Fuzzy Based Multi-Hop Broadcasting in High-Mobility VANETs

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Abstract

Vehicular Ad hoc Network (VANET) is an extension paradigm of moving vehicles to communicate with wireless transmission devices within a certain geographical limit without any fixed infrastructure. The vehicles have most important participation in this model is usually positioned quite dimly within the certain radio range. Fuzzy based multi-hop broadcast protocol is better than conventional message dissemination techniques in high-mobility VANETs, is proposed in this research work. Generally, in a transmission range the existing number of nodes is obstacle for rebroadcasting that can be improved by reducing number of intermediate forwarding points. The proposed protocol stresses on transmission of emergency message projection by utilization subset of surrounding nodes with consideration of three metrics: inter-vehicle distance, node density and signal strength. The proposed protocol is fuzzy MHB. The method assessment is accomplished in OMNeT++, SUMO and MATLAB environment to prove the efficiency of it.

Keywords:

Forwarding nodes; Fuzzy logic; Multi-hop broadcast; Vehicular Ad hoc Networks (VANETs).

.1. Introduction

A Vehicular Ad hoc Network (VANET) is enhanced form of mobile ad hoc network, uses moving vehicles as nodes for communication among the vehicles and roadside signal transmission unit. These are swiftly introduced in both education and trade bodies as a version of essential characters of driver helping systems. Due to human error approximately 60 % accidents are occurring across the world, can be reduced with the utilization of the VANETs. Generally, it is inconvenience for the drivers to pay attention for all the incoming messages because of adjacent number of moving vehicles, sometimes that may be cause of accident. By using safety alerts: cooperative collision warning system, access of internet and emergency signals, drivers can be alarmed on different road conditions for the necessary steps to avoid any type of accidents. An efficient more than one hop broadcast protocol can be introduced to resolve such issues. The proposed protocol is considered as fuzzy Multi-Hop Broadcast (fuzzyMHB).

The several-hop broadcast technique is extremely challenging task for sending text from source till destination in the environment of VANETs. Conventional broadcast methods may not have better performance by the avoidance of redundant broadcast, packet loss and degradation of packet dissemination ratio. With a maximum PDR, it is the problem to decrease several redundant broadcast packets. In research work [1], a new multi hop broadcasting protocol for vehicular ad hoc networks is proposed with Multi-Point Relay (MPR) of OLSR [2] in a low overhead rebroadcasting and high-mobility network scenario. The algorithm considers vehicles density in the selection of forwarder nodes. This method employs to reveal predetermined receivers packets to rebroadcast in a critical situation for establishment of an effective and suitable broadcasting proposal of VANETS. For the capacity that follows vehicular safety applications for 100 senders within the broadcast range, PDR (packet delivery rate) is varying up to 95%, because of the unsaturation behavior of the channel. The PDR rate decreases according to the growth rate of sender nodes [3].

The research paper is organized as follows: Nonfuzzy algorithm and Fuzzy algorithm is detailed in Section 2 and 3 Section 4 presents a brief outline of related work. Section 5 represents performance analysis and section 6represents the description of Forwarder Node Selection like fuzzy sets, defuzzification with Matlab figures. Simulation results are explained in section 7. Finally, conclusion and future work are in Section 8.

2. Non Fuzzy Algorithm

Step 1: If (redi>=ten and redi<=fifty)
and (redi>=ten and redi<=thirty)
then betr = ninety percentage
else betr = hundred percentage
redi = range effective distance
betr =Bernoulli trial

3. Non Fuzzy Algorithm

Step1:Fuzzy-Optimal-Broadcasting-method(signal strength good, Longest Distance, less Vehicle Density):

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Step2:if (signal strength == good &&distance== long &&vehicle density==less)
step2.1 betr probability is hundred percentage
step2.2 else if (NN < six)
betr probability is ninety percentage
step2.3 else if (NN < eight)
betr probability is eighty percentage
step2.4 else if (NN < ten)
betr probability is seventy percentage
step2.5 else if (NN < twelve)
betr probability is sixty percentage
step2.6 else if (NN< fourteen)
betr probability is fifty percentage
step2.7 else if (NN< sixteen)
betr probability is forty percentage
step2.8 else if (NN< eighteen)
betr probability is thirty percentage
step2.8 else if (NN < twenty)
betr probability is twenty percentage
else
betr probability is ten percentage
NN=Number of surrounding nodes.

Non-fuzzy comprises with only one condition i.e. the vehicle with longest distance within 300 meters is given priority for the next forwarder. In this approach, emergency message can forward to the vehicle based on its remoteness where waiting time is direct proportional to the distance. In other hand, the vehicle which is ready to deliver an emergency message can be decided with the three factors: distance, density and signal strength where fuzzy rules are framed with respect to the above factors to make the decision for efficient data dissemination in VANETs.

4. Related Work

4.1Muti-Hop Broadcasting In Vanets

In VANETS, information is passed by one of eminent technique known as flooding. In this network, packets are retransmitted by each node to promulgate information as soon as it receives. Generally, in high- mobility network, always flooding includes with more redundant broadcasts that may acquire crashes in a little broadcasting rate. So many sender-oriented protocols are proposed yet to decrease the redundant broadcasts in a high-mobile network. In existed protocol, the relay nodes are included with the sender information whereas in proposed protocol, the nodes are automated.

The receiver related broadcast protocols have been published in [4-6]. Wisitpongphan et al stressed on rebroadcasting schemes as “p-persistence with the weight” and “1 and p-persistence by the slot” [4]. In all the schemes, broadcasting probability is formulated upon receiving message from sender. The probability calculated by Suriyapaiboonwatana et al. was observed to be high for long distance transmission [5]. How to rebroadcast with the choice of definite probability for all nodes is discussed as a stochastic broadcast by Slavik and Mahgoub[6]. Speed Adaptive Probabilistic-Flooding algorithm was proposed by Mylonas et al. [7] where rebroadcast probability was solely based on the vehicle speed. Rebroadcasting decision was taken independently, and hence redundant broadcasting was unavoidable. This problem can be resolved using sender-oriented protocols as it exhibits relay nodes specifically where the relay-nodes are chosen from the content of sharing hello messages. Multi point relay (MPR) is proposed by Qayyum et al. with the special relay technique [8]. An exclusive broadcast technique proposed by Djedidet. al. where interconnected dominant set procedure is followed to select the relay nodes [9]. F.Bai et.al demonstrated MANET on a battlefield where the waving of the soldiers was commander independent, which presents fundamental of fuzzy sets that differentiating from conventional crisp sets, and instituting a novel idea of membership function [10]. The differences between classical and fuzzy relations are present, as illustrations of fuzzy relations, fuzzy equivalence relations, and fuzzy partial orderings [11].

Wireless channel is always unstable, where the receiving process of a hello message from a neighbor is very uncertain. Hence the selection of a forwarder node among the adjacent points with the high probability may be the perfect solution of it [12-14].The advanced distance-based multi-hop broadcast scheme for inter vehicle communication is suggested in this paper through the application of two major approaches with the exponential waiting time (EWT) for faster collision avoidance. In terms of urgent messages broadcasting with higher prioritization intersection waiting time (IWT) is more for message dissemination beyond the intersections. The distance-based multi-hop broadcast system assurances not only fast broadcast but also consistently probable of successful transmission, moreover, the Manhattan map model is applied for the traffic movements of the simulation for performance evaluation in urban areas by providing security [15-17].

Rebroadcast procedure changes according to the vehicle density with minimum delay for generating better throughput in terms of message forwarding. Broadcast Suppression scheme is one of the advanced techniques to decrease the delay rate comparison to a contention-based window technique where minimization of propagation delay is an objective of this paper to enhance the transmission speed. A basic broadcast suppression method for reliable message delivery and its security is presented as the hybrid scheme to cater the highway environment that includes data dissemination strategy for better performance in terms of dissemination delay is presented [18-20]. The research paper proposes space–time diversity with the STNC (space–time network coding) and no-collision transmissions performs better in the dense network in the sparse scenario, which is in sharp contrary to the Code On-Basic random-access strategy [21]. MANETs are prone to various types of attacks. To overcome these attacks different mechanisms like watchdog schemes in IDS are introduced with forge acknowledged packets [22-24, 29].

An Urban Multi-hop Broadcast Protocol (UMBP) introduces a novel forwarding node selection procedure that utilizes iterative partition, mini-slot, and black-burst for a quick selection of remote neighboring nodes, where a single forwarding node is successfully chosen from the asynchronous contentions among them. Multi-directional broadcast is adopted with the appearance of an emergency message in an intersection area to conduct the forwarding node selection process simultaneously in multiple road directions. Moreover, an analytical model is developed to measure the performance of UMBP in terms of one-hop delay, message propagation speed, and message reception rate. Analytical and simulation results demonstration that the UMBP is not only able to transmit emergency messages quickly but also successfully reduce message redundancy and enhance message reliability [25-28].

Proposed Protocol the fuzzy MHB (Multi Hop Broadcast) protocol can be engaged on a portion of mobile network for minimization of rebroadcast redundancy. A sender node with the address of all neighborhoods within a transmission range can connect with the forwarder without any hesitation for rebroadcasting the packets towards the destination. A source node incorporates forwarder packet address of its dissemination. Next broadcast can be possible only after labeling or listing the neighborhoods. The proposed technique incorporates inter-vehicular distance, density, and signal strength for selection of next forwarder. If distance is long, density and mobility are high between the intended moving vehicles then inference of signal is bad, similarly other inferences can be assigned according to the signal strength (discussed in Table 1).

5. Performance Analysis

A. Distance Factor

For reception of emergency message from neighborhood X_1, a node computes a distance factor (DF) as in equation (1).

$$DF(X_1) = \begin{cases} \dfrac{d(X_1)}{R_1}, & d(X_1) <= R_1 \\ 1, & d(X_1) > R_1 \end{cases} \qquad (1)$$

Where $d(X_1)$ is the distance between the exiting node and node X_1 and R_1 is the maximum distance.

B. Density Factor

Density is the number of vehicles per unit length on the road. A vehicle with the lowest waiting time has highest priority.

$$WT_1 = Maxw_1T_1 - (Maxw_1T_1 \times ds \times Rg^{-1}) \qquad (2)$$

Where WT_1 is waiting time, $Maxw_1T_1$ represents maximum waiting time, Rg stands for nodes in a radio range, ds the distance between two nodes. Waiting time for rebroadcast message set as 0. 1000 mtrs is considered as one hop area.

C. Signal Strength

After receiving message from a neighborhood node X_1, it estimates 'Received Signal Strength Indication Factor' (RSSIF)as Eq.3. 'Rx_1Pr_1' denoted as received signal power, 'RXThresh' represents reception threshold.

$$\mathrm{RSSIF}(X_1) \leftarrow (1 - \alpha)\times \mathrm{RSSIF}(X_1) + \alpha \times (1 - \frac{\mathrm{RXThresh}}{\mathrm{Rx_1\,Pr_1}}) \qquad (3)$$

6. Forwarder Node Selection

A. Fuzzy set theory and Fuzz logic: In fuzzy set-theory, all the elements possess degrees of membership. On other hand Fuzzy logic refers IF/THEN rule to represent with the fuzzy inference.

B. Fuzzification: Conversion of a numerical to fuzzy value by the membership function is known as 'fuzzification'. The graphical representation of membership function of the distance, density and RSSI are in Fig. 1., Fig. 2., Fig. 3., and Fig. 4. The sender finds the membership function which degree the belongs: { low, medium, long}, {low, medium, high}, {weak, medium, strong} and {VeryBad; Bad; NotAcceptable; Acceptable; Good, Perfect}.

C. Rule Base: The fuzzy inferences of three metrics have been calculated by the fuzzy logic IF/THEN rules according to assumption of various situations (Table 1).

IF Distance is long, density is low, and Signal Strength is Good THEN Grade is Perfect. In a rule IF part is familiar as "precedent" and THEN part is known the consistent. Combine evaluation results are produced by Min-Max method, since multiple rules applying at a time.

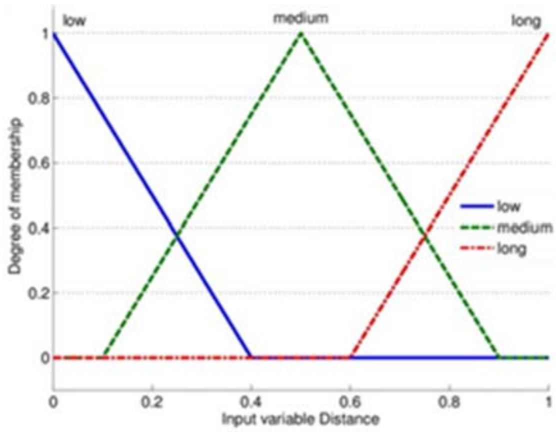

Fig. 1. Distance membership function (mf)

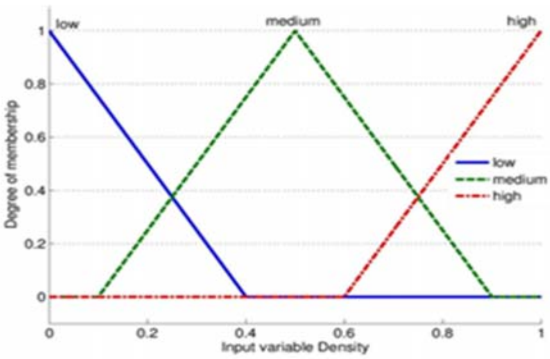

Fig. 2. Density membership function

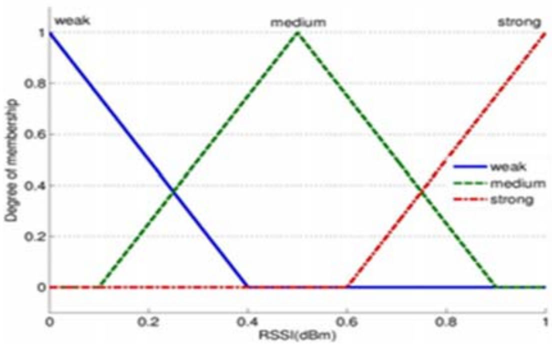

Fig. 3. RSSI (Received Signal Strength Indication) Membership function

In the Min-.Max method, the least value of the predecessor is used as the required degree for each defined rule. The optimal consequent value can be obtained by merging all the rules. A superlative of 27 rules is created in the design. Finally, defuzzification purposiveness is performed using MATLAB.

By using MATLAB software with the Fuzzy command we can obtain above three figures. By utilizing plot mf command, we will get input, output and Grade variables. If applied Grid i.e x then dotted lines came in x axis and if selected Grid i.e y then dotted lines came in y axis. From the above three figures the x axis range can be taken from 0 to 1 and y axis can be taken from 0 to 1. In fuzzy logic techniques for selection of the next forwarder node for the better performance, compared to the non-fuzzy techniques in terms of delay, hops, rebroadcast counts, number of bytes obtained [30].

TABLE 1. RULE BASE

Rule No	Distance	Density	Signal Strength	Grade
Rule1	Long	Low	Good	Perfect
Rule2	Long	Low	Medium	Good
Rule3	Long	Low	Bad	NotAcceptable
Rule4	Long	Medium	Good	Good
Rule5	Long	Medium	Medium	Acceptable
Rule6	Long	Medium	Bad	Bad
Rule7	Long	High	Good	NotAcceptable
Rule8	Long	High	Medium	Bad
Rule9	Long	High	Bad	VeryBad
Rule10	Medium	Low	Good	Good
Rule11	Medium	Low	Medium	Acceptable
Rule12	Medium	Low	Bad	Bad
Rule13	Medium	Medium	Good	Acceptable
Rule14	Medium	Medium	Medium	NotAcceptable
Rule15	Medium	Medium	Bad	Bad
Rule16	Medium	High	Good	Bad
Rule17	Medium	High	Medium	Bad
Rule18	Medium	High	Bad	VeryBad
Rule19	Low	Low	Good	NotAcceptable
Rule20	Low	Low	Medium	Bad
Rule21	Low	Low	Bad	VeryBad
Rule22	Low	Medium	Good	Bad
Rule23	Low	Medium	Medium	Bad
Rule24	Low	Medium	Bad	VeryBad
Rule25	Low	High	Good	Bad
Rule26	Low	High	Medium	VeryBad
Rule27	Low	High	Bad	VeryBad

In Table 1, the distance, density and RSSI factors are assigned as: {long:1, medium:0.5, low:0.25},{low:1, medium:0.5, high:0},{Good:1, Medium:0.5, Bad:0} respectively, which maps to the Rule1,2,4 and 5 . Where in Rule1: the degree of Long distance is 1, Low density is 1 and the Good Signal Strength is 1, hence the degree of the antecedent is 0.5. Comparatively the degrees of the records for Rule2, Rule4 and Rule5 are 1, 1 and 0.5, respectively. As both Rule4 and Rule5 lead to the Grade denoted as Good, the maximum value of antecedents and the degree of Grade is 0.75. A complete fuzzy result can be obtained by this way.

D. Defuzzification

Defuzzification is the process of producing a numeric result from the fuzzy value of corresponding membership degrees. The output membership function explained in Fig. 4. i.e. Center of Gravity (COG) method is referred in defuzzification process. For the example given above, the degree for Grade {Good} is 0.75 and the degree for Grade {Perfect} is 1. Then, defuzzification value can be calculated as The X coordinate of the centroid will be the defuzzified value.

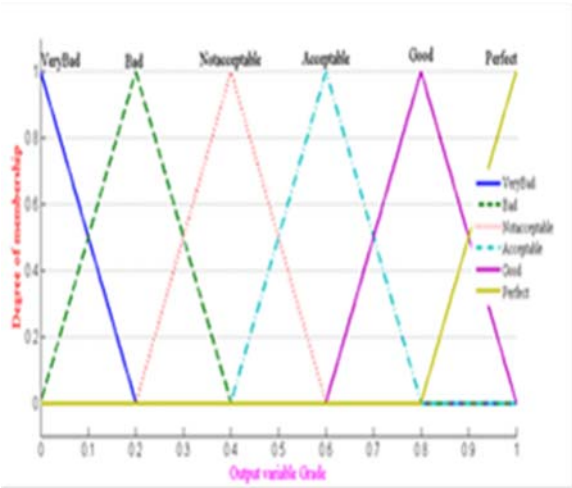

Fig. 4. Membership function of the Grade Output

VeryBad=Grade F, Bad= Grade E, NotAcceptable= Grade D, Acceptable= Grade C, Good= Grade B, Perfect= Grade A.

Mathematically the Center of Gravity method (COG) represents the following equation:

$$X1^* = \frac{\int \mu_a(X1) \times X1dX}{\int \mu_a(X1)dX} \quad (4)$$

$\int \mu_a(X1) \times X1dX$ shows the area within the curve μ_a

X1 be the Distance on X- axis, μ_a is defined with a discrete membership function on Y- axis. Where 'X1 *' is the equation (4) of X –coordinate of COG.

7. Simulation Results

The proposed network simulations and the specifications are area is hundred meter * hundred meter, number of nodes are zero to six hundred, multiple packets are two hundred packets and data rate is two packets/rate.

The Fig. 5. represents x axis includes number of nodes and y axis includes packet delivery ratio (PDR). The PDR is the number of packets received at destination node to the number of packets transmitted from source node. The results show a significant increase in Packet delivery ratio at fuzzy technique as compared to nonfuzzy technique.

The Fig. 6 shows x axis includes number of vehicles and y axis includes delay in seconds. With the increases of node density, the number of emergency messages also increases along with delay at fuzzy technique as compared to nonfuzzy technique. If delay is reduced, then enhance the efficiency of fuzzy logic technique.

The Fig.7.represents the number of options increases is possible according to the rising number of nodes, the x axis includes hop distance and y axis includes number of hops. When the number of nodes is increasing the hop account is increasing in both fuzzy and non-fuzzy logic. However, the number of hops is reducing at fuzzy logic compared to the non-fuzzy logic.

The Fig. 8. represents x axis includes number of vehicles and y axis includes rebroadcast per vehicle. The results show a significant when the sender node sends the packets to the destination node i.e the fuzzy logic technique protocol has less rebroadcast packets compared with non-fuzzy logic.

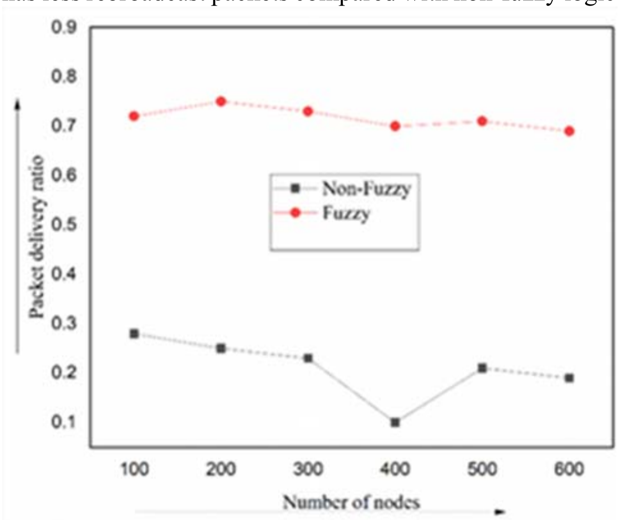

Fig. 5. Number of nodes versus PDR (Packet Delivery Ratio)

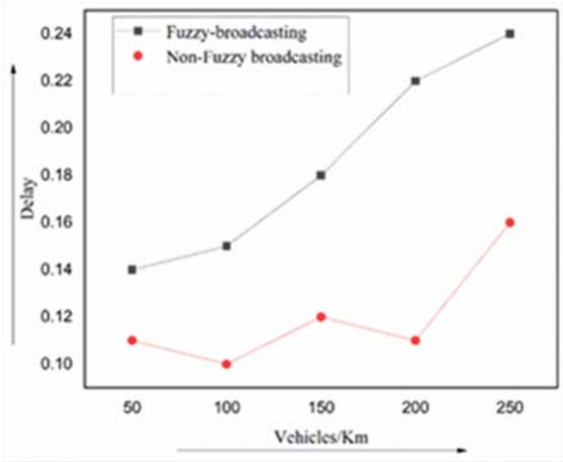

Fig. 6. Vehicles versus Delay

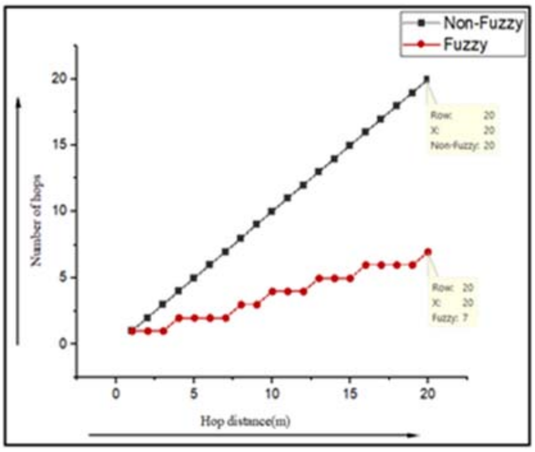

Fig. 7. Hop distance versus Number of hops

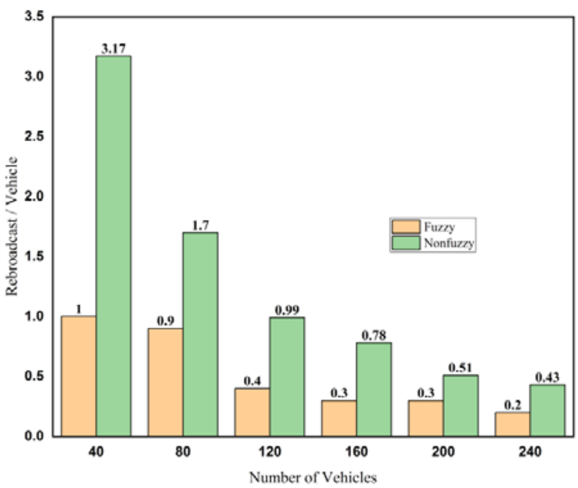

Fig. 8. Number of vehicles versus Rebroadcast / vehicle

8. Conclusions and Future Works

The research claims a protocol Fuzzy MHB that suppresses the number of redundant broadcasting nodes coherently by using Fuzzy selection methods. In this method next forwarder node selection completely relies on the inter-vehicle distance, density and signal strength. Number of hops and rebroadcast counts can be reduced to enhance packet dissemination ratio by referring such type of approach. The performance of the protocol can be improved in further. During the simulation, it confirms the decrement of delay on packet delivery as well as increment on number of packets interms of packet dissemination by referring fuzzy approach in comparison to nonfuzzy methods. Simulation results may be confirmed about significant improvement of the proposed real time methodology on conventional alternatives. In summary, the proposed work is an efficient broadcast solution for message propagation from source to destination via optimum number of intermediate nodes in the dynamic VANETS. A more sophisticated protocol can be developed for real time complicated scenario in future works.

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