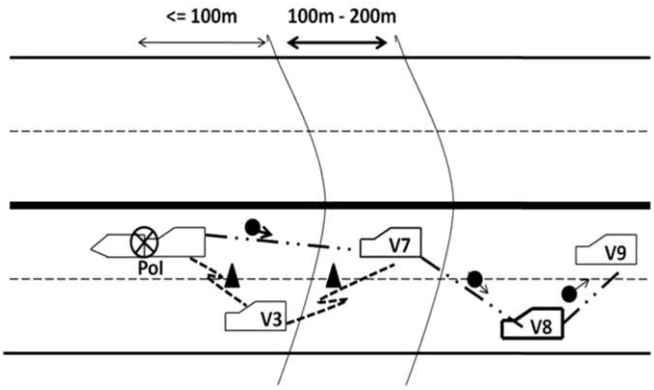

Fig. 4 Scenario for No Vehicles in Opposite Direction

c. No Vehicles in the Proximity of PoI

The scenario in the Fig. 5 shows that there is no vehicle in both the direction in the proximity of *PoI*. At every time interval t_1 and t_2 the *SRM* and *LRM* are sent within the range of *100m* and *100m-200m* respectively. Any vehicle from any direction comes in the proximity of *PoI* it first receives *LRM* and it will try to forward the message when any other vehicles comes in its proximity. Further, the routing of messages will happen as per the discussion of the previous sections A and B. In this case, there will be an initial delay in delivering *SRM* and *LRM* from *PoI*.

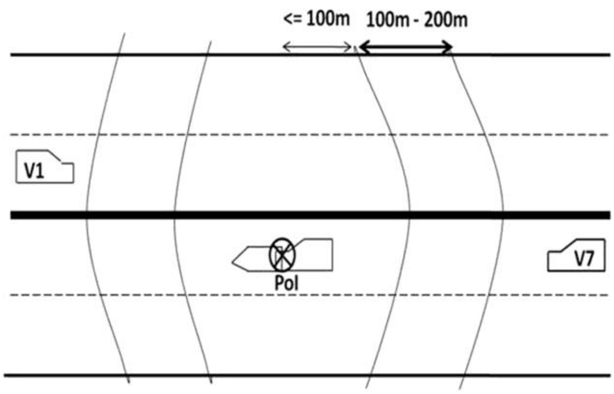

Fig. 5 No Vehicles in the Range of PoI

d. Scenario for Accident Assistance

As per the discussion in scenario-1, once a vehicle met an accident the emergency message will be passed in both directions through *LRM*. It has been assumed that the ambulance is always available in the reachable area of highway. Obviously, the message will reach the ambulance with minimal delay based on the *NAG* method. The ambulance will receive emergency message from more than one vehicle. Upon receiving the emergency message from more than vehicles, the ambulance will generate a Request to clearance *(RTC)* message to the vehicles in the respective lane through *NAG* as depicted in the Fig. 6(a). For example, as shown in the figure the *RTC* information will be disseminated to every vehicle v_7 and v_6 which are in the same lane of *PoI* through *NAG*. Upon receiving the *RTC* message the vehicles in the same lane of *PoI* generate the Traffic Clearance *(TC)* message and sends to ambulance by flooding which is shown in the Fig. 6(b). The ambulance will have the clear path to reach the *PoI* with minimal delay once it gets the *TC* message from the vehicles v_6 and v_7 in the same lane.

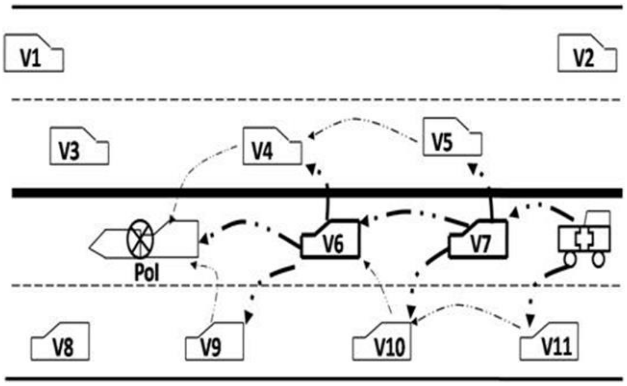

Fig. 6(a) Scenario for Request to Clearance

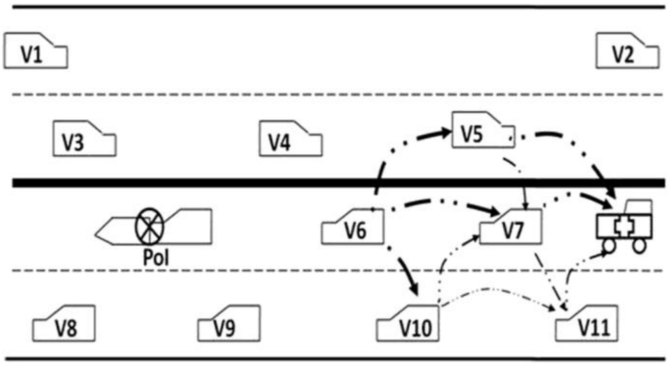

Fig. 6(b) Scenario for Traffic Clearance to Ambulance

D. EMDAI Procedure

A.Initial set-up

The initial set-up procedure defines the format of the message which is used to send beacons, *SRM*, *LRM*, *RTC* and *TC*. The message formats are defined in the following (1)–(5), respectively. The beacons are flooded by the vehicles to identify the neighbors. The format of the beacons is as follows:

$$< Beacon, V_{ID}, M_{ID}, EM_S, Vel, Dir > \text{----------------} \quad (1)$$

Where,

Beacon - Control packet to identify nearby vehicles

V_{ID} - Vehicle ID

M_{ID} - Message ID

EM_S - Emergency message status

Dir - Direction of the vehicle

Vel - Velocity of the vehicle

The *SRM* message is generated by the *POI* and disseminated to the one-hop neighbors to avoid further collision. The message format of the *SRM* is given below:

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$< SRM, V_{ID}, M_{ID}, T_{STAMP}, N_i, R_i >$ --------------------(2)

Where,

SRM - Short range emergency message packet

V_{ID} - Vehicle ID

M_{ID} - Message ID

T_{STAMP} - Time stamp

N_i - No. of vehicles in need of message

R_i - No. of vehicles already received the message

The *LRM* message is generated by the *POI* and disseminated to the one-hop neighbors to avoid further collision. The message format of the *LRM* is given below:

$< LRM, V_{ID}, M_{ID}, T_{STAMP}, N_i, R_i, V_{LANE}, H_{COUNT} >$ -(3)

Where,

SRM - Short range emergency message packet

V_{ID} - Vehicle ID

M_{ID} - Message ID

T_{STAMP} - Time stamp

N_i - No. of vehicles in need of message

R_i - No. of vehicles already received the message

V_{LANE} - Lane of the vehicle

H_{COUNT} - Hop count

The *RTC* message is generated by the ambulance to provide immediate assistance. The message format of the *RTC* is given below:

$< RTC, A_{ID}, M_{ID}, V_{LANE} >$ --------------------------------- (4)

Where

RTC - Request to clear the traffic for ambulance

A_{ID} - Ambulance ID

M_{ID} - Message ID

V_{LANE} - Vehicle lane

The *TC* message is generated by the vehicles after receiving the RTC message from ambulance. The message format of the *TC* is given below:

$< TC, V_{ID}, M_{ID}, V_{LANE} >$ -------------------------------(5)

Where

TC - Traffic clearance message disseminated to the ambulance

V_{ID} - Vehicle ID

M_{ID} - Message ID

V_{LANE} - Vehicle lane

B. EMDAI Algorithm

In the algorithm the *PoI* generates the *SRM* message and broadcast to one-hop neighbors which are available in the proximity (R_1 – range less than 100m from PoI). Upon receiving the *SRM*, the one-hop neighbor forwards intern to their one-hop neighbors. There are two lists *R* and *N* maintained by each vehicle to avoid redundant transmission. *R* represents the vehicles that are already received the *SRM or LRM* message and *N* represents the vehicles that are in need of *SRM or LRM* message. Upon receiving the *LRM* message, the vehicles in the range R_2 (between 100m to 200m) will compute the NA*G* for selective retransmission to all the vehicles. Once the ambulance receives the *SRM or LRM* message, it generates the *RTC* packets and broadcasts through NA*G*. The vehicles that receive the *RTC* message in the same lane of PoI will acknowledge *ACK* to ambulance. The ambulance maintains the *ACKList* to make decision to start based on the threshold value (acknowledgments from 2 vehicles).

Pseudo-code of EMDAI approach

1. Initialization

$PoI \leftarrow$ Point of Incidence
$R_1 \Rightarrow$ Range of *SRM*
$R_2 \Rightarrow$ Range of *LRM*
$N \Rightarrow$ Vehicles in need of message
$R \Rightarrow$ Vehicles already received the message
$S \Rightarrow$ Neighbor set of PoI
A $\Rightarrow$ Neighbor set of ambulance
For every n $\in S$
begin
    if dist(n, PoI) <= R_1
    begin
        $R \leftarrow R \cup \{n\}$
        $N \leftarrow N / \{n\}$
        Broadcast emergency alert SRM to n
        for each w $\in$ R
        begin
            $R \leftarrow R \cup \{w\}$
    Broadcast emergency alert SRM to w
            End
        end
    if dist(n, PoI) = R_2
        begin
        $R \leftarrow R \cup \{n\}$
        $N \leftarrow N / \{n\}$
        end
end

2. Sending warning message

if s $\in R$ and s in reverse direction
    begin
        add s to neighbor set N
        compute NAG_P
    end
if $N \neq \varphi$
    begin

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R $\leftarrow R \cup N$
for each $n \notin N$ and n in reverse direction
broadcast warning message LRM
end
3. Assistance to Ambulance to Reach PoI
If s = ambulance
begin
for each w $\in A$
begin
$I \leftarrow I \cup \{w\}$
Broadcast RTC
end
end
add w to I
compute NAG_P
if $I \neq \varphi$
begin
broadcast RTC
schedule TC
update ACKList
end
if ACKList >= threshold
ambulance starts moving towards PoI

Pseudo-code for NAG_P

Initialization
V_i - Set of vehicles
Vel_i - Velocity of i^{th} vehicle
Dir_i - Direction of i^{th} vehicle
n - No. of vehicles
begin
compute NAG
max = a[1]
for i = 2 to n
begin
if a[i].Vel > a[i+1].Vel
begin
max = a[i].Vel
priority [i] = high
return i;
end
else if a[i].Dir == a[i+1].Dir and a[i].Vel < a[i+1].Vel
return i;
end
end

Pseudo-code for NAG

Initialization
Let NAG be a set
Let V_i be the set of vehicles
Let V_k and V_j be the neighbors of V_i
if $Neighbor[V_k] \cap Neighbor[V_j] = NULL$
Add V_k and V_j to NAG

V. PERFORMANCE EVALUATION

A. Simulation Setup

This section presents the evaluation of the EMDAI approach using network simulator ns-2.0. To evaluate the performance, this approach use different scenarios of national highways. The simulation was done for 50 vehicles with the network area of 500m x 500m. Two channels with the capacity of 10 MHz and 20 MHz used for two different proximity of 100m and between 100m-200m respectively and the underlying protocol was defined by IEEE 802.11p DSRC. The vehicle speed increases from 10 – 30 m/s with initial speed. The simulation was set to 500s for each set of simulations. The proposed EMDAI approach has been compared with the existing ABSM [21] protocol, which has been discussed in Chapter 3. The same kind of simulation scenarios and parameters has been considered for the performance evaluation of both the protocols. Summary of the simulation parameters are presented in Table 1. The following sections represent the evaluation methodology, the metrics for comparing protocols and simulation results.

TABLE 1
SCENARIO PARAMETERS

Parameters	Value(s)
Simulation Time	500s
Scenario Dimension	500m X 500m
Channels	10 MHz and 20 MHz
Wireless Radio Range	100m and Between 100m-200m
Protocol	IEEE 802.11p DSRC
No. of Vehicles	50
Initial Vehicle Speed	N km/h
Vehicle Speed	Increase in vehicle speed from N * (10 to 30) m/s
Lanes	Two Lanes
Routing Approach	Proposed EMDAI, ABSM

B. Performance Metrics

The outcome of the proposed EMDAI approach is analyzed based on the evaluation metrics of reliability, channel occupancy and no. of message dissemination per involved vehicles for the intimation of accident information to the other vehicles. The metrics traffic clearance delay and delay to reach PoI are taken in to account to analyze the performance of accident assistance. Reliability*:* The ratio between the number of vehicles that receive the disseminated information and the total number of information that received it. Every vehicle may not receive the broadcast message because they may be partitioned from the source due to various scenarios as discussed in the section C. To determine the message delivery the following formula has been used:

Reliability $R = NVR_m / TNV$ ----------------------(6)

Where,
NVR_m – No. of the vehicles received the emergency message
TNV – Total no. of vehicles to receive the emergency message

Channel Occupancy: The average fraction of time used to transmit all the messages in the channel. In this work, there are two kinds of channel has been implemented for the transmission range of up

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to 100m from *PoI* and the transmission range between 100m to 200m from *PoI* to transmit the messages *SRM* and *LRM* respectively.

Channel Occupancy *CO* = $(\lambda * p_n * d_v)/t ----(7)$

Where,

λ - the generation rate of messages at *t*

p_n - no. of packets transmission at *t*

d_v - density of vehicles at *t*

t - time interval

No. of Message Transmissions per Involved Vehicle*:* The no. of messages transmitted by every vehicle involved in broadcasting the emergency message with respect to total no. of vehicles.

Average No. of Message Transmissions per Involved Vehicle

$$AVG_{MTV} = \sum_{i=1}^{n} NMT(V_i)/TNV ----(8)$$

NMT - no. of messages transmitted by vehicle V_i

TNV - total no. of vehicles

Message Delivery Delay: The time taken to reach the *SRM* and *LRM* messages to all the vehicles in forward and opposite direction

Traffic Clearance Delay*:* The time taken to reach the *RTC* message to all the vehicles and the time taken for the *ACK* packet to reach ambulance.

Delay to Reach PoI*:* The time the ambulance takes to reach the *PoI* is measured in minutes.

C. Results and Analysis

a. Reliability with Respect to Density (Day and Night)

The Fig. 7 shows that the reliability factor is measured for *SRM* and *LRM* messages. Normally in day time density of the vehicles are high in highways. The light vehicles which move in high speed during day time whereas heavy vehicles moves in low speed during day time. The figure shows that when the number of vehicles is increased the reliability is getting decreased gradually for both EMDAI and ABSM approaches with respect to *SRM* and *LRM*. Due to the increase in density and mobility it may not be possible for the message to reach all the vehicles in a particular time interval which affects the reliability factor. But the proposed EMDAI approach outperforms the existing ABSM approach due to fact that the EMDAI uses two kinds of channel for two different messages *(SRM and LRM)* in a particular time interval. This has been implemented for the scenarios discussed in section C.

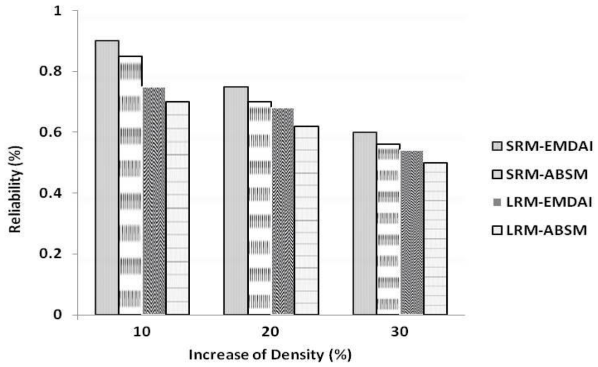

Fig. 7 Increase of Density Vs Reliability (Day)

During night time the average speed of the vehicles are lesser than in the day time and also the density will be less in highways during late nights. The implementation has been done to determine the reliability by increasing the density of the vehicle as shown in the Fig. 8. When the density of the vehicle is less the *SRM* will be delivered to all the vehicles with in its proximity whereas the *LRM* will be delivered almost 80% of the vehicles that are in the range between 100m to 200m. When the density increases the delivery of *SRM* and *LRM* is brought down but not lower than the day time because during night time the heavy vehicles are more which moves with low speed than the light vehicles. This leads to delivery of message to more number of vehicles in a particular time interval. The implementation has been done for EMDAI and ABSM for different scenarios as discussed earlier.

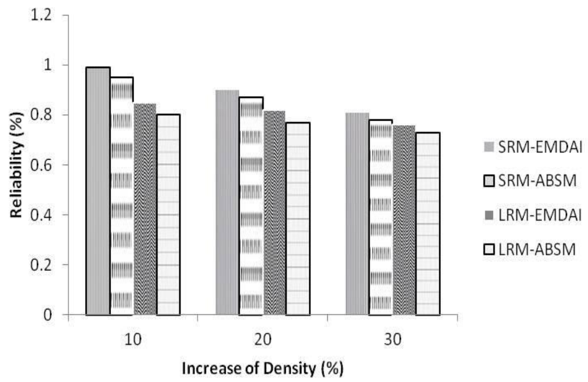

Fig. 8 Increase of Density Vs Reliability (Night)

b. Message Transmission with Respect to Mobility (Day and Night)

The number of messages forwarded by individual vehicles for two different approaches may vary when mobility increases as shown in the Fig. 9. In the day time, the number of transmissions per involved vehicle increases to a factor of 2 for both the *SRM* and *LRM* messages for two different approaches EMDAI and ABSM. This factor may reach the highest values 6 and 5 for *SRM* and *LRM* messages respectively. For all the three scenarios the proposed EMDAI approach proves to be higher number of message delivery among the total number of vehicles than the existing ABSM approach. In the third scenario in section C, The increase of mobility for vehicles will be an advantageous because it comes to the proximity quickly. This reduces the delay for message delivery to the vehicles.

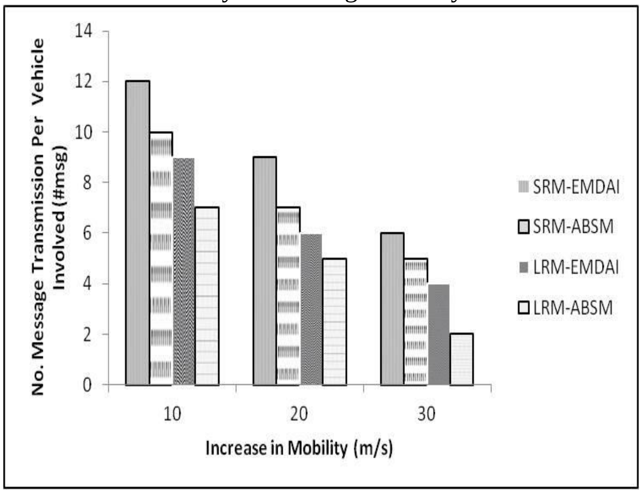

Fig. 9 Increase in Mobility Vs No. of Message Transmission per Vehicle Involved (Day)

In night time the number of message dissemination may the reach the maximum value 14 when the increase in mobility is 10% for all the vehicles as shown in the Fig. 10. There is a noteworthy difference between the EMDAI and ABSM has been observed in the simulation. When mobility increases the number of SRM and LRM messages delivered to the vehicles will be decreased drastically. In scenario 1 of section C, when the mobility is increased to the vehicles in the opposite direction may lead to high message transmission for individual vehicles. Whereas in Scenario 2 of section C, there is no vehicle in the opposite direction which may lead to reduce the message transmission for individual vehicles.

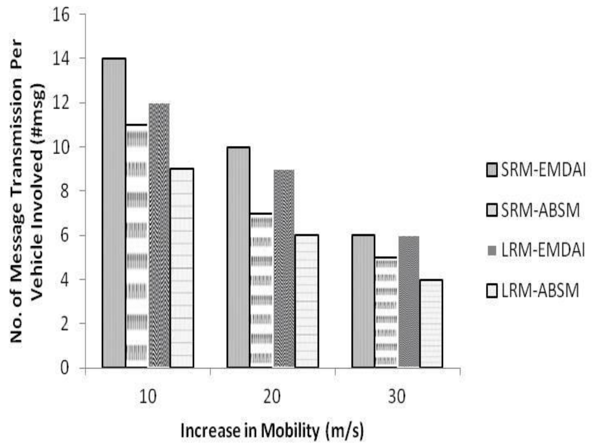

Fig. 10 Increase in Mobility Vs No. of Message Transmission per Vehicle Involved (Night)

c. Channel Occupancy with Respect to Density

The channel occupancy caused by vehicle-to-vehicle communication must be low in highways because the density varies from time-to-time. When the density increases more number of vehicles may try to use the channel to send or forward emergency messages. This may leads to congestion into a channel which may reduce the number of vehicles receiving emergency messages. The comparison is made with respect to two different approaches EMDAI and ABSM by varying the density of the vehicles as shown in the Fig. 11. When the density is increased from 10% to 30% the average channel occupancy of EMDAI increased by 8.5% whereas ABSM is increased by 9.5%. This ensures that the EMDAI is better than ABSM.

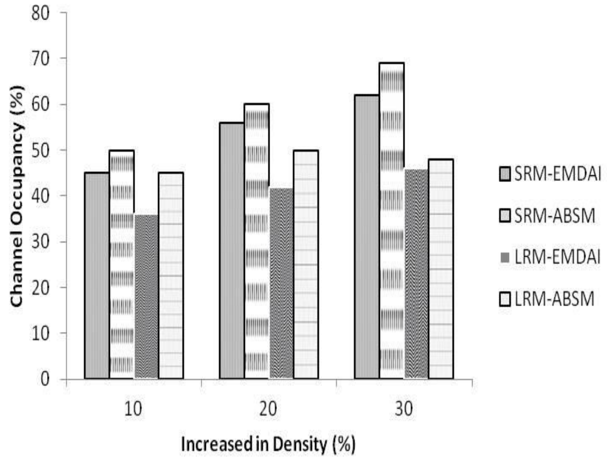

Fig. 11 Increase in Density Vs Channel Occupancy

d. Message Delivery Delay with Respect to Mobility

The Fig. 12 depicts that the message delivery delay increases when the mobility increases in the forward direction whereas it is reduced in the opposite direction. In forward direction EMDAI has reduced to a factor of 0.09 when compared with ABSM. In opposite direction EMDAI has reduced to a factor of 0.34 when compared with ABSM. This proves that the proposed EMDAI approach has less delay than ABSM.

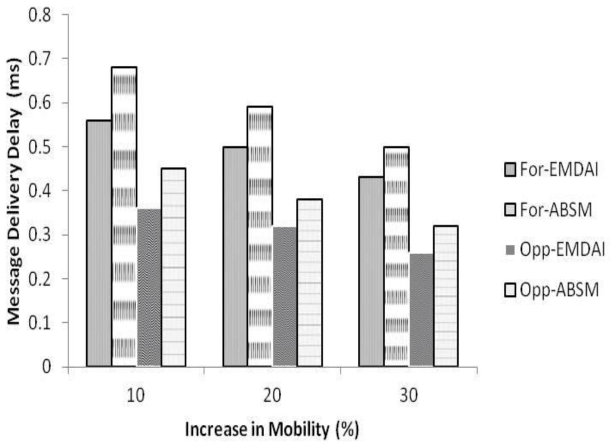

Fig. 12 Increase in Mobility Vs Message Delivery Delay

e. Traffic Clearance Delay

The traffic clearance delay when the density is increased from 10% to 50% in the same lane is presented in the Fig.13. The average difference in traffic clearance delay is measured based-on density of vehicles in the same lane as 0.072 ms. When the density in the same direction is increased the *RTC* message will reach to the other vehicles in the lane with minimum delay. Then the vehicles in the same lane send the *TC* message with minimum delay when density is increased in opposite direction.

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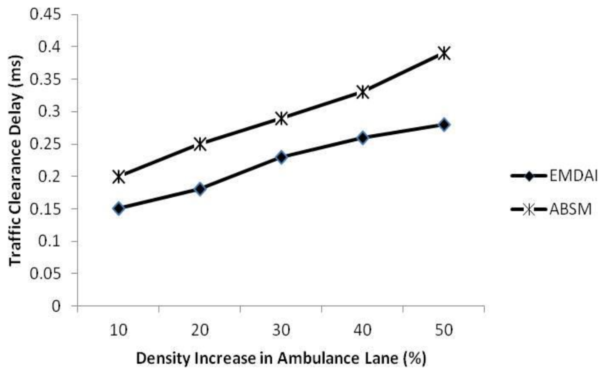

Fig. 13 Density Vs Traffic Clearance Delay

f. Delay to Reach PoI

As soon as the emergency message is received by the ambulance, it has to reach the *PoI* with minimum delay in order to provide medical assistance. The average delay with respect to two different approaches is evaluated as 5.2 mins. The delay is decreased when the mobility increases as shown in the Fig. 14.

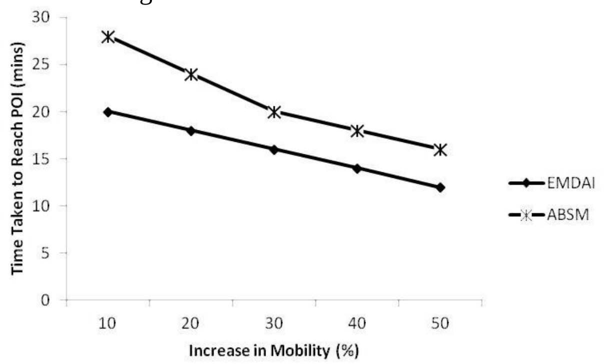

Fig. 14 Increase in Mobility Vs Time Taken to Reach POI

VI. CONCLUSIONS AND FUTURE WORK

In this paper, the EMDAI approach has been proposed to provide emergency message dissemination in VANETs. The concept of *NAG* has been applied to overcome the broadcast storm problem. To reduce the channel occupancy in *SRM* and *LRM* delivery, two different channels with two different communication ranges have been used. A new strategy has been designed to make the ambulance to reach the *PoI* in very short span of time. The results are analyzed with respect to reliability, transmission of message per involved vehicle for two different times day and night. The EMDAI performs well when compared with ABSM. The channel occupancy ratio with respect to increase in density of vehicle proves to be optimal when compared with the existing protocol. The traffic clearance delay is made minimal by choosing the vehicles in the same direction to disseminate the *RTC* message. The EMDAI protocol is implemented for all the scenarios in Section C. In all the three scenarios the EMDAI approach outperforms over the ABSM.

The EMDAI approach is implemented in vehicle-to-vehicle communication which can be enhanced for vehicle-to-roadside unit to disseminate the additional information to improve the performance of the proposed approach further.

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