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ORIGINAL RESEARCH

EE-FMDRP: energy efficient-fast message distribution routing protocol for vehicular ad-hoc networks

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Abstract
Vehicular ad-hoc network (VANET) is a promising communication framework that provides connectivity between vehicles via vehicle-to-RSU (road side unit), inter-RSU and inter-vehicle communications and is features by high dynamic topological formation of nodes in the network. In VANET, the message distribution delay and reliable communication are the significant factors in case of emergency based communications. The main contribution of this paper relies on reducing message distribution delay with minimal communication overhead. Moreover, energy efficient-fast message distribution routing protocol (EE-FMDRP) has been proposed with the collaborative features of both time and direction oriented routing models. It has been proposed for broadcasting messages in case of emergencies from the source end to the defined target in fast, reliable and efficient manner. For that, bi-directional evaluation model for moving vehicles and message delivery time derivation model has been framed. This helps in performing fast message broadcasting in emergency cases with maximal throughput and reduced delay. Also, the EE-FMDRP offers consistent and efficient route between source vehicle and the destination with optimal intermediates and reduced complexities. Further, the protocol takes less message distribution time by selecting optimal intermediates, thereby providing energy efficiency and minimized network overhead. For evaluation, NS-2 simulation tool is used and the results prove that the proposed model achieves improved results than the compared existing protocols.

Keywords VANET · Energy efficient-fast message distribution routing protocol (EE-FMDRP) · Distribution delay · Throughput

1 Introduction

In present days, amount of vehicle usage has been increasing tremendously. Hence, there is a great demand in safety applications for resolving traffic and accident issues on road transportation. Vehicular ad-hoc networks (VANET) is a rising technology developed for supporting smart road transportation and enhancing road safety by managing the traffic flow efficiently and avoiding accidents and congestions. In general, VANET is one of the progressions of mobile ad-hoc networking (MANET) for offering road safety and other services to the people. The proposed EE-FMDRP model achieves lesser transmission delay than other compared models, attains minimum transmission overhead than the compared models. It produces 6% greater throughput than the previous work. It attains higher rates of packet delivery ratio compared with others. It achieves lesser energy consumption rate than other compared models Moreover, the VANET model provides location based GPS oriented services to the customers. The components of VANET are on board unit (OBU)—responsible for data collection from different sensors and communication with other OBUs and road side unit (RSU)—infrastructure which enables communication to the outside network and communication technology—wireless access in vehicular environment (WAVE) supports multi-hop communication between vehicles.

Typically, there are two major types of VANET based services, which are as follows,

1. safety oriented services
2. non-safety oriented services.

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The major intention of safety oriented services is to enhance the safety of both the traveller and the vehicles concurrently (Rubin and Yang 2014). This can be attained by dissemination of emergency messages to the corresponding devices that are located in the region for disaster management or emergency situations (Busson et al. 2011). The Fig. 1 shows the VANET architecture, which comprises three kinds of links, inter vehicle (vehicle-to-vehicle) communication; inter RSU (RSU-to-RSU) communication and vehicle to RSU communication (Javed et al. 2014). These links are responsible for sharing or forwarding vehicle oriented information.

In a typical VANET, the nodes are considered to as road side unit (RSU) and on board unit (OBU) that are situated in the traffic area, which are in connection with the internet. Additionally, each vehicle is equipped with the GPS for updating the concern people with the speed and location of a particular vehicle. Moreover, VANETs are featured with dynamic topological changes, high rate of flexibility and adaptability. Due to these characteristics of VANET, there are always some issues on finding directions, reliability, data dissemination, overall network performance degrade and lack of security.

The communication between vehicles and the architecture in VANET is accomplished through efficient routing, but because of the continuous topological changes, there may cause network division, transmission delay, data loss, collision, etc. In case of any critical situations, the emergency alert will be created by the vehicles that are around the particular regions and then, distributed by the adjacent node instantly (Li et al. 2016).

The protocol in this work realizes the VANET prospective to improve the traffic safety and traffic management and to provide smart transportation model. Moreover, EE-FMDRP works on considering the direction in which the vehicle running and the message delivery time for minimizing the message distribution delay and communication overhead in emergency situations. The fast message distribution model works on four phases: adaptive beaconing (AB) initialization, vehicle direction (VD) based authorization, message delivery time (MDR) based confirmation and energy efficient route framing. Further, the contributions of the proposed model are given as follows.

- The vehicle at the source end forwards a call request to the adjacent transmitting nodes to the limited nodes that are in the specified communication range, listed in the neighbour set [$Ns(V_x)$].
- The EE-FMDRP is improved with the vehicle direction based authorization or rejection by bi-directional evaluation model of moving vehicles. Through this, the unwanted message broadcasting is decreased, thereby reducing the communication overhead issues and enhancing energy efficiency.
- The appropriate positions of the vehicles are evaluated on using the vector-angle oriented classification model.
- The protocol selects the optimal intermediates (forwarding neighbours) for forwarding data with minimum message delivery time.
- The best route is framed with the selected optimal intermediates.

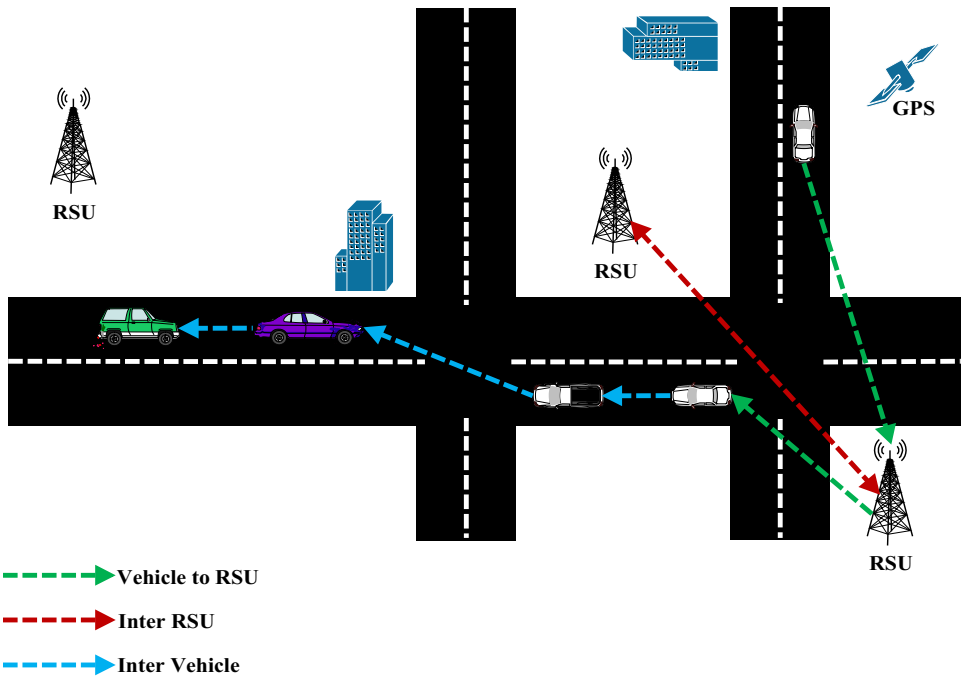


Fig. 1 VANET architecture

- It improves the traffic management, mobility, QoS and information exchange.

The rest of this paper is ordered as follows: Sect. 2 deliberates the related works. Section 3 describes about the proposed EE-FMDRP model and its operation on optimal best route framing for reducing message distribution delay and energy consumption. The results and comparative assessments are given in Sect. 4. Finally, Sect. 5 concludes the paper with some paths for future enhancement.

2 Related works

This section describes about the various existing protocols on message broadcasting in VANET. Message broadcast storm problem has been discussed in Tseng et al. (2002) and developed a mitigation model called Three Pioneering Scheme. The scheme comprised of counter based scheme, distance based scheme and location based scheme, as it name represented. But, schemes are well adaptive for the MANET environment, without concerning about the dynamic nature of VANET. Further, the authors of Wisitpongphan et al. (2007) derived three predominant schemes for VANET: weighted p-persistence, slotted 1-peristence and slotted p-persistence. Following that a new protocol called distributed vehicular BroadCAST (DV-CAST) has been proposed, which provided sufficient information about the restricted topology for finding the vehicles in well-communicative networks. For those implementations, the weighted p-persistence model has been requested to utilize for holding back the broadcast storms (Tonguz et al. 2010).

Further, the enhanced version of slotted 1-persistence scheme was provided in Schwartz et al. (2011) with the developed protocol called simple and robust dissemination (SRD). The enhanced model described priority levels for both vehicle directions at highways. In Torrent-Moreno et al. (2009), a different protocol called emergency message dissemination for vehicles (EMDV) has been proposed. The protocol enhanced the message transmissions consistency by using a forwarding region and a contention model. In a different way, the two-dimensional city scenarios have been considered in Korkmaz et al. (2004) and the developed protocol is named as urban multi-hop broadcast protocol (UMB) for solving the issues of broad cast storm, hidden node and network reliability. Moreover, the designed protocol used two handshaking models such as request to broadcast and clear to broadcast for optimal vehicle selection for message transmission. Further, the UMB protocol routes to repeaters located at the junction points for initializing a new relay based on the final destination. But, the repeaters employment was more cost effective for implementation, which was the drawback for the protocol usage.

Another work in Fogue et al. (2012), enhanced message dissemination based on roadmaps (eMDR) has been developed, which used the city map and GPS for detecting the vehicle location. Further, the enhanced model of DV-CAST has been given in Viriyasitavat et al. (2011), named urban vehicular broadcast (UV-CAST), in which the waiting time for re-dissemination of data is evaluated on the basis of distance between vehicles and location. The minimum delay rate is attained at the vehicle at the junction points that meant to broadcast messages into multi-directional points. DRIVE-data dissemination protocol in vehicular networks (Villas et al. 2014) discussed about grouping the neighbour nodes into several groups for efficient message both city and highway circumstances. In DRIVE model, the communication region is divided into four sections and selected a sub-region in each section called sweet pot. It was evaluated in the paper that the vehicles at the sweet pot are generating minimum re-dissemination delay.

A cross-layer broadcast protocol for a consistent emergency message distribution has been given in Shibu et al. (2014). In addition to decrease the message repetition and communication delay, it provided fast and reliable message delivery. Initially, an appropriate relaying node was chosen for transmitting messages. Cluster based broadcasting model is given in Berlin and Sundari (2011). The authors of Makwana (2011) proposed an efficient message dissemination (EMD) model in cases of emergency. The model involved in choosing a transmitting node, which is farer from the source end. Moreover, the work concentrated on reducing the broadcast storm problem in critical situations.

A profile-driven adaptive warning dissemination scheme (PAWDS) has been provided in Srinivetha and Gopi (2014) for enhancing the emergency message distribution. The scheme changed some of the key factors of the broadcasting process. Through this process, vehicles at critical positions can be easily identified and alerted using a warning message. Further, in Javed et al. (2014), the number of transmissions was reduced using an capable time slot based multi-hop broadcasting protocol in warning message distribution. The model worked on choosing a vehicle subset from RSU for working as an efficient relay node. Each set has a segment leader to forward the emergency messages that are forwarded to the particular road segment. For avoiding interferences, separate time stop has been used for broadcasting emergency messages. And, Particle Swarm Optimization (PSO) based intelligent emergency message broadcasting model has been developed in Samara and Alhmiedat (2014).

Road accident prevention (RAP) has been proposed in Gokulakrishnan and Ganeshkumar (2015) for immediate distribution of emergency warning signals to the vehicles. Using the protocol, the accidents to be happened in high way environments can be prevented effectively. In the road accident prevention model, the road side unit identified the

accident probability or the happenings of emergency situations, immediately an emergency message is generated and distributed to the overall network with high priority of reception rates.

Content based broadcasting (CBB) model has been given in Ghassan Samara et al. (2011) for enhancing the overall performance of the VANET in emergency message distribution. The warning message was being transmitted through the multi-hop forwarders in multi-hop fashion module. The forwarder nodes were selected on the basis of segment localization and progression criteria. The warning messages are further re-disseminated via network segments.

3 Proposed model for efficient message dissemination in VANET

In this paper, energy efficient-fast message distribution routing protocol (EE-FMDRP) has been proposed for broadcasting messages in case of emergencies from the source end to the defined target in fast, reliable and efficient manner. In the overall process of efficient routing, optimal intermediates (forwarding neighbours) are selected on the basis of vehicles position, directional flow and the message delivery time. The complete work process of the proposed EE-FMDRP has been provided elaborately in the following sections.

3.1 Initial VANET set up

As mentioned earlier, in vehicular ad-hoc networks, the vehicles that are included are designed with GPS for providing the appropriate information about the current location and time. Moreover, the vehicular nodes are dispatched with several sensors, thereby, the emergency situations of the vehicle or its environment can be determined effectively through the sensors. Therefore, the nodes can obtain and deliver the communicational data even in emergency scenarios.

The critical condition covers all the emergency cases such as natural calamities, dynamic environmental situations, accidents etc. It is also to be assumed that OBU also designed in the vehicular nodes and RSU is located in road sides. The road side units have greater storage capacity and computational efficiency than OBUs. The road side units are communicated with each other through wireless communication medium. Hence, the proposed model uses the road side units when it receives the emergency messages from the vehicular node. After that, the emergency messages are forwarded to the Rescue Centers for rescue operations.

3.2 Work process of EE-FMDRP in VANET

The protocol is mainly designed from serving communication in emergency cases. Energy efficient-fast message distribution routing protocol forwards fast and directional oriented messages to the target vehicle. This increases the energy efficiency and reduces message distribution delay and message overhead in VANET. The operations of EE-FMDRP comprise five phases: adaptive beaconing (AB) initialization, vector-angle oriented classification model, vehicle direction (VD) based authorization; message delivery time (MDT) based confirmation and energy efficient route framing.

3.2.1 EE-FMDRP framework

The energy efficient-fast message distribution routing protocol framework is represented in the Fig. 2. In this paper, all the vehicles are considered to be registered in the vehicle management authority using their Ids, which controls the overall identity related data of vehicles. When the vehicles are under critical situations, adaptive beacon messages are passed to the adjacent vehicles. The emergency message comprises, EM_ID (emergency_message ID), position of source vehicle, vehicle velocity, direction and time.

In this protocol design, the direction, position, distance and speed of the vehicles are used for identifying the vehicles at next-hop to distribute the emergency message to the target vehicle. The communication links that are used by the protocol are: vehicle-to-vehicle, vehicle-to-RSU and RSU-to-RSU.

3.2.2 Adaptive beaconing (AB) initialization

The main purpose of incorporating adaptive beaconing (AB) is to share knowledge based data by forwarding beacons often, thereby preserving congestion less wireless communication. This can be attained through the estimation of two factors, quality of the communication medium and message efficiency. This helps in increasing the performance of traffic information system. This section deliberates the process of AB initialization.

During the process, the vehicle at the source end distributes the emergency beacon signal to the adjacent nodes that are surrounding the source, in the range of signalling. The neighbour set $[Ns(V_x)]$ comprises the adjacent nodes of vehicle V, within a specific region of communication. When the vehicle starts forwarding the beacon message, a vehicle is selected from the neighbour set $[Ns(V_x)]$. The initialization process starts by forwarding a call request to all the vehicular nodes in the $[Ns(V_x)]$ and also satisfies the condition that are in the range of communication. The calling function is executed in regular intervals to update the present neighbours, since the nodes are highly mobile in nature. The Table 1 presents the procedure for AB initialization.

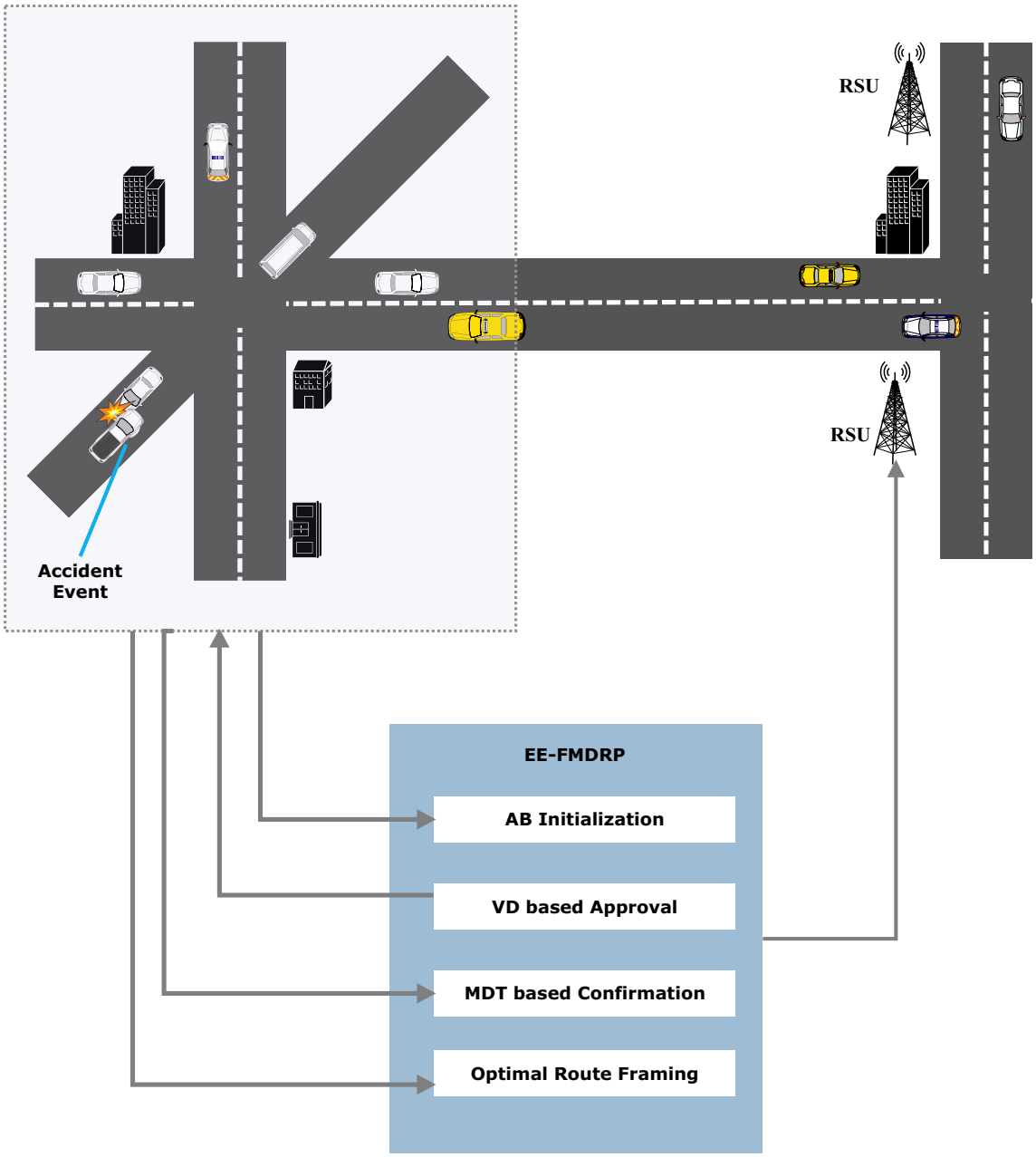


Fig. 2 EE- FMDRP framework

3.2.3 Vector-angle oriented classification model

The process achieves the fast and efficient message distribution by focusing on the position, location and directional flow of the vehicles, moving on roads. Here, vector-angle oriented classification model is used for identifying the position of the vehicle, corresponding to a specific region. The Table 2 gives the algorithm for vector angle based position detection.

In the Table 2, 'SV' denotes the sending vehicle, which intend to forward the emergency messages, 'λ' is the angle threshold value and 'n_a' and 'n_b' are denoted as the co-ordinates of the neighbour set. From this process, the position of the each vehicle in the defined VANET and its neighbour vehicular nodes are identified for efficient emergency message forwarding.

3.2.4 Vehicle direction (VD) based authorization

The determination of moving vehicles direction helps to find if the current vehicle is moving to the target or not. From this determination, the optimal intermediates

Table 1 Procedure for AB initialization

Begin
Start Adaptive Beaconing
Let *'x'* be the source vehicle
Let $\boldsymbol{Ns}\ (\boldsymbol{x}) \in \boldsymbol{V} \rightarrow$ Neighbour vehicle set present around the source vehicle 'x', in the communication range
// $Ns \rightarrow$ Neighbour vehicle set in communication range
// $V \rightarrow$ Vehicle set $\{V_1, V_2, V_3,..., V_n\}$
For each $y \in Ns\ (x)$
Node 'x' forwards call request to node 'y'
End For

Table 2 Vector angle based position detection for vehicles

Condition : Sender Vehicle V_s receives the message
Input: position of V_s and its neighbour set *[Ns(Vs)]*
While $Ns\ (V_s) \neq \emptyset$ do
For a=1 to numb*[Ns(Vs)]*, m=1 **do**
Ns(Vs)= Ns(Vs)-{n_a}$\rightarrow$ remove n_i from *Ns(Vs)*
$R_m \leftarrow n_a \Rightarrow$sort n_a into directional region R_m
For b=a to numb*[Ns(Vs)]***do**
If (n_a SV n_b <λ) **then**
$R_m \leftarrow n_b \Rightarrow n_b$ into the same R_m of n_a
Ns(Vs)= Ns(Vs)-{n_b}
End if
b++
end for
store R_m into section buffer
d++
end for
end while

called forwarding neighbours can be estimated. The vehicle nodes are denotes as $V \rightarrow$vehicle set $\{V_1, V_2, V_3,\ldots, V_n\}$, which is constant and each vehicle has the ability to realize whether it is running towards the target vehicle or not, in accordance analysis of distance between the present vehicle and the corresponding source vehicle.

In the AB periodic intervals, the vehicle at the reception point finds the distance rate as Dis(t_{AB}). At an instant, the vehicular node finds the distance from the source node is given as Dis(t). The direction of the moving vehicle is estimated through the following Eq. (1)

$$VD = \begin{cases} 1, \ if\ Dist(t_{AB}) > Dist(t) \\ 0, \ Otherwise \end{cases} \quad (1)$$

If the result is 1, then, the condition is satisfied and it can be taken that the present vehicular node is moving towards the destination. If the result is 0, the condition is not satisfied. Hence, the vehicle is moving opposite to the required directional motion.

Moreover, in the phase of vehicle direction (VD) based authorization, the vehicle intends to make a decision, whether to participate in message transmission as an optimal forwarding neighbour for getting the approval. From the above equation of determining the vehicle direction, when the VD results in 1, the node is running towards the target, it receives the call request and replies the source node with a message called call_request_approval. Otherwise, when it obtains 0, then the reply will be call_request_rejection from the current vehicle to the source. All Vehicular nodes that are participating in the communication in VANET are maintaining a list called request approval list (RAL) and a request confirmation list called (RCL).

It is significant to determine the VD to find the moving direction of the vehicular node, whether it is towards the destination or opposite to that. When a sender vehicle intends to distribute an emergency_message to a specific target, some most optimal intermediates are selected among the vehicles from request approval list (RAL). By this selection process, the unwanted message distribution can be effectively avoided, thereby, improving the energy efficiency. The algorithm for call_request_Approval based on VD is given in Table 3.

3.2.5 Message delivery time (MDT) based confirmation

The estimation of message delivery time makes the process of forwarding_neighbour detection easily. By determining MDT, the message reaching time to the target vehicle can be evaluated. Based on that, the vehicular node has the aptitude

Table 3 Vehicle direction (VD) based approval

Procedure Message Distribution
Switch case ('emergency_msg')
Case('emergency_msg') is call_request ('N' receives call_request from 'M')
Begin
If $Dis_N(t_{AB}) > Dis_N(t)$
Send call_request_approval
Add vehicle M to (RAL_M)
Else
Send call_request_rejection
End if
End
Case('emergency_msg') is call_request_approval ('M' receives call_request_approval from 'N')
Begin
If 'N' obtains Min (MDR)
Send call_request_confirmation message
Add 'N' as an optimal intermediate for 'M'
End if
End
Case('emergency_msg') is call_request_confirmation ('N' receives call_request_confirmation from 'M')
Begin
Delete from RAL_N and add to $Confirmation_list_M$
End
End case
End Procedure

to find the optimal forwarding neighbours for efficient and fast emergency message distribution. Therefore, MDR is evaluated based on the Eq. (2)

$$MDT(V) = \frac{Dis(V)}{Speed(V)} \tag{2}$$

Using the derivation, it is determined that the received call_request_approval is confirmed or not. After the reception of call_request_approval response, the optimal intermediates are confirmed for distributing the emergency messages to the destination vehicle. If a source vehicle obtains more than a call_request_approval response, it can be selected as one of the best forwarding_neighbor, which is farer from the initial vehicle and capable of distributing messages with low message delivery time. The Low MDT (LMDT) is given as,

$$LMDT = Min(MDR_M), \quad M = 1, 2, \ldots, n \tag{3}$$

where, MDT_M denotes the message delivery time of vehicular node 'M'.

Based on the equation, one of the forwarding_neighbour is confirmed by sending the call_request_confirmation. Further, the particular node is deleted from the RAL list and inserted into the confirmation list. This can be accomplished at specific time intervals. Following the confirmation part based on the message delivery time, the optimal route establishment has been accomplished for message distribution.

3.2.6 Energy efficient route framing

The route is framed with the vehicular nodes, that are received the call_request_confirmation message. That is, the route framing has been done by connecting the nodes

Table 4 Route framing

Input: Confirmation_list
Output: Framed Route from Source Vehicle to Destination
Procedure (Route Framing)
Let M = Source Vehicle
While (M≠Destination)
Add M to Route
M=Confirmation_list (N_M)
End While
End Procedure

that are selected as optimal intermediates for forwarding the emergency messages in fast and efficient manner. Initially, the node 'M' forwards a call_request_confirmation message to node 'N'. Then, the node 'M' initiates the route framing. The confirmed vehicles are added to the route path, till it reaches the desired destination vehicle. Hence, the EE-FMDRP model frames an energy efficient routing by analysing the distribution nature of the vehicular nodes in case of emergencies. The procedure for route framing is provided in the Table 4.

4 Performance evaluation and result analysis

For analyzing the performance of energy efficient-fast message distribution routing protocol (EE-EMDRP), it is implemented in NS-2.34 tool. The simulation condition has been designed for managing message distribution in emergency cases in high ways and city traffic model. In order to provide evident for the efficiency of the EE-EMDRP, the obtained results are compared with the existing protocols such as, emergency message dissemination for vehicles (EMDV) and profile-driven adaptive warning dissemination scheme (PAWDS) and the previous work of the author called traffic dynamism-balanced routing protocol (TDBRP) for VANET. The essential simulation parameters are given in the Table 5 with their corresponding values. The vehicular nodes are considered to be in random motion. The target vehicles are positioned at the road side. The vehicle at the source end starts forwarding AB messages from the emergency area.

The protocol evaluation has been carried out on the basis of the significant parameters of VANET such as packet delivery ratio, throughput, transmission overhead, energy consumption rate and transmission delay. Typically, transmission delay is defined as the time taken by the message to reach the target vehicle from the source end. The results obtained for transmission delay with respect to time is given

Table 5 Simulation parameters with initial setup

Parameters	Values
Simulator	NS-2.34
Simulation area	3000 m × 2900 m
Simulation time	300 s
No. of roads	36
No. of junctions	22
No. of vehicles	75–150
Vehicle speed	Random
MAC protocol	802.11 DCF
Capacity of channel	2 Mbps
Mobility model	Random waypoint
Transmission range	256 m
Propagation model	Two way ground
Traffic type	16 CBR connections
Packet size	128 byte

in the Fig. 3 and the corresponding values are given in the Table 6. The simulation derives for delay for distribution and re-distribution of emergency messages. It is explicit from the graph that the proposed EE-FMDRP model achieves lesser transmission delay than other compared models.

Transmission overhead is the next significant factor to be considered on the performance analysis of a VANET protocol. It is defined as the ratio of the total number of beacon messages distributed to the total amount of data packets forwarded. The Fig. 4 portrays the results on transmission overhead and the corresponding values obtained are given in the Table 7 for reference. The EE-FMDRP model involves in selecting optimal intermediate to transmit the emergency messages. By this process, the proposed model avoids unwanted transmission of messages to some other vehicles, which may move opposite to the destination. This makes the process energy efficient. The results in the chart show that the proposed model attains minimum transmission overhead than the compared models.

The Fig. 5 depicts the results obtained for throughput analysis, which is defined as the number of data packets reached the target vehicle per second. From the figure, it is shown that there is an increase in the throughput of the proposed model than the others. Therefore, it can be stated that the emergency messages are forwarded to the destination with minimal time. From the figure, it is explicit that the proposed model obtains higher throughput value and it keeps on increasing with respect to time. The EE-FMDRP produces 6% greater throughput than the previous work.

Moreover, in this evaluation, the efficiency of the protocol has been evaluated by estimating the packet delivery ration (PDR) it is defined as the ratio of data packets received by the destinations to those generated by the sources it is based on the vehicle numbers and vehicles mobility speed

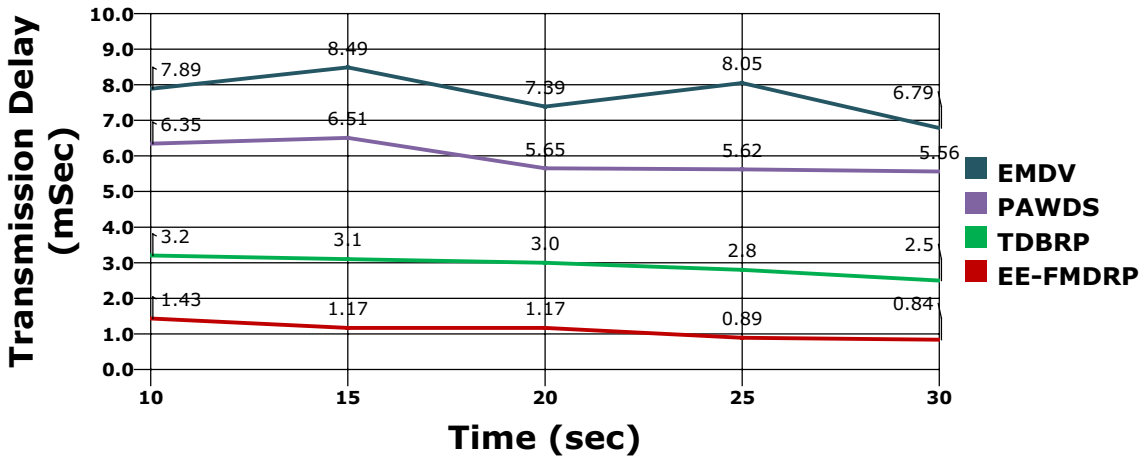


Fig. 3 Transmission delay evaluation

Table 6 Results obtained for transmission delay

Time (s)	10	15	20	25	30
EMDV	7.89	8.49	7.39	8.05	6.79
PAWDS	6.35	6.51	5.65	5.62	5.56
TDBRP	3.2	3.1	3.0	2.8	2.5
EE-FMDRP	1.43	1.17	1.17	0.89	0.84

Table 7 Values for transmission overhead comparison

Vehicle mobility (m/s)	2	4	6	8	10
EMDV	2.6	4.6	6.2	7.1	7.6
PAWDS	2.5	3.2	4.8	6.8	6.8
TDBRP	1.4	1.9	2.5	3.2	3.8
EE-FMDRP	1.0	1.4	1.6	1.8	2.6

respectively. The evaluation results are given in the Figs. 6 and 7, and the corresponding resultant values are provided in the Tables 8 and 9. It is clearly portrayed from the graphs that the EE-EMDRP attains higher rates of packet delivery ratio compared with others in both the cases of evaluation. This shows the efficiency of the proposed work in cases of forwarding messages in emergency cases.

Another important factor to be included in the process of performance evaluation of the designed protocol is energy consumption. Moreover, energy consumption rate is defined as the ratio of the total energy consumption of a vehicular node to the amount of data packets received. Here, the analysis has been made according to the mobility speed of the vehicles. The results are presented in the Fig. 8 and the corresponding values are given in the Table 10. In this, the energy is efficiently consumed by avoiding unwanted message transmissions, identifying optimal forwarding_neighbors. Hence,

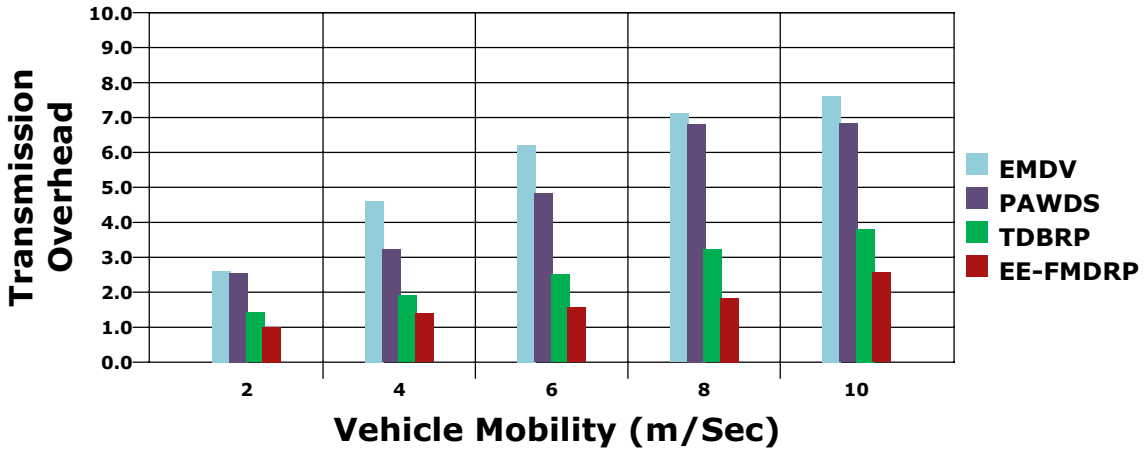


Fig. 4 Comparative analysis on transmission overhead

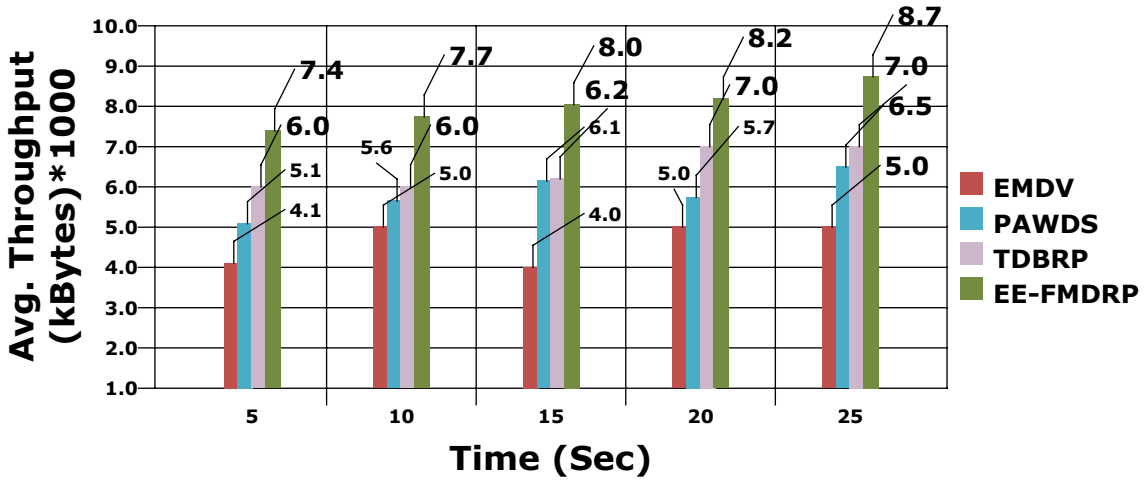


Fig. 5 Throughput evaluation between models

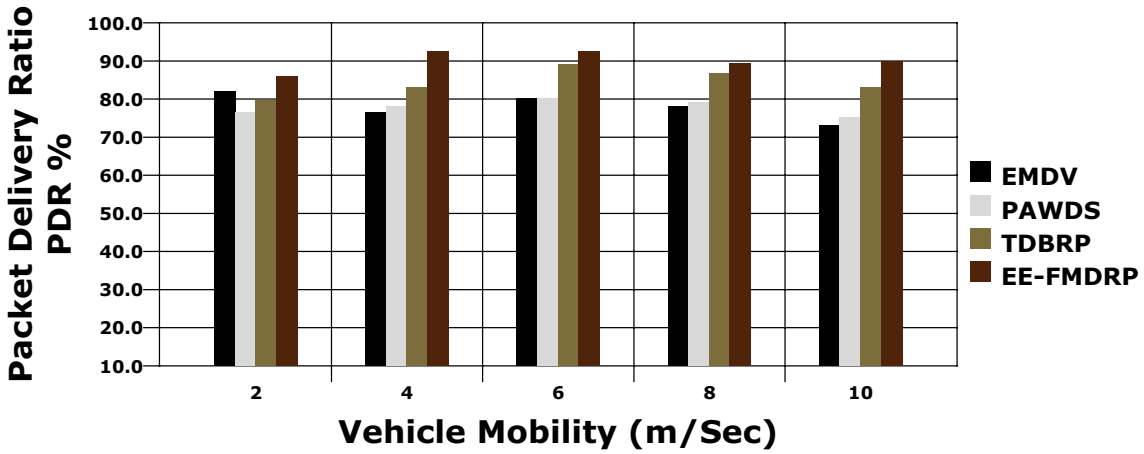


Fig. 6 Results for PDR vs vehicle mobility

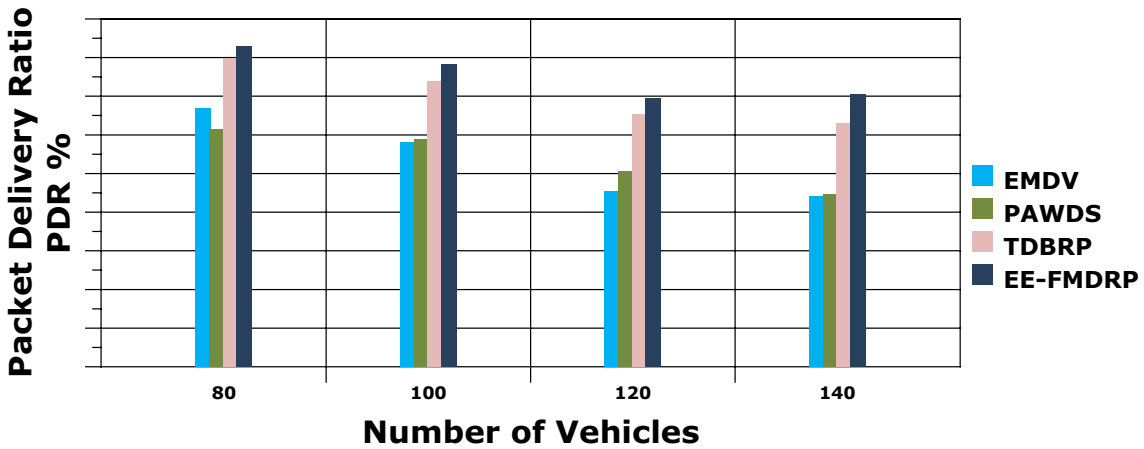


Fig. 7 Packet delivery ratio vs no. of vehicles

Table 8 Results for vehicle mobility based pdr evaluation

Vehicle mobility (m/s)	2	4	6	8	10
EMDV	82.0	76.2	80.0	78.0	73.0
PAWDS	76.2	78.0	80.0	79.0	75.0
TDBRP	80.0	83.0	89.0	86.0	83.0
EE-FMDRP	85.8	92.0	92.0	89.0	90.0

Table 9 Values obtained for PDR vs no. of vehicles

Number of vehicles	80	100	120	140
EMDV	77	68	55	54
PAWDS	71	69	60	54
TDBRP	90	84	75	73
EE-FMDRP	93	88	79	80

the proposed EE-FMDRP achieves lesser energy consumption rate than other compared models.

5 Conclusion and future work

In this paper, energy efficient-fast message distribution routing protocol has been designed for broadcasting emergency messages in fast and reliable manner in VANET. The protocol involves in selecting optimal intermediates to efficiently forward the emergency messages to the target vehicle, for avoiding collisions and accidents. Further, message distribution works on analysing the position and direction of the moving vehicles through the vector angle based position detection method and vehicle direction based approval. After the process of approval, message delivery time is estimated for providing confirmation. Hence, there is set of vehicles in confirmation list, which are considered to be the selected optimal intermediates. The direction and time based estimation saves the energy consumption effectively. With the vehicular node in the confirmation list, the optimal energy efficient route has been established for forwarding the messages. The simulation results have been analysed with various parameters for evidencing the efficiency of the EE-EMDRP. The protocol achieves minimum transmission delay, maximum throughput and minimum consumption of energy.

The work can be further extended in terms of various attacks and security related issues on message broadcasting in VANET.

Table 10 Values obtained for the models in energy consumption analysis

Vehicle mobility (m/s)	2	4	6	8	10
EMDV	8	14	25	32	37
PAWDS	7	13	22	28	34
TDBRP	6	12	19	24	29
EE-FMDRP	4	9	12	15	20

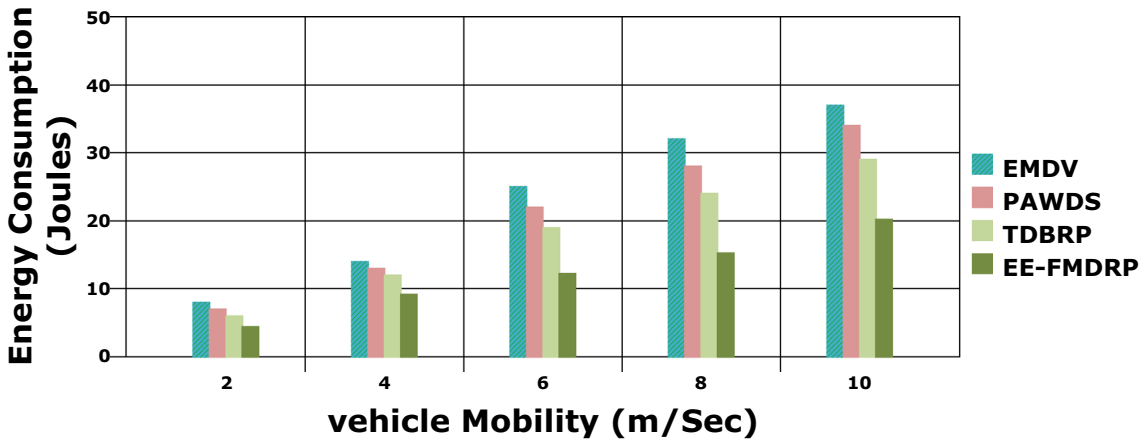


Fig. 8 Energy consumption rate vs mobility speed

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