International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-11, September 2019

An Intelligent Fuzzy Based Location Aided Routing in Vehicular Ad Hoc Networks

E. Gurumoorthi, A. Ayyasamy

***Abstract**: In the Vehicular Ad hoc Networks (VANET), performance is the key factor for the development of a standard routing protocol. The general characteristics of VANET are dynamic vehicle network topology and mobility. The choice of a better next forwarding hop vehicle among the available neighboring vehicles will lead better use of the route and also minimize the delays. However, there is a need for an efficient decision making in selecting the route for successful packet delivery. This paper proposes a new hybrid routing protocol called "Fuzzy assisted Location Aided Routing using Cache" (FLAR-C). FLAR-C uses a fuzzy logic technique that helps in better decision making to select the next hop for packet forwarding. Metrics like distance, direction, velocity, density and position of next hop vehicle are placed into the fuzzy logic system. And moreover, the proposed technique uses cache schemes to forward packets to the destinations under the Geocast zone. An experimental study is carried out to prove the performance of the proposed protocol and the simulation results highlights that FLAR-C is more effective in selecting the better forwarding hop for improved performance*

***Keywords** : Vehicular Ad hoc Networks, Location aided routing, Fuzzy logic, Geocast, Cache, Membership function, Intelligent Transport System.*

I. INTRODUCTION

Intelligent Transport Systems (ITS) are intended to reduce the risks associated with the transport system since traffic congestion and traffic jams in developing countries are the prime causes of the failure of the transport system [1]. Nowadays, with an increase of vehicles on roads, the researchers show more interest over Vehicular Ad hoc Network (VANET). Even though numerous research works have been conducted by the researcher to solve routing issues in VANET, it still needs improvement. The VANET communication IEEE 802.11p is defined as the standard for wireless communication. IEEE802.11p supports V2X communication with Wireless Access in Vehicular Environment (WAVE), which also sup-ports V2V and V2I [2]. VANET has a general characteristic like Dynamic network architecture and mobility of vehicles. These characteristics form the issues as well. Since the architecture is dynamic in nature, the infrastructure is unpredictable. The movement of the vehicle makes the routing more complex. For better routing, we need a better Vehicle to Vehicle (V2V) communication. VANET consider the vehicle as a broadcast medium and the basic components of VANET are Road Side Unit (RSU), Application Unit (AU) and On-Board Unit (OBU) [3]. Each vehicle is embedded with GPS which is used in helping the application to enhance road safety. Most of the routing algorithm uses GPS to track vehicle/neighbor node location. One of the significant approaches for a vehicle is to specify the destination at the next forwarding nodes. This makes the packet to reach the destination with minimum time and choosing the right routing technique will lead to minimum delay, higher Packet De-livery Ratio (PDR), high throughput and minimum re-transmission ratio. This system is used to create a unicast forwarding mechanism.

In certain roads, like tunnels, the position of vehicles is unreachable or inaccurate, and the various metrics used to select relay nodes can also some-times conflict with each other, resulting in uncertain-ty. Therefore, fuzzy logic concepts being used in the paper that handle information that is imprecise, un-certain, inaccurate and incomplete.

Fuzzy logic is a well-known model with a powerful theoretical background that can intelligently combine approximate, imprecise, and uncertain information. In this research paper, Fuzzy logic is employed to select the neighboring node for further packet transmission. The normal routing-based protocol uses the greedy algorithm.

The Greedy algorithm finds the shortest path for broadcasting. But it has limitation such as non-backtracking. In Greedy, if there is no node to forward further then packets are stored into the node and forward after while the node is live. This problem can be resolved by using fuzzy logic using these five-routing metrics: distance, direction, velocity, position and density as inputs to the fuzzy logic system. The proposed protocol has the potential of selecting forwarding the vehicle with highly reliable route with more available bandwidth, and getting closer to the destination.

Fuzzy logic is Boolean logic extension to enable uncertainty modeling. If any inappropriate selection of relay node leads to packet loss and thus fails in achieving successful message delivery. Fuzzy systems are more accurately referred to as Fuzzy inference systems or Fuzzy rule-based systems. Fuzzy rule-based system is a well-known framework based on fuzzy sets, fuzzy IF-THEN rules and approximate reasoning. A typical Fuzzy Interference System (FIS) architecture is as shown in fig.1 and the functioning is based on:

Manuscript published on 30 September 2019.
***Correspondence Author(s)**
E. Gurumoorthi*, Department of Computer Science and Engineering, Annamalai University, Tamil Nadu, India. Email: egurumoorthiphd@gmail.com
A. Ayyasamy, Department of Computer Science and Engineering, Annamalai University, Tamil Nadu, India. Email: samy7771@yahoo.co.in

i. Fuzzification component transforms each input into a membership grade or value based on a defined membership function.
ii. Inference engine that conducts fuzzy reasoning by evaluating the fuzzy rule antecedents and consequents to generate system output.
iii. The output from the inference is almost always fuzzy and sometimes needs to be converted into a crisp value which is performed by applying a specific type of de-fuzzification operation.

The fuzzy score is used to select a better neighbor node. The fuzzy score value is classified as low, medium and high. The higher value is considered for selection of the neighbor node. This system uses five input variables like Velocity, Direction, Position, Distance and Density. Fuzzification is processed on the basis of the membership function with fuzzy rules. De-fuzzification with separate membership function with output Fuzzy rules are processed to obtain the output value [4]. This process continues until the Geocast zone is reached. Once the Geocast zone is reached, the cache scheme will forward the packet further. In this cache scheme, the cache user and cache forwarder are used to forward the data packet to the destination.

The rest of this paper is regulated as follows: Section 2 provides an overview of the related work. Section 3 describes the proposed work in detail. Section 4 provides an analysis of our proposed algorithm simulation and results with existing routing protocols. Section 5 concludes and recommends future direction.

II. RELATED WORK

Li et al [5] presented a new Adaptive Fuzzy Multiple Attribute Decision Routing (AFMADR) in VANET. This system uses packet carriers as the decision maker to choose the next forwarding hop. This protocol works in two steps such as step 1 uses fuzzy to characterize the neighboring vehicle. In step 2 calculate the weight attribute using adaptive weight algorithm. Finally, the fuzzy attribute score was generated based on this decision for packet broadcast. Jabraeil and Rahimi [6] proposed a hybrid geographic-DTN routing protocol called fuzzy assisted position-based routing with DTN (FPBR-DTN) for VANET. This system proposed to overcome the local maximum problem. This system uses fuzzy logic with density, speed, direction, and distance to find the irrationality nodes for packet forwarding. From the fuzzy weight, the node with highest weight will be chosen for the next forwarding node.

Ghorai and Banerjee [7] presented a New Data Dissemination Protocol (NDDP) in VANET. This system uses a healthy transmission node selection scheme for better V2V communication. Delaunay Triangulation is used to avoid obstacles on the selected path and then Torricelli point was removed at the optimized path. The shortest path is then selected from the forwarding zone. A node is selected using fuzzy logic. Priyan et al [8] presented IOV with a colony optimization algorithm to overcome the issues such as traffic jams, congestion and road accidents. This system makes the street map into a sub-map and then apply the ant colony optimization algorithm to each sub-map. Fuzzy logic is used to calculate the intensity of traffic over heavy traffic.

Zidani et al [9] proposed an Extended Adaptive Beaconing approach (E - ABRP) in VANET. This system manages to estimate the neighboring position with an adaptive beaconing approach. This approach also demonstrates that the adaptive beaconing approach is used to manage the wireless channels more efficiently. Wagh and Gomathi [10] proposed a modified lion algorithm with minimized routing costs. In this case, the routing costs are managed by QoS awareness costs under fuzzy logic. Jaiswal and Jaidhar [11] proposed to Predict Position-based Routing Protocol (PPRP) for VANET. This system was developed to minimize position errors. This system predicts the vehicle's previous and current location based on the Kalman Filter. The new routing protocol designed by Abbasi et al [12], known as the Reliable Path Selection and Packet Forwarding routing protocol (RPSPF), which initially selects the shortest optimal distance between sender and destination and then uses a new reliable packet forwarding mechanism between intersections. Jyoti and Basavaraj [13] presented a routing protocol based on a moving object zone (MoZo).

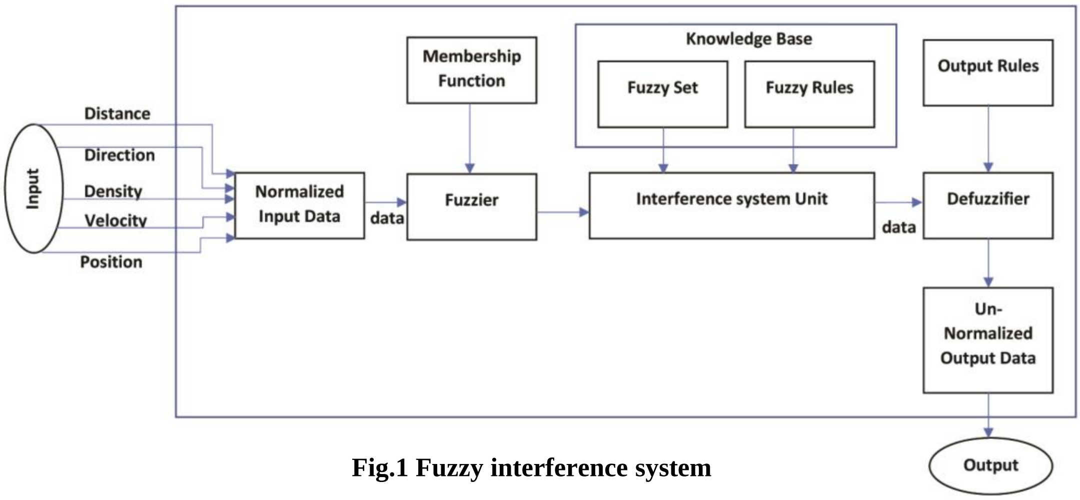

Fig.1 Fuzzy interference system

This protocol focuses mainly on the routing method for path estimation based on positions. The distance-based routing algorithm is used to find the effective routing path. Abbasi et al [14] presented a Dynamic Multiple Junction Selection-based Routing (DMJSR) for VANET. This protocol uses an improved greedy forwarding mechanism on selecting one hop neighbor among junctions.

Chen et al [15] presented an Artificial Geographic Spider Routing (ASGR) in urban VANET. This system builds a network topology at the base of the spider web. It selects the optimal path to the destination from the topology. To select the best route, routing selection metrics are generated using the transmission latency model and connection quality model. Zhou et al [16] proposed a novel data delivery scheme, which improves routing by not relaying GPS. In the selection of relays, a fuzzy rule-based approach is used, including speed, hop count, direction and time of connection. Ozera et al [17] presented Fuzzy-Based Cluster Management Systems (FBCMS) in VANET. This system introduces two sub-models as FBCMS1 and FBCMS2. FBCMS1 uses three parameters, such as security, relative acceleration, and group speed, to cluster head selection. In FBCMS2 uses four parameters such as security, group speed, relative acceleration, and connectivity degree.

Lim et al [18] presented a new Heuristics and adaptive Fuzzy Logic scheme (HaFL) for VANET performance improvement. This system focuses on transmission power and window size based on traffic and network conditions. Fuzzy logic is applied here to optimize the window size. Elham and Hamid [19] proposed a Reliable Multi-level Routing Protocol (RMRPTS) based on clustering. This system uses a Tabu search to solve the problem of hybrid optimization. Fuzzy logic is applied over AODV to get AODV extension as RMRPTS. Clustering-based multi-level routing was used in a dynamic network environment to maintain balanced routing. Alzamzami and Mahgoub [20] proposed a new routing protocol based on the fuzzy system. The proposed Fuzzy Logic based Geographic Routing (FL-DGR), which coordinates and analyzes the challenging metrics. This protocol combines a number of metrics to select the next hop for forwarding packets. Hassan et al [21] proposed Multi-metric Geographic Routing (M-GEDIR) for the next node selection from the dynamic forwarding region. Major parameters such as future vehicle position, signal strength, vehicle speed, distance, direction and vehicle at the border of the transmission range were revealed for the next node selection.

The Greedy algorithm makes the best optimal solution at every small iteration of the problem, which leads to find the global optimum solution. By this, the greedy algorithm resultant with the best solution for the given problem. Majority of the routing algorithm utilizes a greedy scheme for decision making to forward the packet to the destination. In location aided routing, the existing protocols use distance, direction, velocity, bandwidth, viz. as the parameter into the greedy to find the optimal routing path or to choose next forwarding vehicle. Some researchers use a combination of parameters to select the best optimal path to forward the packet to the next vehicle /destination. Choosing of best path leads to better performance in terms of maximum PDR, maximum throughput, and minimum delay. Even greedy perform better, also having some drawback like go back or reverse the decision [22]. This leads performance degradation of routing protocols. To overcome those issues, additionally Fuzzy logical is added along with greedy to get better performance. Therefore, fuzzy logic is aided with greedy in making decision over vehicle node selection for better route selection with packet delivery ratio.

III. PROPOSED WORK

A. Next hop vehicle selection using Fuzzy Logic

Normally the routing protocols uses greedy as the route/ path selector. Those system needs a better selection of next hop forwarder. The protocol which uses greedy, focus only on the shortest path. The drawback of greedy is, it doesn't go back or reverse if there is no further path to select and so, the communication starts from the beginning. Those issues can be avoided by having an alternative method to choose forwarded hop selection.

The wireless radio communication device was attached to all the vehicles for multi-hop communication. In ITS vehicle was equipped with GPS to get the live position of vehicles. The transmission range of the vehicle is denoted as 'R'. When the source vehicle wants to communicate with its neighbor then the source chooses the neighbor based on neighbor traveling in the same direction as one of the parameters. But at the same time, source vehicle fixes its neighbor by those vehicles which are available at the transmission range intersect with the request zone.

The special characteristics of VANET are dynamic network structure with the mobilization of the vehicle. The mobility of the vehicle makes the network architecture dynamic. Those characteristics make VANET implementation complex. For the proposed system, the velocity of the vehicle is ranged as 1 to 60 km/h and also assumed at least one vehicle will be available for further communication at an area of a quadrant.

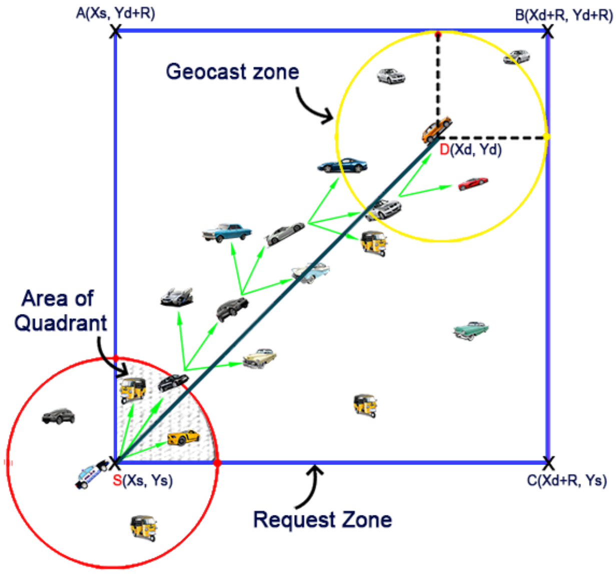

Fig.2 Schematic diagram of VANET architecture

To obtain neighbor information, the current forwarding node sends a HELLO packet to the neighbor. Then the route reply packet will be sent back to the source with neighbor Id, neighbor location, neighbor velocity, neighbor direction, and the information will be updated into route table for future reference. The FLAR-C uses unicast method for V2V communications, this happens after the best NHV is selected. Thus, the main goal of FLAR-C is to choose the appropriate neighbor for forwarding packet. Here the Fuzzy logic is applied for selection of next hop vehicle. Normally all the Fuzzy logic system implements three steps, 1) input 2) process and 3) output.

Table 1 Fuzzy input variable with minimum and maximum value

Input Variable (Fuzzy)	Minimum Value	Maximum Value
Distance	0	250
Direction (angle)	0	90
Velocity	1	60
Density	0	200
Position	0	1

At step 1, for each input variable, set minimum and maximum range as shown in Table 1. Each input variable is categorized into three fuzzy sets with their respective membership functions revealed in Table 5 to 9.

The numeric value will be converted to a linguistic variable. The linguistic variable takes the word as its value instead of numbers (Refer Table 2). At the fuzzification, membership function along with linguistic variable was used to convert numeric data to Fuzzy value.

In step 2, it maps Fuzzy value with predefined fuzzy rules to pass fuzzy output. In Interference System unit (ITU), IF part is known as “Antecedent” and THEN part is known as “Consequent”. At step 3, Defuzzification happens. In defuzzification, the fuzzy output was converted into numerical values. Those numerical values were called as “Crisp value”. The defuzzification uses output rules with output membership function to represent Crisp Value.

The FLAR-C aims to work into two stages. At stage one, the forwarded choose the desired neighbor node as the next forward node through Fuzzy logic. This process continues until the reach of Geocast zone as shown in Figure 2.

After reaching the Geocast zone, further forwarding and communication happen through cache schemes like cache user and cache forwarder. The role of cache user is to pass the packet to the other cache user until reaching the destination. In case if there is no further node to communicate, then cache forwarder act to store packet and then forward packet to other cache forwarder or cache user until reach of the destination.

At the initial stage, our proposed protocol checks that source transmission range intersects within the Geocast zone. If so, the packet will be forwarded to the destination directly. In case, if the source and the destination is too far to communicate then Fuzzy logic is utilized to choose better next hop forwarded.

B. Steps for selection of best next hop

Step 1: For the proposed FIS, a set of Fuzzy rules are prepared. In this system, we have framed 243 rules through five input variables. Some of the rules were displayed in Table 2.

Table 2: The proposed FLAR-C (Fuzzy logic truth

Rules	Input					Fuzzy Score (Output)
	Direction (Angle)	Distance	Density	Velocity	Position	
1	Less	Close	Spare	Slow	Close	Low
2	Less	Close	Spare	Slow	Intermediate	Low
3	Less	Close	Spare	Slow	Far	Low
4	Less	Close	Spare	Medium	Close	Low
5	Less	Close	Spare	Medium	Intermediate	Low
6	Less	Close	Spare	Medium	Far	Low
7	Less	Close	Spare	Fast	Close	Low
8	Less	Close	Spare	Fast	Intermediate	Low
9	Less	Close	Spare	Fast	Far	Low
10	Less	Close	Medium	Slow	Close	Low
11	Less	Close	Medium	Slow	Intermediate	Low
12	Less	Close	Medium	Slow	Far	Low
13	Less	Close	Medium	Medium	Close	Low
14	Less	Close	Medium	Medium	Intermediate	Medium

Step 2: Totally five input variables were used for Fuzzification, like Direction, Velocity, Distance, Location, and position (Refer Table 2).

Step 3: For the input variable, a separate membership function was created. The five input values were converted into Fuzzy values by Fuzzification.

Retrieval Number: K21410981119/19©BEIESP
DOI: 10.35940/ijitee.K2141.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

ISSN: 2278-3075 (Online), Volume-8 Issue-11, September 2019

Step 4: Mapping of Fuzzy values with the preset Fuzzy rules to get Fuzzy Output.

Step 5: In FIS, IF part is known as "Antecedent" and THEN is known as "Consequent". Here min-max method is used for each rule. The minimum value of the IF part is considered as final value. By combining all to an aggregated final value, the maximum value is obtained.

Step 6: The Fuzzy output were converted into numerical values by Defuzzification. For this, separate Fuzzy output rules were framed. The numerical value is called 'Crisp value'. This crisp value was obtained through the Center of Gravity (CoG) method. This crisp value specifies the score to the neighbor node.

Step 7: Step 1 to 6 were applied to all neighbor node which is present at quadrant zone. Then neighbor node having maximum value will be selected as the best forwarder.

Those seven steps were repeated until reaching the Geocast zone. The same can be referred in Algorithm1. Table 3 represents the notation used in the algorithm.

Table 3: Notation used at algorithm

Notation	*Meaning*
S	Source
D	Destination
R_{Zone}	Request Zone
G_{Zone}	Geocast Zone
Ack	Acknowledgement Packet
Pkt	Data Packet
NN	Neighbor Node
$R_{Request}$	Route Request
R_{Reply}	Route Reply
Max_{Score}	Maximum Score
NHV	Next Hop vehicle

Algorithm1: FLAR-C Algorithm

Process:

1 **BEGIN**
2 Get $S_{Location}$, $D_{Lococation}$ and calculate $D_{Direction}$, $D_{Velocity}$
3 Fix 4 Co-ordinates from S as R_{Zone} and fix G_{Zone} from D
4 Draw a Line between S & D as 'SD' line
5 **If** ($S_{Range} \cap G_{Zone}$)
6 Forward Pkt to G_{Zone} through Cache Scheme
7 Send Ack to S
8 **else**
9 Transmit $R_{Request}$ Pkt to all NN ⊂ (R_{Zone} ∩ Area of Quadrant)
10 S receive R_{Reply} (NN_{ID}, $NN_{Location}$, $NN_{Velocity}$, $NN_{Direction}$)
11 Define $Fuzzy_{Sets}$ for $Input_{Variable}$ and $Output_{Variable}$
12 For Input and output metrics – create separate Member Function
13 Generate $Fuzzy_{Rules}$ with Position, Distance, Density, Direction and Velocity
14 Set Max_{Score}=0 and i=1
15 **Do**
16 Calculate $NN_{Distance}$ from SD line
17 Generate $Fuzzy_{Value}$ by $Fuzzy_{(Member\ Function)}$
18 Input $Fuzzy_{Value}$ to Fuzzy Interference System
19 Map $Fuzzy_{Value}$ with $Fuzzy_{Rules}$ to get $Fuzzy_{Output}$
20 Use Defuzzifier to generate Numerical Value
21 **If** (Max_{Score} <= Numerical Value)
22 Max_{Score} = Numerical Value
23 Selected NHV = NN_{ID}
24 **End if**
25 Set NN_{ID}=Next->NN_{ID} and increase i by 1
26 **While** (i < NN(n))
27 Set Best NHV =Selected NHV
28 Forward Pkt to Best NHV and Fix Best NHV as S
29 Repeat step 9 to step 27 until Best NHV ∩ G_{Zone}
30 **End if**
31 END

C. Criteria for neighbor node evaluation

- *Distance:* Euclidean distance method was used by Greedy forwarding scheme for calculating the distance between each forwarding neighbor node and the destination. Instead, FLAR-C calculates the distance between source to the neighbor node present within the area of quadrant. All the neighbor node present within the selection zone will be calculated the distance by assuming X1, Y1 from source and X2, Y2 to 'A' neighbor node. And the Equation (1) shows the calculation of the distance from forwarding the node.

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (1)$$

In Figure 3, 'd' represents a distance between S to the neighbor node. S is the source node and 'A', 'B' was the neighbor node. X_1, Y_1 represents the position of 'S' and X_2, Y_2 represent the position of 'A'.

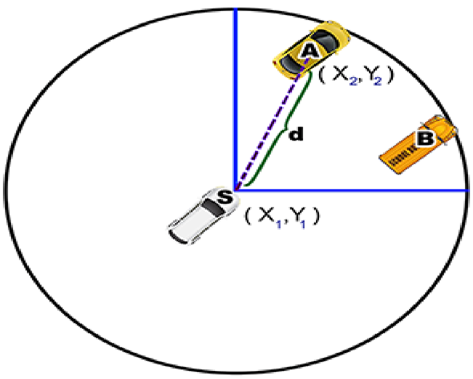

Fig. 3 Distance Calculated in FLAR-C

- *Direction:* In dynamic network architecture, monitoring the mobility of a neighbor node is very important to ensure continuous and stability of packet transmission towards the destination. From Equation (2), X_1, Y_1 was a position of source and X_2, Y_2 was the position of a neighbor node. The direction (Angle) of the neighbor node were calculated. And the neighbor node having a minimum angle will be selected for further transmission.

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

In Figure 4, 'S' represent source, 'D' represents the destination and 'A', 'B' represents as neighbor node. θ_1 and θ_2 represent as measured angles between 'S' to neighbor node. Those direction (angles) were calculated from SD line.

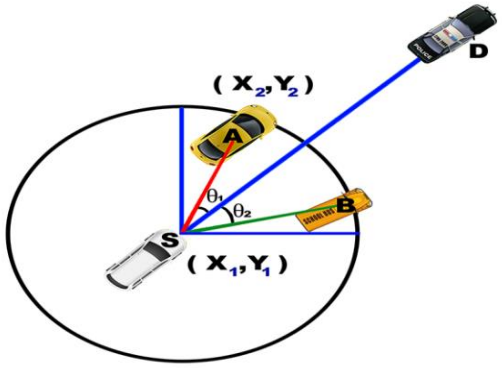

Fig. 4 Angle calculated in FLAR-C

Retrieval Number: K21410981119/19©BEIESP
DOI: 10.35940/ijitee.K2141.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Velocity: One of the significant metrics to find the best neighbor node is "Velocity". Velocity is classified into three fuzzy sets as represent in Table 7. Low velocity of vehicle leads to increasing delay, maximize packet loss and make retransmission higher. Average (Medium) velocity makes the system comfortable for smooth communication. A high velocity leads the neighbor node to overtake the destination if the destination is slower one. Sometimes it makes the transmission irrelevant. Low, Average and High velocity are represented in Fuzzy variable as slow, medium and fast.

- *Density*: This metric makes the transmission better based on the availability of nodes. Density is divided into three fuzzy sets as represented in Table 9, as spare, medium and dense. In spare density, transmission barrier occurs frequently. If there is no node available, then the forwarder has to wait, until neighbor node available further, due to this PDR reduces and delay increases. In the case of medium density, the performance is moderate/ high. At dense density, the number of hops is high, due to this Packet delivery time increases. To calculate the number of nodes (Density) available at an area of the quadrant, Equation (3) is used.

$$Node_{Density} = \frac{\lambda \pi r^2}{4} \qquad (3)$$

where nodes follow the Poisson distribution process 'λ' (node density per unit area), 'r' is the broadcast range of a vehicle. In Figure 5, 'S' represents the source and 'r' is the broadcast range of the S. The shaded area signifies the area where the S can communication with the neighbor node.

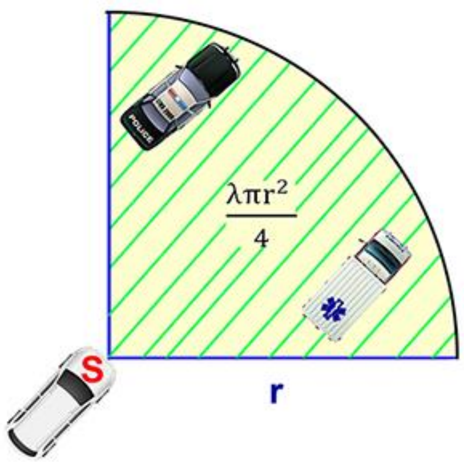

Fig. 5 Illustration of the availability of nodes in shady areas

- *Position:* This input metrics perform to calculate the position of the neighbor node through GPS and also by HELLO packet. All vehicle in VANET normally utilizes GPS to find its destination and neighbor node location. Table 8 shows three classifications of position in fuzzy sets as close, intermediate and far. Equation (4) shows the position metrics. The ratio of a distance between a point of SD line and forwarding node is known as $NN_{Position}$

$$NN_{Position} = \frac{P}{p} \qquad (4)$$

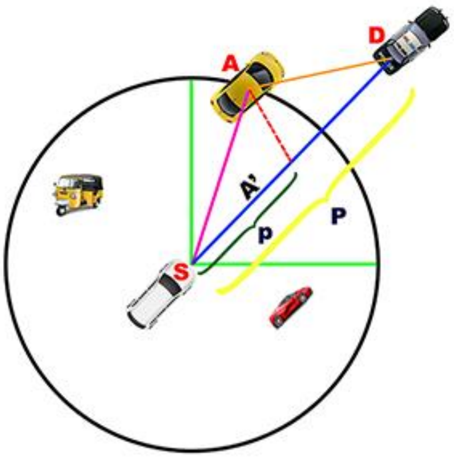

Fig.6 Position calculated in FLAR-C

Figure 6 represents $\acute{A}$ as the projection for neighbor node A over SD line having P distance.

For all five-input metrics, a separate membership function was created. Similarly, for those input metrics, linguistic variables were generated as shown in Table 2.

IV. SIMULATIONS AND RESULT ANALYSIS

The performance of FLAR-C protocol is evaluated through various simulation condition. The simulation is performed under a dynamic environment to evaluate FLAR-C performance.

The Experiment analysis is supported under SUMO 0.24.0 with NS 2.33 tools. NS 2.33 tool can be downloaded from https://www.isi.edu/nsnam/ns/ns-build.html / "https://www.nsnam.org/releases/older/" and SUMO 0.24.0 tool can be downloaded from "https://sumo.dlr.de/wiki/Downloads". Table 4 provides parameters for Network Simulation and Mobility Model.

The proposed method has been executed in NS-2.33 along with SUMO-0.24.0 (Intel Core I7 processor, 8 GB RAM, 1TB Hard Disk, Windows 10 Operating System) for a group of 200 nodes and each node is considered as VANET user. In our analysis, we used Gaussian Membership Function (MF) because it is suitable for highly dynamic random networks like VANET. These MF are well presented in the sub-sections that follow.

Table 4 Stipulates parameters used for mobility model and network simulation.

Parameter	Value
Radio range	250 m
Simulation Area	1500 m X 1500 m
Acceleration	0.25 m/s^2
Packet Rate (Data)	1-7pkts / sec
Movement step	1.2 sec
Ad hoc Network Simulation	NS-2.33
Mobility Model	SUMO-0.24.0
MAC protocol	IEEE 802.11P
Channel Type	Wireless
Antenna Type	Omni direction based

Retrieval Number: K21410981119/19©BEIESP
DOI: 10.35940/ijitee.K2141.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Simulation Time	1500 sec
Size of packet	1024 Byte
Traffic Type	Constant Bit Rate
Velocity of Vehicle	1-60 km/h
Vehicle Density	20-200 step 20
Protocols used	FL-DGR, HaFL, RMRPTS, FLAR-C
Maximum Connection	80%
Buffer Size	64k
TTL of Packet	130s

A. Input variable for fuzzification

All the simulation metrics are illustrated follows:

- *Distance*: Here the distance input is classified into various linguistic variable as defined in Table 5. Gaussian membership function is used for each performance metric as defined in Equation (5), based on which three Membership Functions (MF) are defined for fuzzy sets as shown in Equation (6), (7) and (8). where, 'y' is a linguistic variable, 'a' and 'σ' are MF center and MF width respectively.

$$Gaussian(y, a, \sigma) = e^{-\frac{1}{2}\left(\frac{y-a}{\sigma}\right)^2} \quad (5)$$

Table 5 Linguistic variable for Distance metrics

Input variable range	Fuzzy Variable
0 – 100 m	Close
100 – 180 m	Intermediate
180 – 250 m	Far

$$\mu_{Close}(y) = exp^{-\frac{1}{2}\left(\frac{y-100}{100}\right)^2} \quad (6)$$

$$\mu_{Intermediate}(y) = exp^{-\frac{1}{2}\left(\frac{y-180}{80}\right)^2} \quad (7)$$

$$\mu_{Far}(y) = exp^{-\frac{1}{2}\left(\frac{y-250}{70}\right)^2} \quad (8)$$

- *Direction*: Similarly, we can define functionality of Gaussian membership for direction variable. The direction (Angle) of the neighbor node were calculated though 'θ'as shown in figure 4 considered only the neighbor. The direction variable is categorized in the following three configurations as shown in Table 6 with their respective MF given below as Equation (9), (10) and (11).

Table 6 Linguistic variable for Direction (angle) metrics

Input variable range	Fuzzy Variable
0° – 30°	Less
30° – 60°	Moderate
60° – 90°	More

$$\mu_{Less}(y) = exp^{-\frac{1}{2}\left(\frac{y-30}{30}\right)^2} \quad (9)$$

$$\mu_{Moderate}(y) = exp^{-\frac{1}{2}\left(\frac{y-60}{30}\right)^2} \quad (10)$$

$$\mu_{More}(y) = exp^{-\frac{1}{2}\left(\frac{y-90}{30}\right)^2} \quad (11)$$

- *Velocity*: This is an important metric in analyzing the next hop vehicle section while the frequency change in network topology is due to the high dynamic nature of the VANET vehicle node. The velocity metrics are classified into three categories as shown in Table 7. Equation (12), (13) and (14) defines the speed classification membership function.

Table 7 Linguistic variable for Velocity metrics

Input variable range	Fuzzy Variable
1 – 20 km/h	Slow
20 – 40 km/h	Medium
40 – 60 km/h	Fast

$$\mu_{Slow}(y) = exp^{-\frac{1}{2}\left(\frac{y-20}{20}\right)^2} \quad (12)$$

$$\mu_{Medium}(y) = exp^{-\frac{1}{2}\left(\frac{y-40}{20}\right)^2} \quad (13)$$

$$\mu_{Fast}(y) = exp^{-\frac{1}{2}\left(\frac{y-60}{20}\right)^2} \quad (14)$$

- Position: This metrics helps in estimating the progress distance of a neighbor node towards destination vehicle by drawing a projection on the line SD as shown in Figure 6. This metrics are classified into three membership functions as shown in Table 8 according to the progress distance from the source vehicle and mathematically presented theses MF in the Equation (15), (16) and (17).

Table 8 Linguistic variable for Position metrics

Input variable range	Fuzzy Variable
0 – 30 m	Close
30 – 60 m	Intermediate
60 – 100 m	Far

$$\mu_{Close}(y) = exp^{-\frac{1}{2}\left(\frac{y-30}{30}\right)^2} \quad (15)$$

$$\mu_{Intermediate}(y) = exp^{-\frac{1}{2}\left(\frac{y-60}{30}\right)^2} \quad (16)$$

$$\mu_{Far}(y) = exp^{-\frac{1}{2}\left(\frac{y-100}{40}\right)^2} \quad (17)$$

- Density: This metric makes the transmission better based on the availability of nodes. we have classified this metrics into three membership functions as shown in Table 9 according to the density availability from the source vehicle and mathematically presented theses MF in the Equation (18), (19) and (20).

Table 9 Linguistic variable for Density metrics

Input variable range	Fuzzy Variable
0 – 60	Spare
60 – 120	Medium
120 – 200	Dense

Retrieval Number: K21410981119/19©BEIESP
DOI: 10.35940/ijitee.K2141.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

$$\mu_{Spare}(y) = exp^{-\frac{1}{2}\left(\frac{y-60}{60}\right)^2} \quad (18)$$

$$\mu_{Medium}(y) = exp^{-\frac{1}{2}\left(\frac{y-120}{60}\right)^2} \quad (19)$$

$$\mu_{Dense}(y) = exp^{-\frac{1}{2}\left(\frac{y-200}{80}\right)^2} \quad (20)$$

Table 10 Linguistic variable for Output Variable

Input variable range	Fuzzy Variable
0 – 35	Low
35 – 70	Medium
70 – 100	High

B. Output variable

The output reflects the routing metrics feature that helps to determine the best routing next hop vehicle. The optimum output function value ranges from 0 to 100 and is also defined by the function of Gaussian membership. Therefore, as shown in Table 10, the output variable is classified as low, medium and high. The higher that function's value, the higher that neighbor's vehicle's chance of being selected. Equation (21), (22) and (23) give the membership function of the above classification.

$$\mu_{Low}(y) = exp^{-\frac{1}{2}\left(\frac{y-35}{35}\right)^2} \quad (21)$$

$$\mu_{Medium}(y) = exp^{-\frac{1}{2}\left(\frac{y-70}{35}\right)^2} \quad (22)$$

$$\mu_{High}(y) = exp^{-\frac{1}{2}\left(\frac{y-100}{30}\right)^2} \quad (23)$$

C. Rule based Fuzzy Inference System for metrics

The human knowledge is represented in the Fuzzy Inference System (FIS) in terms of fuzzy IF-THEN rules. These rules are designed to bond the variables of input and output with the routing criteria of the Greedy routing protocol in knowledge. This fuzzy based IF-THEN rule is a conditional statement expressed as

IF <fuzzy preposition>, THEN<fuzzy preposition>

Where, IF-part of the rule is known as antecedent or premise and the THEN-part of the rule is known as the consequent or conclusion [23]. Consider Rule 1 of Table 2, was shown in the table, if distance is close and direction is less and position is close and density is spare with slow speed then the fuzzy output is low. When the distance of the neighbor vehicle is far from the source vehicle within the communication range, then the number of nodes required for forwarding packet and number of hops can be reduced. Moreover, when the speed of the vehicle is fast, neighbor nodes are more likely to move out of the transmission range but on the other hand are more likely to reach the destination in a short time-span compare to other nodes. This helps in reducing end-to-end delay. If the neighbor node forms less angles with itself, previous node and the destination node then it is more likely to be far away from the Current Forwarding Node. Thus, its progress towards the destination is more and helps in reducing the number of hops between source and destination node. In this case, the fuzzy output is defined as high. In this way, all these facts and notions, are designed rules to get the optimum value of the neighbor nodes. Among these neighboring nodes the node having maximum optimum value will be selected as the next-hop forwarding node. There are 243 possible rules are defined for this work. Here considered first thirty-five possible rules were shown in Table 2.

D. Defuzzification

Defuzzification is a necessary and significant process in fuzzy logic to produce a quantifiable result. In the real world, we need a single numerical value as an output to any problem that any application can use instead of resulting in linguistic forms such as high, medium, low etc. Therefore, defuzzification was applied in this work to obtain the optimum function's crisp value. In the section 4.2, FIS actions are based on all rules being tested. The rules defined in Table 2 were combined together to make a decision. Thus, before the aggregation process of defuzzification is performed, all the fuzzy sets representing the outputs of each rule are combined to obtain a single fuzzy set. Thus, this single fuzzy set obtained are serves as an input to a defuzzification process and output of each rule will be the single number. There are many methods of defuzzification. This research paper has used the centroid method which is the most widely used method and calculated as Equation (24)

$$Center\ of\ Area = \frac{\int \mu(y) y dy}{\int \mu(y) dy} \quad (24)$$

Where ' y ' denotes fuzzy variable and its membership function is represented by ' $\mu(y)$. It is also known as the Center of Gravity (CoG) or Center of Area (CoA) method that provides the crisp value of the optimum fuzzy function.

E. Performance Analysis

The performance analysis for FLAR-C was examined below as PDR, Delay, Throughput and Packet lost ratio.

- *Analysis of PDR*

A comparison of the PDR of FLAR-C, FL-DGR, RMRPTS and HaFL protocols is shown in Figure 7 considering different vehicle density. Here the node density is 20 to 200 nodes. If the vehicle density increases, then the PDR also increases.

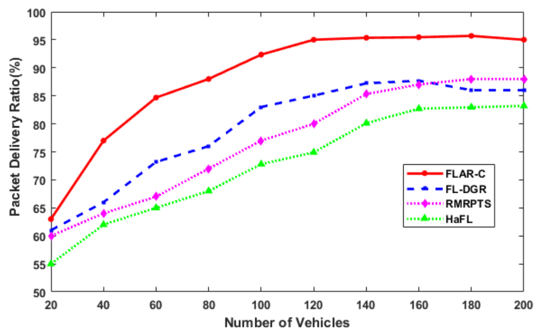

Fig.7 Impact of vehicle density on the Packet Delivery Ratio

The mechanism used by FLAR-C to predict the location of Next Hop Vehicle (NHV) with Fuzzy Logic is the best result of FLAR-C. This leads to the selection of best next-hop vehicles and reduces unwanted transmission.

Retrieval Number: K21410981119/19©BEIESP
DOI: 10.35940/ijitee.K2141.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

Using the cache scheme in the Geocast zone, the packet forwarding destination can be found accurately. Figure 7 shows that FLAR-C performs 11.43%, 14.73%, and 21.31% better than FL-DGR, RMRPTS and HaFL respectively.

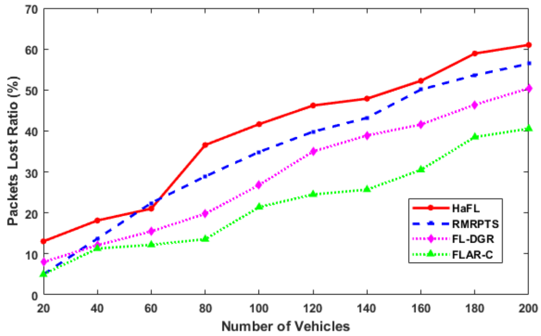

Fig.8 Impact of vehicle density on the Average Delay

- *Analysis of Average Delay*

Figure 8 shows the average delay of FLAR-C, FL-DGR, RMRPTS, and HaFL protocols for varying node density. The average delay of FLAR-C, FL-DGR, RMRPTS, and HaFL Protocols also increased as the number of vehicles increased. It is obvious that the average delay of FL-DGR, RMRPTS and HaFL is higher than proposed. This performance is due to the right selection of NHV by using position, direction, speed, distance and density as an input variable for Fuzzy logic. This leads to a proper route selection mechanism and provides a better result with the help of the Geocast zone cache scheme. Figure 8 shows that FLAR-C outperformed than the other FL-DGR, HaFL, and RMRPTS by 14.98%, 25.27% and 18.11% respectively.

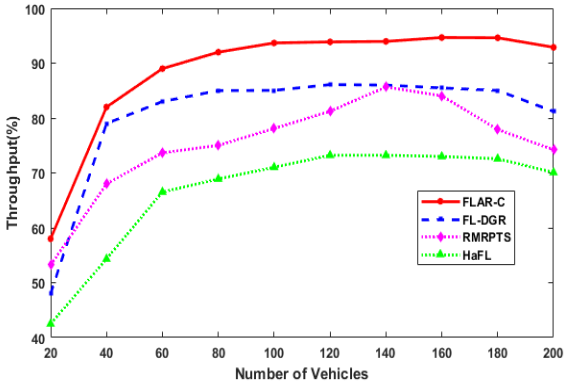

Fig.9 Impact of vehicle density on the throughput

- *Analysis of Throughput*

The outcomes in Figure 9 show the throughput for FLAR-C, FL-DGR, RMRPTS and HaFL protocols. The throughput of FLAR-C, FL-DGR, RMRPTS, and HaFL Protocols also increases as the number of vehicles increases. It is apparent that the throughput of FL-DGR, RMRPTS and HaFL is lower than proposed. This performance is due to cache scheme used at Geocast zone to find a destination to forward the packet accurately. From the Figure 9 shows that FLAR-C outperformed than the other FL-DGR, RMRPTS and HaFL by 10.06%, 17.79% and 32.96% respectively.

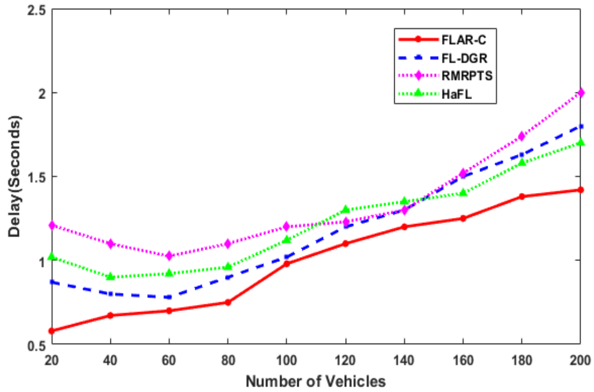

Fig.10 Impact of vehicle density on the packet lost ratio

- *Analysis of Packet Lost Ratio*

The results in Figure 10 show the Packet Lost Ratio for FLAR-C, FL-DGR, RMRPTS and HaFL protocols. The Packet Lost Ratio of FLAR-C, FL-DGR, RMRPTS, and HaFL Protocols has also increased as the number of vehicles increases. It is clear that the packet loss ratio of FL-DGR, RMRPTS, and HaFL is higher than the proposed protocol. This is because of FL-DGR chooses a closer node that exists at the border of the transmission range, whereas RMRPTS use Tabu search to solve the optimum local problem and also manage to route from the cluster head to the destination, and HaFL uses fuzzy logic to manage containment window size and transmission power. FLAR-C uses Fuzzy cache logic to choose NHV and forward the packet to the destination. FLAR-C utilize Fuzzy logic with cache scheme in choosing NHV and forwarding the packet to reach the destination. Figure 10 shows that FLAR-C outperformed than the other FL-DGR, RMRPTS and HaFL by 24.18%, 35.85% and 43.71% respectively.

V. CONCLUSION

The proposed FLAR-C protocol used the Fuzzy Logic and Cache scheme in LAR to improve VANET's performance. This leads to the degradation of routing protocol performance. But to perform skillfully, FLAR-C uses a two-step procedure. Step 1 uses Fuzzy logic to select better NHV and step 2 uses the cache scheme to accurately forward a data packet. The performance of FLAR-C was analyzed in terms of PDR, throughput, average delay, packet loss ratio, and the simulation result shows that FLAR-C improved performance are compared with other HaFL, FL-DGR and RMRPTS protocols and also observed that FLAR-C is feasible with VANET Artificial Intelligent.

REFERENCES

1. Gurumoorthi Elangovan and Ayyasamy Ayyanar. (2017). A Comprehensive study for Geocast routing and its tool on VANET, International Journal of Pure and Applied Mathematics, 117(15), pp 1177-1184.
2. Gurumoorthi, E. & Ayyasamy, A. (2019). Wireless Pers Commun. https://doi.org/10.1007/s11277-019-06610-9

Retrieval Number: K21410981119/19©BEIESP
DOI: 10.35940/ijitee.K2141.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

3. Nebbou T., Fouchal H., Lehsaini M., Ayaida M. (2017). A Realistic Location Service for VANETs. In: Eichler G., Erfurth C., Fahrnberger G. (eds) Innovations for Community Services. I4CS 2017. Communications in Computer and Information Science, vol 717. Springer, Cham
4. Johanyák, Zsolt. (2019). Fuzzy rule interpolation based model for student result prediction. Journal of Intelligent and Fuzzy Systems. 36 (2). pp 999-1008.
5. Li, G., Ma, M., Liu, C., & Shu, Y. (2015). Adaptive fuzzy multiple attribute decision routing in VANETs. International Journal of Communication Systems, 30(4).
6. Jabraeil Jamali, Mohammad & Rahimi, Saeideh. (2018). A hybrid geographic-DTN routing protocol based on fuzzy logic in vehicular ad hoc networks. Peer-to-Peer Networking and Applications.
7. Ghorai, Chinmoy & Banerjee, Indrajit. (2018). A robust forwarding node selection mechanism for efficient communication in urban VANETs. Vehicular Communications. 14. pp 109-121
8. Malarvizhi Kumar, Priyan & Devi G, Usha & Manogaran, Gunasekaran & Sundarasekar, Revathi & Chilamkurti, Naveen & Varatharajan, Ramachandran. (2018). Ant colony optimization algorithm with Internet of Vehicles for Intelligent Traffic Control System. Computer Networks. 144. pp 154-162.
9. Zidani, Ferroudja & Semchedine, Fouzi & Ayaida, Marwane. (2018). Estimation of Neighbors Position privacy scheme with an Adaptive Beaconing approach for location privacy in VANETs. Computers & Electrical Engineering. 71. pp 359-371.
10. B. Wagh, Mukund & Gomathi, N. (2018). Route discovery for vehicular ad hoc networks using modified lion algorithm. Alexandria Engineering Journal. 57(4).
11. Raj K. Jaiswal and Jaidhar C. D. (2017). PPRP: Predicted Position Based Routing Protocol Using Kalman Filter for Vehicular Ad-hoc Network. In Proceedings of the 18th International Conference on Distributed Computing and Networking (ICDCN '17). ACM, New York, NY, USA, Article 23. pp 1-8.
12. Abbasi, Irshad & Shahid Khan, Adnan & Ali, Shahzad. (2018). A Reliable Path Selection and Packet Forwarding Routing Protocol for Vehicular Ad hoc Networks. EURASIP Journal on Wireless Communications and Networking. 2018. 236.
13. R. Maranur, Jyoti & Mathpati, Basavaraj. (2017). VANET: Vehicle to vehicle communication using moving zone based routing protocol. International Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT). 1-7.
14. Abbasi, I.A.; Khan, A.S.; Ali, S. (2018) Dynamic Multiple Junction Selection Based Routing Protocol for VANETs in City Environment. Appl. Sci. 8(5). 687.
15. Chen, Chen & Liu, Lei & Qiu, Tie & Yang, Kun & Gong, Fengkui. (2018). ASGR: An Artificial Spider-Web-Based Geographic Routing in Heterogeneous Vehicular Networks. IEEE Transactions on Intelligent Transportation Systems. pp 1-17.
16. Yi Zhou, Huanhuan Li, Chenhao Shi, Ning Lu, and Nan Cheng. (2018). A Fuzzy-Rule Based Data Delivery Scheme in VANETs with Intelligent Speed Prediction and Relay Selection. Wireless Communications and Mobile Computing, vol. 2018, Article ID 7637059, 15 pages.
17. Kosuke Ozera, Kevin Bylykbashi, Yi Liu, Leonard Barolli. (2018). A fuzzy-based approach for cluster management in VANETs: Performance evaluation for two fuzzy-based systems.Internet of Things, 3(4). pp 120-133.
18. Lim, Joanne & Choon Chang, Yoong & Loo, Jonathan & Alias, Mohamad Yusoff. (2015). Improving VANET Performance with Heuristic and Adaptive Fuzzy Logic Scheme. Wireless Personal Communications. 83(3). pp 1779-1800.
19. Moridi, Elham & Barati, Hamid. (2016). RMRPTS: a reliable multi-level routing protocol with tabu search in VANET. Telecommunication Systems. 65(1), pp 127–137.
20. Alzamzami, Ohoud & Mahgoub, Imadeldin. (2018). Fuzzy Logic-Based Geographic Routing for Urban Vehicular Networks Using Link Quality and Achievable Throughput Estimations. IEEE Transactions on Intelligent Transportation Systems. PP. 1-12.
21. Nazar Hassan, Ahmed & Abdullah, Hanan & Kaiwartya, Omprakash & Cao, Yue & Khalid Sheet, Dalya. (2017). Multi-metric Geographic Routing for Vehicular Ad hoc Networks. Wireless Networks. 24(7), pp 2763–2779.
22. Agrawal, Shilpy & Tyagi, Neeraj & Iqbal, Asif & Raw, Ram. (2018). An Intelligent Greedy Position-Based Multi-hop Routing Algorithm for Next-Hop Node Selection in VANETs. Proceedings of the National Academy of Sciences, India - Section A. 88.
23. Wu, Celimuge & Ohzahata, Satoshi & Kato, Toshihiko. (2012). VANET Broadcast Protocol Based on Fuzzy Logic and Lightweight Retransmission Mechanism. IEICE Transactions. 95-B. 415-425. 10.1587/transcom.E95.B.415.

AUTHORS PROFILE

E. Gurumoorthi is a Full Time Research Scholar, Department of Computer Science and Engineering, Annamalai University, Chidambaram, Tamilnadu. He received his MCA in Computer Applications from Pondicherry University 2007. He received his M.Tech in Computer Science and Engineering from PRIST University 2012. He has the credit of publishing nearly 10 research articles in the referred and peer reviewed international journals / conferences and presented nearly 5 papers in the international / national conferences. His research interest is in Wireless Sensor Networks, VANET, QoS and enhancement of routing protocol, computer network as well as network security

Dr. A. Ayyasamy is B.E. & M.E. in Computer Science and Engineering from Annamalai University, Chidambaram, Tamil nadu, India in the year 2006 and 2008 respectively. He is working as Assistant Professor in Department of Computer Science and Engineering, Faculty of Engineering and Technology, Annamalai University from 2007 where he obtained his Doctorate in 2015. He has the credit of publishing nearly 47 research articles in the referred and peer reviewed inter-national journals/conferences and presented nearly 17 papers in the international conferences. He acts as co-author for book “Micro Controller” (ISBN:978-81-934315-5-9). His areas of interest are mobile ad-hoc network, wireless network, video streaming services, streaming media architectures, QoS and routing protocol, computer engineering as well as network security. He is also serving as Editor-in-chief of International Journal of Net-working (Bio Info publications). He is also serving as an editorial board member for various international journals, and reviewer in IEEE, Springer, Ad Hoc and Sensor Wire-less Networks (AHSWN) etc. He also accepted an invitation to be a Technical review committee member for many international conferences (India, USA, London, Malaysia...). He is a professional member of ACM journals, International Association of Engineering, and senior member in Universal Association of Computer and Electronics Engineers. He received Young Faculty award from Center for Advanced Research and Design in 2015.