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Increase efficiency and reliability in multicasting geographical routing based on Fuzzy Logic in VANETs

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Abstract- Vehicular ad hoc Network (VANET), a subclass of mobile ad hoc networks (MANETs), is a promising approach for the intelligent transportation system (ITS). VANET protocols have to face high challenges due to dynamically changing topologies and symmetric links of networks. A suitable and effective routing mechanism helps to extend the successful deployment of vehicular ad-hoc networks. The task of routing data onto a source node to the base station is a critical issue in VANETs. One of the efficient routes of these networks is geographical routing. In this type of routing, vehicles for special regions are included in a multicast group to prevent broadcasting packets. In this paper, intervehicle geo-cast routing protocol has been improved with fuzzy logic which called f-IVG. In the proposed protocol, we utilized fuzzy logic to choose a link with most link expiration time and probability adapts density to preventing the packet rebroadcasting. In the proposed routing protocol, effective parameters such as distance, direction and velocity have been used to find the next hop node. Results of simulation have shown that the proposed protocol has higher packet delivery ratio and less packet loss and end to end delay.

Keywords- VANET, Geo-cast routing, IVG, Fuzzy Logic.

I. Introduction

VANET is a special type of MANETs of which nodes will be vehicles. Each vehicle can identify the vehicles for it at any time and create a network by connecting to them and establish necessary communication. This vehicle will create another network of its surrounding vehicles later with new vehicles. Therefore, this type of networks can change topology rapidly [1]. VANETs have three mains and definite applications including, safety, convenience, and commercial application. An example of safety applications for the intervehicle networks is that drivers will brake suddenly at times of accident. In such condition, any delay of drivers in the back vehicles can cause chain collision and leads to high financial and life losses. In such condition, VANETs can prevent such accident without interference from drivers as far as possible [2].

Work mechanism of the inter-vehicle networks is such that Inter-vehicle geo-cast has spread warning message for the back vehicles at times of brake. Message receiving vehicles automatically reduced the speed of the vehicle by observing warning message. Of course, different messages are spread periodically to create necessary space for safe driving [3]. On the other hand, general goals of using VANETs are:

- To provide efficient inter-vehicle communication with Intelligent Transportation Systems (ITS)
- To create overall communication for users in roads i.e. communication with other networks and internet for moving vehicles.

One of the problems of VANET is routing. Therefore, routing protocols designed for VANET must be highly scalable, robust and easy to deploy [4]. In addition, the frequent arrival and departure of vehicles bring many challenges to routing research. Due to the high speed of nodes in this type of network, it is a great challenge to find and maintain route in them. In VANET, the conventional method of packets delivery is the use of broadcast. Of the disadvantages of the broadcast are to receive repetitive packets and increase resources particularly bandwidth. Therefore, considering limitations of resources and instability of communicative link of these networks, it is better to avoid delivering repetitive packets.

Fuzzy Logic is a decision system approach that works similarly to the human control logic. It is a useful technique since it uses human language to describe inputs and outputs, and provides a simple method of reaching a conclusion from imprecise, vague or ambiguous input information. Fuzzy logic systems include a fuzzy rule set to define the relationship between the input and output variables. Furthermore, just a few data samples can provide quite accurate results. In this paper, the fuzzy module is designed based on the Mamdani fuzzy inference system. In Mamdani system, input and output are expressed in fuzzy [5].

All types of routing in VANET can be divided into three categories: Unicast, Multicast, and broadcast routing. Geocast is a multicast routing type [6]. Geo-cast routing protocols are suitable for VANETs, because of the adaptation to the mobility of vehicles. The purpose of the geo-cast routing protocols are to send packets to vehicles located in a particular geographic area [7]. Each vehicle stores or discards a package depending on its geographical location. If the vehicle is located in a particular geographic area, the vehicle will receive packages. Otherwise, this vehicle discards the packet. In this paper, we present a geographic routing because of the advantages of Geo-cast routing in VANETs. The proposed protocol is an inter-vehicle geo-cast routing based on a fuzzy logic (f-IVG). In our fuzzy system, Link expiration time and probability adapts density as the input fuzzy systems and probability of selection link are intended as a fuzzy system output. Main advantages of f-IVG are: Packet loss rate is reduced by selecting longer LET. When the number of packet loss reduced general delay is decreasing and lower resources and bandwidth are consumed and efficiency of the network increases. Furthermore solves the spatial broadcast storm problem was solved, improved packet delivery rates and lower channel contention.

In rest of the paper, related work is given in section 2, proposed protocol is mentioned in section 3, simulation and results is explained in section 4 and conclusion of the paper is given in the last section.

II. RELATED WORKS

One of the most challenging issues of VANET is routing. The dynamic nature of VANET which is due to the high velocity and movement limitations (due to special traffic conditions on the road) of road vehicles, has led to the fact that MANET routing protocols have proven useless and insufficient for VANET [8].

Multicast routing method is applied to deliver an equal data to a group of nodes of the network. It is better to deliver a copy of equal data to several destinations with multicast method than to deliver data to each of the destination nodes with the unicast method [9]. Generally, the geo-cast routing protocol is defined based on broadcast routing but it can be defined as a multicasting routing based on the region [10].

In [11], an adaptive routing protocol based on reinforcement learning (ARPRL) is proposed. ARPRL is designed for VANETs and aims to find an optimal route between the source and destination. ARPRL employs distribute Q-learning algorithm to learn the best multi-hop route considering the distinguishing characteristics of VANETs. Through distributed Q-Learning algorithm, ARPRL constantly learns and obtains the fresh network link status proactively. Therefore, ARPRL's dynamic adaptability to network changes is improved. Also, to speed up the convergence of Q-learning, reactive routing probe strategy is applied. ARPRL performs better and is more suitable for packet loss and delay sensitive applications.

In [12], VNIBR protocol is proposed. In VNIBR, three types of routing entities are differentiated. The level 1 entities (L1VNs) are the VNs placed at the intersections. In L1VNs the routing decisions are made, using a procedure adapted from AODV logic. The level 2 entities (L2VNs) are the VNs neighboring an intersection. These VNs start forwarding packets along a road segment as mandated by the neighboring L1VN, irrespective of whichever PN actually does the transmission. The level 3 entities (L3VNs) are the VNs in intermediate positions of road segments that simply relay packets from one side to the other. The simulation results show that VNIBR is Suitable for routing in urban scenarios with medium to high traffic densities and ensures moderate overhead, good packet delivery ratios, and low end to end delay.

Broadcasting packet of the whole nodes increases repetitive and overhead packets and the main goal of geographical routing is to prevent broadcasting of packet by defining a destination region. The best strategy for the definition of a region is special delivery in of the network so that packets out of that region are drop. As a result, middle nodes deliver the packet only when they are included in the delivery region (with increasing the delivery region, overhead also increases). Geo-cast protocols of each node receiving the packet specify if it belongs to a delivery region by determining its geographical distance to a destination region. In this routing, each node compares its distance between destination regions which has been included in the received packet with a distance of the sending node to the same zone and if its distance is shorter, it will replace with the previous distance and it will deliver the packet to its neighbors [13]. If the distance of the node to the center of the destination region is shorter than that of sending node, the packet will be sent forward to the node, otherwise, the packet will not be sent forward. This process continues until the packet reaches nodes of the destination region [14].

In [15], a Reliable Path Selection and Packet Forwarding Routing Protocol (RPSPF) is proposed. RPSPF firstly it establishes an optimal route for vehicles to send packets towards their respective destinations by considering connectivity and the shortest optimal distance based on multiple intersections. Secondly, to avoid packet loss while forwarding the packet, it uses a reliable packet forwarding technique in-between intersections. RPSPF comprises two phases: (i) dynamic multiple intersection selection mechanism and (ii) reliable greedy forwarding mechanism between the intersections. RPSPF make use of a multiple intersections selection mechanism, a reliable and stable greedy forwarding approach to relay packets in between intersections, and a recovery technique. Simulation results have revealed that RPSPF surpasses in terms of various metrics like packet delivery ratio, end-to-end delay, and routing overhead.

In [16], proposed a routing protocol called F-Ant for VANET that is designed based on fuzzy logic. In this method, route reliability is computed by the different fuzzy uncertainty criteria, such as bandwidth, Received Signal Strength Metric (RSSM) and Congestion Metric (CM). F-Ant guarantees road safety service quality and aims to fulfill some of the quality of service (QoS) requirements such as high data packet delivery ratio in the low end-to-end delay. However, this protocol is vulnerable to a number of security threats. Simulation results show that F-Ant is suitable in the urban scenario and can perform better than ACO and AODV in terms of average end-to-end delay and packet delivery ratio metrics.

In [17] all vehicles located in a geographic zone created with the message initiation must get the message in a specific time duration. Mobicast is the routing protocol that works on carry and forward technique. In Mobicast routing the main goal is to deliver information to all nodes in a special geographical region at a definite time. The factor of time has been mentioned in this protocol.

In [18] the basis of this paper is the probability function. A probability density function (PDF) is a function that describes the relative likelihood for this random variable to take on a given value. It is given by the integral of the variable's density over that range. It can be represented by the area under the density function but above the horizontal axis and between the lowest and greatest values of the range. In this paper, the density of vehicles is considered. Therefore, re-broadcasting of messages is prevented. In [19] IVG protocol is applied to inform vehicles in highways in case of danger such as road accidents. In IVG routing protocol, the destination region is determined through the direction of movement of the vehicle and position of the vehicles. The vehicles in risk areas are included in one group. This group is called multicast group. The group has been defined temporarily and dynamically with location, velocity and direction of the vehicle. IVG protocol applies periodical multicasting method for dominating over the problem of VANETs disintegration in message delivery break members of the group. The retransmission to re-broadcast on the maximum speed of the vehicle is calculated. In addition, IVG protocol reduces hops of message delivery with a delay time in message recasting. The vehicle which has the shortest distance from the source has shorter delay time for recasting. Figure 1 gives an example for showing the performance of IVG protocol. V_A vehicle faces the problem of link breakage; therefore, it should send the packet to one of the members of the group. V_C, V_B and V_D vehicles are members of the multicasting group because they enter the destination region. V_C vehicle is the next choice of V_A because it has a longer distance from V_A to V_B after the V_C vehicle broadcast the packets, V_B needn't carry and send the packet.

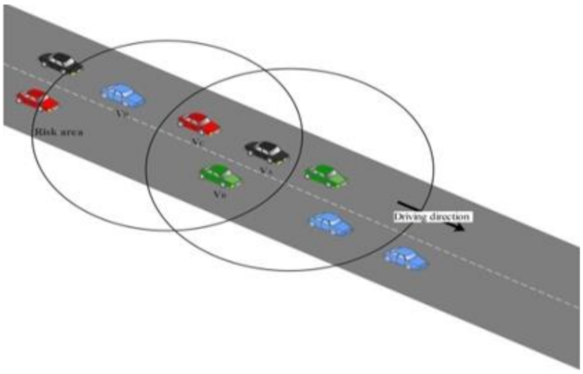


Fig. 1: IVG routing protocol

In [20], a reliable self-adaptive routing algorithm (RSAR) based on this heuristic service algorithm is proposed. By combining the reliability parameter and adjusting the heuristic function, RSAR achieves good performance with VANET. In this method, a link reliability calculation model was developed. The link reliability between nodes was evaluated as a parameter and applied in the QLearning algorithm. The simulation results showed that RSAR had a higher packet delivery ratio under various conditions and a low transmission time delay. RSAR can effectively solve the problems caused by changes in topology through self-learning. However, the routing expense in a large network environment will be enormous.

III. PROPOSED PROTOCOL (F-IVG)

By using IVG with its original settings, nodes that are close to each other at the boundary will have very similar, if not equal, timer values. This means that the nodes' timers will expire at almost the same time, and the nodes will re-broadcast the packet essentially simultaneously, resulting in collisions and thus, a spatial broadcast storm. The failure of successive links between the networks of a vehicle problem exists, for example, may be a vehicle that is selected to send packages in the opposite direction of the current vehicle is in motion. In the proposed protocol, after calculating the reliability of links, node density probability will be considered. In f-IVG routing, a link with the least probability of breakage and the most appropriate density is selected with fuzzy logic to prevent delay, packet loss, and channel contention. In fact, the main goal is to select the most suitable node as the packet receiver from multicasting group.

A. General steps of the proposed protocol

General steps of the proposed protocol are as follows:

Step 1: When a node has a packet to send, we divide the network unto multicasting groups in terms of IVG routing protocol. The main goal of network grouping is to prevent broadcasting of packets and reduce receipt of repetitive packets. Each vehicle maintains a database to store the information of vehicles within its transmission range. Upon receiving a beacon, each vehicle updates its database with the new vehicle information. The database is checked every second and updated.

Step 2: To select the next step, we use fuzzy logic. Fuzzy logic, according to the density of nodes and time of expiry link with adjacent nodes, the next hop is to choose. Information and equations necessary to calculate the fuzzy entries listed in section B.

Step 3: After determining LET and PAD based on the fuzzy rules. We select one of the nodes in the broadcasting group for delivering packet as the next hop.

Step 4: We repeat the steps mentioned 1, 2 and 3 for selection of the next hops until the data packet which we are about to deliver reaches the destination region and is a distribution in nodes of the target region. The flowchart of the proposed protocol is shown in figure 2.

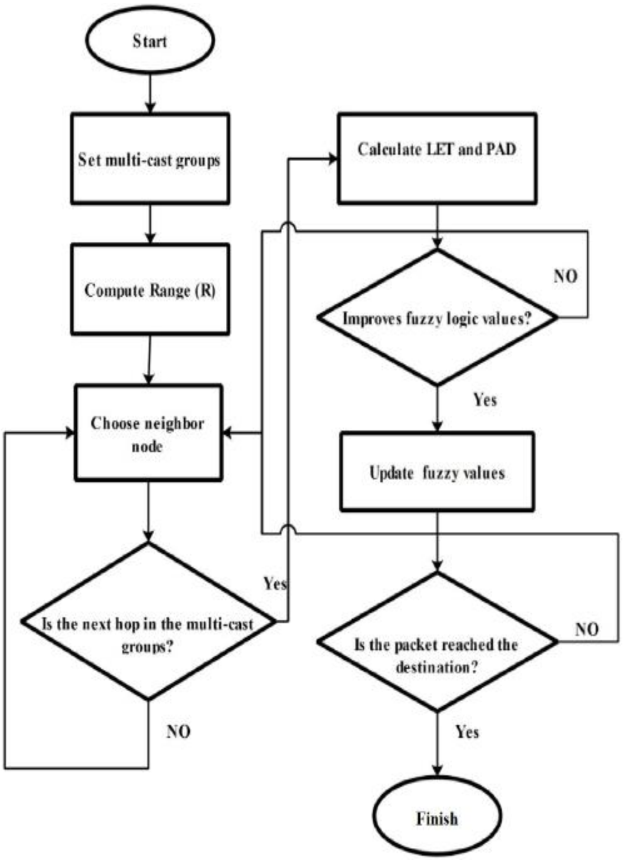


Fig. 2: F-IVG flowchart

B. Fuzzy system in f-IVG

The vehicles move on the roads with high speed in VANET and node-density information frequently change from sparse to dense and vice versa. Optimal decision plays an important role for efficient data packet forwarding in highly dynamic VANET environments. Artificial intelligence techniques such as fuzzy logic perform well in classification and decision-making systems. We have used the fuzzy logic system for making a better decision on the highway for the meaningful performance of the proposed f-IVG protocol.

The design of fuzzy logic decision-making system consists of input membership functions and a set of fuzzy rules. A fuzzy system has composed of three sections: fuzzification , inference engine, defuzzification [21]. Figure 3 shows components of the fuzzy system which we have used in this paper. Fuzzifier assigns an integer or a degree of membership to each fuzzy set.

The fuzzified values are processed by inference engine which includes rules base and different methods for inference of rules. The rules base is a series of If-Then rules which variable input Fuzzy with linguistic variables to output fuzzy variables [22].

In this paper, a suitable node is selected for packet delivery to improve the efficiency of IVG routing with fuzzy logic and input parameters defined in it. The input parameters of LET and PAD of movement as inputs of the fuzzy system are considered for assessment of route. The output of fuzzy system this is the probability of link selection.

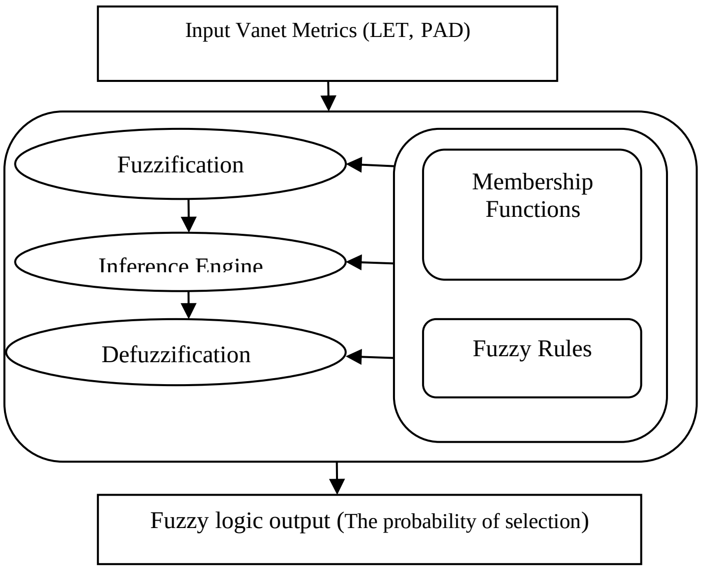


Fig. 3: fuzzy system components

1) The fuzzy input and output parameters in f-IVG

In this section, the necessary equations to calculate the input fuzzy system are described. Fuzzy inputs systems are LET and PAD.

Link expiration time (LET): Link expiration time (LET) will be introduced as the main element to decide which one is the most stable link [23]. Obviously, the path with the longest LET is considered as the most stable link. The detail about the work that is incorporated in each element of the proposed protocol will be described below. LET is calculated according to the figure 4 based on velocities and direction of the vehicle and through equation (1). The velocity of the vehicle (v) and coordinates of the vehicle (x,y) are accessible through GPS. If GPS is not accessible, it can be easily calculated with Doppler value of the distance between two vehicles and the angle between two vehicles is also θ [24].

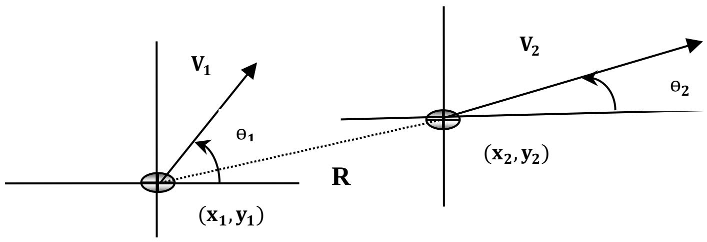


Fig. 4: Parameters between two vehicles for calculation of LET

$$LET = \frac{-(ab+cd)+\sqrt{(a^2+c^2)r^2-(ad-bc)^2}}{a^2+c^2} \quad (1)$$

Where,

$a = v_i \cos\theta_i - v_j \cos\theta_j$

$b = x_i - x_j$

$c = v_i \sin\theta_i - v_j \sin\theta_j$

$d = y_i - y_j$

The equation utilized for calculating the angle parameter θ between two vehicles or movement direction, and then the vehicular direction can be calculated using equation (2).

$$\theta = \tan^{-1}\frac{(y_2 - y_1)}{(x_2 - x_1)} \quad (2)$$

Probability Adapts Density (PAD): Vehicular density is a key parameter that has a great influence on broadcasting techniques. Some of these techniques may fail in certain vehicular densities, so it is important to study the impact of density on purpose protocol. In the case of IVG, as the density increases, the number of candidates for re-broadcasting a packet increases. This increases collisions, resulting in reduced reception rates. The number of candidates depends on both the density and the probability function that is inversely proportional to the density [25]. So, as the density increases, the probability function decreases, and vice versa, keeping the number of candidates almost constant. In IVG, each vehicle starts a timer for each packet it receives. If the timer expires and the packet associated with this timer has not been re-broadcast by any other vehicle within transmission range, the vehicle re-broadcasts the packet. To calculate the parameterT_x, Equation (3) has been used.

$$T_x = T_{max}\frac{(R^{\varepsilon} - D_{sx}^{\varepsilon})}{R^{\varepsilon}} \quad (3)$$

The parameters R and D, respectively, represent the transmission range and the distance between the two vehicles. The parameter ε is a constant value, which is usually considered to be 0/5 to generate a uniform timer value between [0, T_{max}], where T_{max} = 200 ms. One of the main goals of the timer value equation is to reduce the waiting time, T_x before packets are re-broadcast, and thus the overall delay to send the packet to distant areas [26]. In order to achieve this, smaller timer values should be generated as the distance from the original packet sender (D_{sx}) increases. In f-IVG, two steps are taken when a package is received. In the first step, for parameter P, a random value is considered between [0.1]. In the second step, the density of vehicles is determined using light-weight local topology sensing. Therefore, the parameter PAD can be calculated from Equation (4).

$$PA = \begin{cases} \text{The packet will be rebroadcasted by X} & if\ p < {}^{1}/_{Density} \\ \text{The packet will not be rebroadcasted by X} & if\ p > {}^{1}/_{Density} \end{cases} \quad (2)$$

So the density increases the number of nodes that will start their timer's decreases.

2) Membership functions for input and output variables in f-IVG

Membership function assigns an integer between 0 and 1 to a point in the range of the fuzzy set. Trapezoidal membership function has been mentioned for the variable of LET, PAD and triangular membership function is used for the fuzzy system output. As shown in figure 5, Membership function is between 0 and 1 for the LET between two vehicles and Membership function can be divided into three low, middle and high variables. In figure 6, Membership function value has been shown for density around a vehicle. This value is between 0 and 1 and we define three low, middle and high variables. Output membership function value is shown in figure 7 which is calculated based on two fuzzy input variables. The probability of link selection value has been defined between 0 and 1 and has five fuzzy variables. In this paper, Mamdani fuzzy rules have been used. Simple Mamdani fuzzy rules are written in terms of if-then rules. Rules are written generally as follows: IF variable IS set THEN action. Fuzzy rules are shown in table 1.

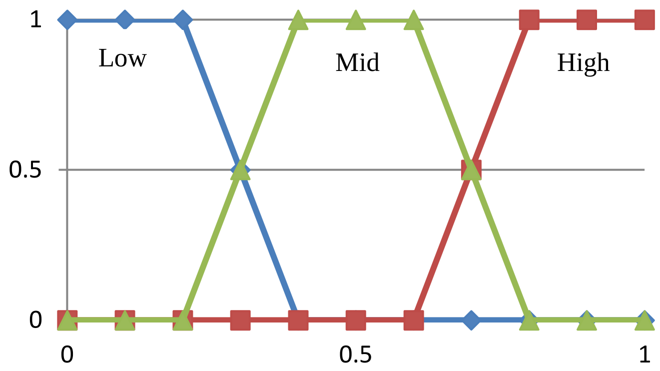


Fig. 5: Membership function for LET

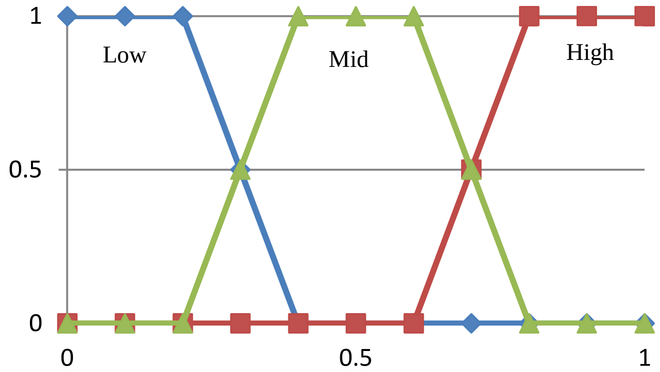


Fig. 6: Membership function for PAD

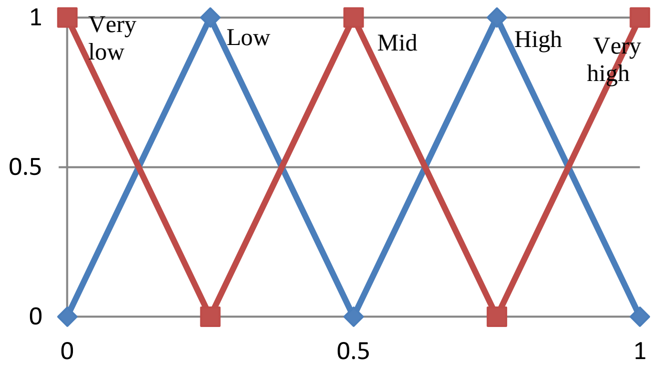


Fig. 7: Membership function for probability of link selection

TABLE1. RULE BASE

Rules	IF		THEN
	LET	PAD	Probability of link selection
1	Low	Low	Very low
2	Mid	Low	Low
3	High	Low	Medium
4	Low	Mid	Low
5	Mid	Mid	Medium
6	High	Mid	High
7	Low	High	Medium
8	Mid	High	High
9	High	High	Very High

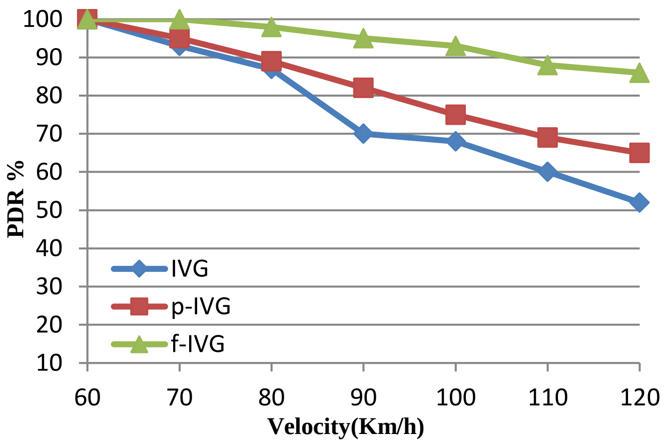
IV. SIMULATION AND RESULTS

In this section, the proposed protocol (f-IVG) is compared with RPSPF [15] and p-IVG [18] protocols. We used network simulator ns-2 (version 2.35). To evaluate the performance of protocol parameters such as packet delivery ratio, end-to-end delay, and packet loss rate is considered. Parameters considered for two views, different speeds and density of vehicle are calculated. The main reason for considering the speed and density of the simulation are to omit the loss of vehicle links between the vehicles, due to the unpredictability of the speed and density of the network between the vehicles. The minimum speed of 60 Km/h and a maximum speed of 120 Km/h are considered. The minimum density of vehicles 10 and a maximum density 100 are parameters applied to the simulation. It is well known that a packet loss in the wireless channel can happen either due to collision or an insufficiently strong signal. In VANET, it can be used to estimate the behavior of time varying vehicular wireless channels. Vehicles are able to communicate with each other using the IEEE 802.11p MAC layer. The simulation area defined is a dual carriage highway scenario in which the maximum radio radius of nodes is considered as being 300 meters. In table 2, the simulation parameters are similar to the ones mentioned for the proposed protocol. The values obtained were compared to graphs, and some performance measures are considered in order to assess the performance of the proposed protocols in the simulation tests.

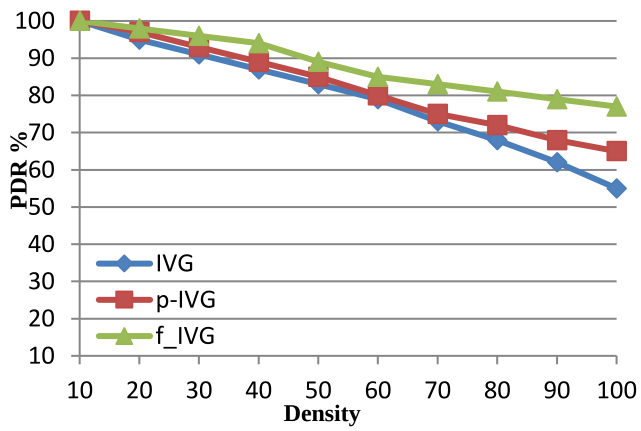
TABLE2. SIMULATION PARAMETERS

Parameters	Values
Ns-2 version	NS-2.35
Simulation Time	250 Seconds
Velocity	60-120 Km/h
Source/Destination	Random
Channel Type	Wireless Channel
MAC Type	IEEE 802.11
Simulation Area	1500*1500 m
Transmission range	300
Data packet size	500-1000 bytes
Number of Vehicles	10-100

Average packet delivery ratio (PDR): It specifies the percentage of packets that reach the destinations compared to the total number of packets that are sent to the destination; however, increasing the probability of distance leads to increased packet loss. PDR may affect by different crucial factors such as packet size, group size, action range and mobility of nodes. As shown in figure 8(a) in protocols, p-IVG and p-IVG an increased velocity leads to a decreased packet delivery rate. In f-IVG uses the LET and PAD parameters, for p-IVG routing, in order to increase the packets delivery rate and reduce the network overhead caused by unnecessary packets retransmissions. Furthermore in the f-IVG, since the most reliable link and appropriate density of every node are selected using fuzzy logic link failure probability is reduced and average packet delivery rate is increased to the destination. As shown in figure 8(b) PDR modulation in the density of vehicles, represent the diversity of density dependence routing protocols between vehicles. The p-IVG rather than other protocols packet rate is less stable. The f-IVG protocol PDR rate is improved on different densities compared with other protocols; because the basic idea of PDR is that choose reliable routes. The reliable route needs longer LET.



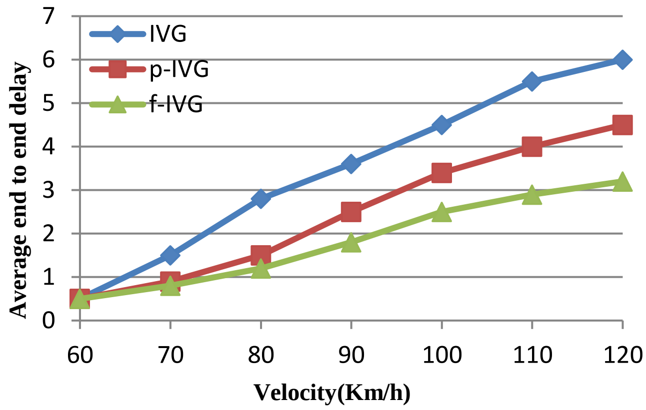
(a)



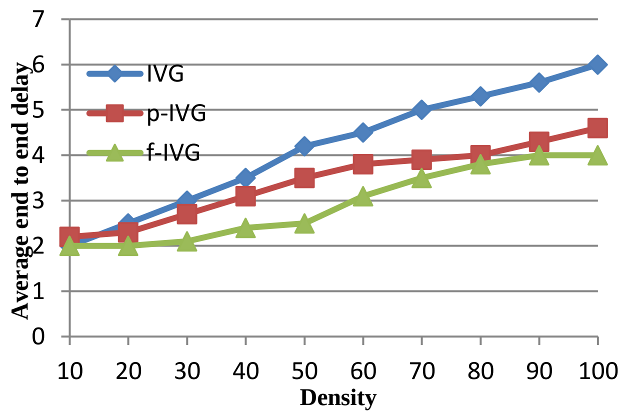
(b)

Fig. 8: Packet delivery ratio base on different (a) Velocity, (b) Density.

Average end to end delay: It shows the average time that it takes a packet to travel between its source and destination. In VANETs, can due to link failure, physical failure and temporary parallel route recovery for frequent link failure. In the network, there is a very frequent link failure due to the high mobility of nodes from available network region. Since stable routes have been selected for the f-IVG, lesser links are broken during data transmission; this reduces end to end delay. As shown in figure 9(a) p-IVG protocols at high speeds deal with greater delays, because the link between the two vehicles for high speeds is broken. In f-IVG, in order to increase reliability and taking into account multiple parameters when selecting the link, which will reduce the probability of failure and the subsequent end to end delay parameter is low at different speeds. As shown in figure 9(b), when traffic density increases, an end to end delay also increases. The p-IVG protocol, an end to end delay is the highest. The problem encountered in f-IVG due to taking into account various parameters was resolved to use fuzzy logic as a result, as shown in the diagram, the average end to end delay of vehicles for different densities of f-IVG with a reduced fixed rate decreased. The main cause of these results is that the f-IVG does not send packets of nodes that have low LET and avoiding unnecessary retransmissions. When many packets are sent and most of the nodes present full cache, there is a slight decrease in the end to end delay.



(a)

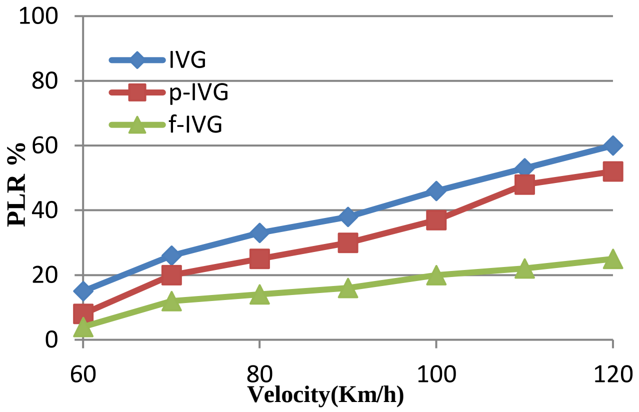


(b)

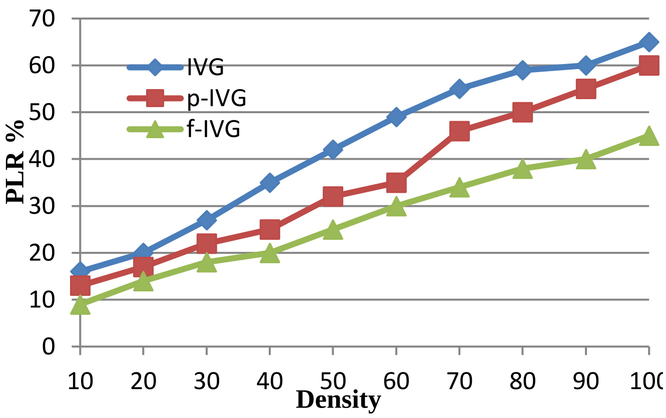
Fig. 9: End to end delay based on different (a) Velocity, (b) Density.

Packets Lost Ratio (PLR): Packet loss ratio is the number of packets that never reached the destination to the number of packets originated by the source. Some of the events that led to the loss of the packages are package collision, link failure, insufficient bandwidth overhead of buffer and problems caused by the publication of corrupted packets. As shown in figure 10(a), through increasing of the speed node, the number of lost packets increases. The number of packets lost is more in the p-IVG protocol as compared to the RPSPF and f-IVG, because, with increasing speed, link failures occurred. When a link is selected with high reliability and less collision, PLR is reduced. In f-IVG, since more stable routes have been selected with fuzzy logic, fewer links have been broken and contention during delivery of data and this leads to a significantly reduction of the number of packets.

As shown in Figure 10(b), the number of packets lost in all routing protocols by increasing the density of vehicles has increased. The p-IVG routing protocol PLR is the highest because in this protocol is not considered any criterion for evaluation links. The RPSPF routing protocol PLR more than the f-IVG, since this protocol only channel collision prevention measure, is intended. The proposed protocol for the consideration of two important parameters LET and PAD in fuzzy logic has the lowest rate of PLR.



(a)



(b)

Fig. 10: Packets Lost Ratio base on different (a) Velocity, (b) Density.

V. CONCLUSION

In this paper, inter-vehicle geo-cast routing has been improved using fuzzy logic. In the proposed protocol, parameters of LET and PAD are considered as inputs of fuzzy logic to select the most reliable link and prevention of rebroadcast packets in the geographical range. Selection of a reliable link will reduce failure of a link between two vehicles which leads to a reduction of repetitive packets and reduction of the overhead of the network. Results of simulation of this algorithm with p-IVG and RPSPF show that Packet delivery ratio will increase in this method and the packet loss and an end to end delay has decreased. In f-IVG, due to reduced packet loss and retransmission of their overall network performance increases and reduced overhead.

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افزایش کارآیی و قابلیت اطمینان در مسیریابی جغرافیایی چندپخشی مبتنی بر منطق فازی در VANET

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چکیده- شبکه موردی بین خودرویی (VANET)، یک زیر کلاس از شبکه موردی متحرک (MANET)و یک روش نوید بخش جهت سیستم های حمل و نقل هوشمند (ITS) است. پروتکل های VANET به دلیل تغییرات پویای توپولوژی و پیوندهای متقارن شبکه با چالش های بزرگی روبرو هستند. یک مکانیسم مسیریابی مناسب و مؤثر به استقرار و گسترش موفقیت آمیز شبکه های موردی بین خودرویی کمک می کند. وظیفه مسیریابی داده ها از گره منبع به ایستگاه پایه یک مسئله مهم در VANET است. یکی از روش های مسیریابی کارآمد در این شبکه ها، مسیریابی جغرافیایی است. در این نوع مسیریابی، وسایل نقلیه مناطق ویژه در یک گروه چند مرحله ای قرار می گیرند تا از پخش بسته ها جلوگیری کنند. در این مقاله، پروتکل مسیریابی جغرافیایی بین خودرویی با منطق فازی که F-IVG نامیده می شود، بهبود یافته است. در پروتکل پیشنهادی، ما از منطق فازی برای انتخاب پیوندی با بیشترین زمان انقضاء لینک استفاده کردیم و احتمال چگالی را برای جلوگیری از پخش مجدد بسته تنظیم می کنیم. در پروتکل مسیریابی پیشنهادی از پارامترهای موثری مانند مسافت، جهت و سرعت برای یافتن گره گام بعدی استفاده شده است. نتایج شبیه سازی نشان داده است که پروتکل پیشنهادی نسبت تحویل بسته بالاتر،تعداد بسته از دست رفته کمتر و تاخیر انتها به انتهای کمتری دارد.

واژه‌های کلیدی: شبکه موردی بین خودرویی، مسیریابی جغرافیایی، IVG ، منطق فازی.