Received: 15 October 2022 | Revised: 10 December 2022 | Accepted: 2 January 2023

IET Electrical Systems in Transportation

DOI: 10.1049/els2.12069

The Institution of Engineering and Technology WILEY

ORIGINAL RESEARCH

Enhanced clustering based routing protocol in vehicular ad-hoc networks

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Abstract

A vehicular ad-hoc network (VANET) is derived from a mobile ad-hoc network that is a part of less infrastructure network design. Vehicular communication in VANET can be achieved using vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communication. A vehicle communicates with other vehicles through onboard units while communicating with roadside units in an infrastructure mode. Secure clustering is required for the communication between nodes in the whole network. The fundamental problem with the VANET is the instability of the network that occurs due to vehicles' mobile nature, which decreases the network's efficiency. This research proposes an enhanced cluster-based lifetime protocol *ECBLTR* that focuses on maximising the network's stability of routing and average throughput. The Sugeno model fuzzy inference system is used for assessing the cluster head (CH) that takes residual energy, local distance, node degree, concentration, and distance from the base station as input parameters. Our enhanced routing protocol shows that the proper channel model with an efficient routing protocol enhances the link throughput of the VANET for fixed network size. Our results show an efficient selection method of CH through the fuzzy system and a 10% increase in network lifetime. Furthermore, performance evaluation also demonstrates the impact of network sizes and routing protocols on packet delivery ratio and packet loss, average end-to-end delay, and overhead transmission.

KEYWORDS

electric drives, fuzzy control, transportation

1 | INTRODUCTION

Intelligent Transportation System (ITS) incorporates all sorts of interchanges between vehicles is a significant cutting-edge transportation structure [1–3]. Vehicular ad hoc network (VANET) is an application of ITS that helps to provide safety for drivers, vehicles, and travellers. VANET provides a system that can revolutionise traffic services and minimise the threat of road accidents. Each vehicle that becomes part of the network also manages and controls the communication on this network [4–7]. Many types of research have been published to utilise and perform reliable connections [8–11]. VANET comprises mobile nodes embedded with sensors, roadside access points, and wireless interconnection that helps the vehicles communicate with each other [12, 13].

VANET is a subcategory of mobile ad-hoc networks that ensures safety for drivers and passengers. In this type of network, messages are sent without any infrastructure. The communication is comprehensive due to the forwarding mechanism over a few hops [14, 15]. The characteristics of MANETs show a distinctive approach in the robust topology, changing time slots, and increasing costs. Moreover, the ability to use GPS and digital plots to navigate the spot is a significant property of VANET [16]. The architecture of VANET offers a method of communication with adjacent vehicles and roadside tools. In VANET, vehicles are furnished with onboard units (OBUs) that can speak with one another, called V2V transactions, and fixed street foundation units, called V2I communication. Three types of communications in VANET are discussed as follows.

1.1 | Vehicle to vehicle communication

An automobile can correspond with the new automobiles in communication when communication is less direct. This communication's primary purpose is to avoid accidents by permitting vehicles to send data related to their position and speed to each other through an ad-hoc mesh network. In this communication, only OBUs have significance [16].

1.2 | Vehicles to infrastructure communication

Vehicle-to-infrastructure communication is bidirectional and wireless. This type of communication permits the vehicles to share information with the components. This approach allows an automobile to relate only through the Road Side Units (RSUs). The RSU is a way that is stable along the way at particular places and performs as an information hub [16, 17]. The RSU is responsible for proposing security and non-security purposes to onboard and RSUs [18].

1.3 | Hybrid architecture

Hybrid architecture involves both V2V and V2I Infrastructure. In this approach, an automobile can resemble the roadside infrastructure and vice-versa inside a specific hop or multiple-hop methodology [16, 19]. VANET has several properties dissimilar from mobile ad-hoc network, comprising high node mobility, limited mobility design, immediate network topology modification, and infinite power supply. The kinds of communication in VANET are shown in Figure 1.

Achievement in the VANET applications depends on how messages are sent among the vehicles. Different protocols have been developed that help in messaging in an Ad-hoc network. High mobility in the nodes causes routing difficulty, due to which the topology changes rapidly [20]. Choosing and maintaining routes is a challenging task that must carefully select [21]. Protocols in VANET are categorised into five types: position-based, topology-based, cluster-Based, GEO-CAST-based, and broadcast-based Protocols. Figure 2 pictorially represents the different protocols in the VANET.

Protocols based on topology store the information from the sender to the receiver in the routing table. It is further divided into proactive and reactive protocols [22]. The main dissimilarity between these two is that proactive initiates a routing path for all the nodes present in the whole network system, which results in enhanced management overhead, and back-to-back interruption (even as the reactive), the discovery initiates for an only intended destination, which results in decreased control overhead [23]. The GEOCAST-based

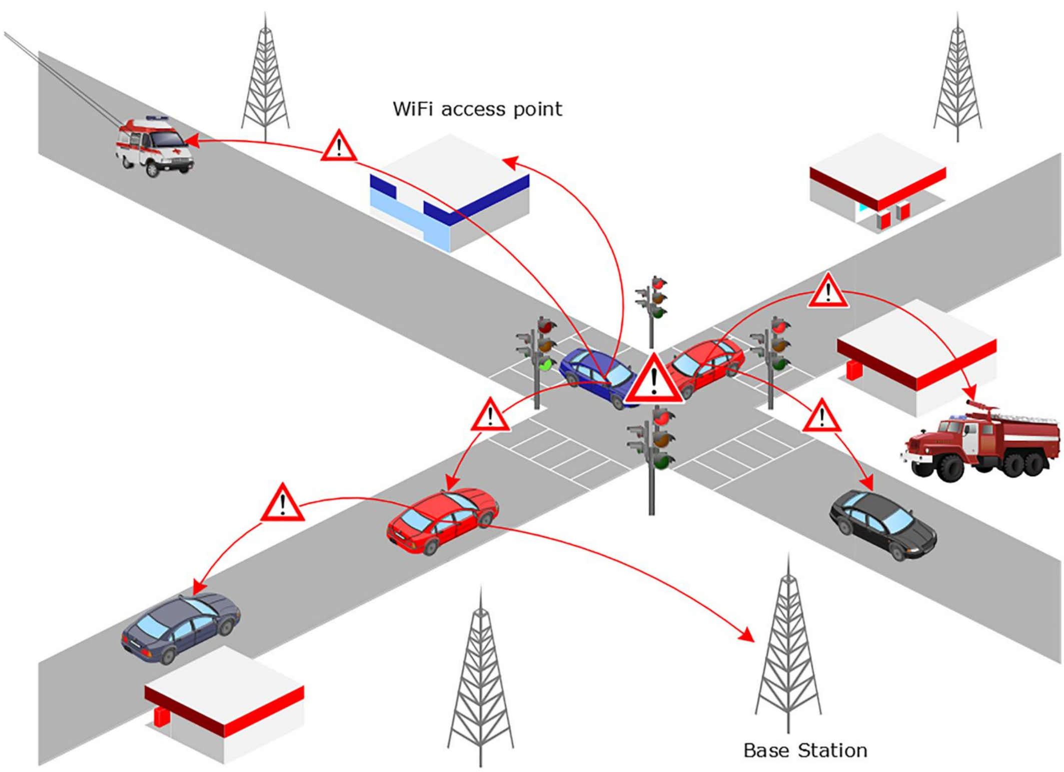

FIGURE 1 Vehicular ad-hoc network communication.

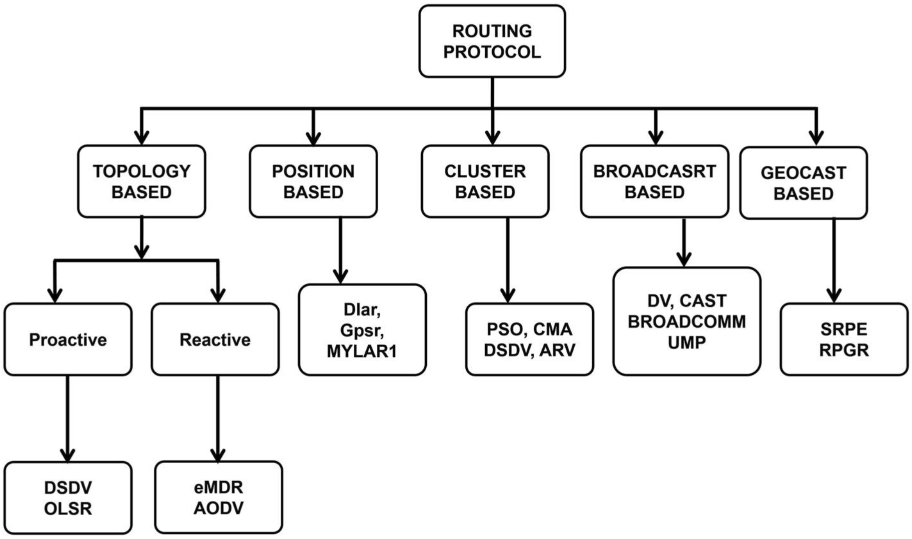

FIGURE 2 Routing protocols vehicular ad-hoc network.

protocol is a multicast protocol based on location. The GEOCAST protocol delivers the message to the destination node from the source node in a specific geographic area [24]. MPR-OLSR protocol with GSA-PSO technique has been proposed to evaluate the performance in terms of delay, packet drops, channel utilisation, packet delivery ratio, and throughput of the cognitive radio-based VANET [24].

Position-based routing protocol routes the information from the source node towards the receiver node, depending on each node's geographic position. Every node in this protocol finds its location and neighbour location via Global Positioning System [25]. The Broadcast Routing Protocol broadcasts communication among vehicles and between Vehicles to Infrastructure [14]. Clustering is a technique that aims to divide ground network vehicles into groups called clusters. In routing protocols based on clusters, the geographic area is divided into clusters. In this protocol, the vehicles close to each other make a group [26]. These are designed to enhance the network's scalability by permitting the cluster nodes to communicate through a selected cluster head (CH).

Enhanced Cluster-based Life Time Routing Protocol is a protocol that involves both the geographic and cluster-based routing protocols [27]. Average throughput is enhanced in this protocol. It eliminates the route detection process and splits the network into clusters. It also minimises the re-election function for selecting a new CH [28]. The CH is selected through the fuzzy system that takes input parameters and gives a selected CH for communication.

To overcome the limitations of the previously proposed routing protocols, this paper uses a novel routing method that uses the Sugeno ANFIS model for CH selection. The paper follows in order; at first, vehicles are divided into various clusters, and every vehicle is given a Cluster ID to keep it unique, then each CH is selected for each cluster to carry the information from the nodes to the sink node, and lastly, *ECBLTR* protocol is used for routing procedure. Previously proposed protocols used algorithms for CH selection, but our paper uses the ANFIS model to handle uncertainty efficiently. The result was compared with different protocols for many evaluation matrices, such as PDR and E2E delay.

1.4 | Problem statement

There is a need to improve the VANET network's stability and increase the average throughput bidirectionally. The dynamic nature of the VANET makes routing difficult due to the unavailability of any base station in the network [29]. Unbalanced energy consumption in the network causes the network's lifetime to decrease. The instability in the network yields reduced network efficiency. Introducing a routing protocol that performs clustering, balances energy consumption, and enhances the network's lifetime is necessary.

The proposed methodology aims to resolve these issues by enhancing routing stability and average throughput (in VANET). The following are the main contributions:

1. The proposed protocol uses Sugeno Fuzzy Inference System (FIS) to select optimal CH in Cluster-Based Routing protocol and handle uncertainty efficiently.
2. The proposed protocol further aims to transfer packets through CHs selected using the fuzzy model efficiently.
3. The proposed protocol achieves enhanced lifetime, maximum stability, and maximum average throughput of the network through the cluster-based protocol.
4. It shows that the proper channel model with an efficient routing protocol enhances the link throughput of the VANET for fixed network size.
5. The results show the impact of network sizes, routing protocols on packet delivery ratio, routing protocols on packet loss, average end-to-end delay, and overhead transmission compared with existing methods.

The rest of the paper is arranged in the following way: Section 2 highlights the related work. Furthermore, Section 3 gives the proposed solution against the problem statement. Section 4 discusses the results of the proposed solution. Section 5 summarises the topic giving concluding remarks.

2 | RELATED WORK

A cluster-based routing protocol is a hybrid protocol that partitions a massive network into multiple tiny cluster areas. Each resultant cluster demonstrates a precise routing protocol known as an intracluster routing protocol [30]. The CHs are responsible for communication between connecting clusters within the network [31]. The CH moreover needs to discover the target and optimal route after the development of clusters in the network [32]. Clusters help in decreasing the control overhead and enlarge the network size.

The CH election process in VANET is selected through a variety of algorithms. Authors in Ref. [33] proposed a Cluster-Based Directional Routing Protocol for public road development. The constraints used in this algorithm, such as direction, location, and velocity, are used to compute the CH election process. According to research in ref. [34], the researchers have used the protocol to choose the CHs (by considering the automobile movement parameter), and for connection among vehicles, the structure of CHs is kept constant. The protocol minimises the communication overhead and MAC layer argument time on every vehicle while continuing a high Packet Delivery Ratio. The CH is selected according to the automobile's moving path in this scenario. In other research papers, the writer discusses the Cluster-Based algorithm (for connectivity maintenance purposes) in VANET (AODV-CV) to increase the rate of velocity. The authors proposed an improved greedy traffic-aware routing protocol (GYTAR) and a crossroads-based routing protocol (to consider the detachment to a cluster) to select the CH.

According to the author in ref. [35], a Greedy Perimeter Coordinator Routing (GPCR) oriented set of rules is used to transport the small package by using a direct route to the target (in case of any intersection). In ref. [36], the researchers discuss the Vehicle Density & Load Aware protocol for VANET that outperforms GPCR in the condition of common PDR and back-to-back delay.

The protocol (IRTIV) develops the PDR and minimises the end-to-end delay contrast with GYTAR & AODV. A position-based routing protocol is IRTIV trying to discover the directly connected path to the target (in a city scenario). The protocol IRTIV sometimes determines an actual instant rate worth by considering traffic density. In ref. [37], the author proposed a Beacon Less Routing algorithm for Vehicular Environment (BRAVE) to minimise the control overhead communication in broadcast approaches. The author in ref. [38] discussed a (MoZo) Moving Zone-based design consisting of a moving zone group made on a similar movement.

According to the author in ref. [39] proposed an approach that clustering plays a significant character in the combination of VANET and 5g. This survey discussed the classification of algorithms based on clustering in VANET and a detailed overview of previous research work. According to research, [40], the author has proposed a cluster-based lifetime direction-finding protocol is introduced, in which section topology is discussed. The CH selects the highest LT (lifetime) in this method, and the re-election process is required (when CH reaches on threshold point). The IDVR protocol selects an optimal route, destination location, and maximum throughput for SCSRs. A Control Overhead Reduction algorithm minimises the cluster's overhead control communication by exchanging messages between CH & CMs. According to research, study [41], LEACH protocol is the base for fuzzy LEACH protocol. This protocol holds poor clustering difficulty associated with the LEACH protocol. The FIS uses three input parameters for selecting the CH: centrality, concentration, and node power. CH was selected based on considered ability value by FIS using three fuzzy descriptions. The appropriate node selects CH because Base Station (BS) has complete information about nodes. The author in ref. [42] established the CHEF protocol for CH selection. This set of rules uses two descriptions: the node's energy and the local distance to select the node CH.

CHEF ensures that nodes are nearby optimal and through high energy level chosen as CH. According to research, [43], the researcher proposed the CH collection method, in which they used fuzzy logic rules for optimising the WSN and period. This method is parallel to CHEF but among a few significant changes. CHEF uses two fuzzy descriptions, but four fuzzy rules are used (such as BS, the remaining power of the nodule, node attention, and local distance).

The research in ref. [44] proposed a directional-based clustering algorithm suitable for the town areas. The vehicles that are captivating the identical spin are grouped in one cluster. The researcher planned an algorithm called AMACAD that pursues the mobility model of the network, enlarges the cluster lifetime, and minimises global overhead. This algorithm's parameters are speed, location, and final position. According to ref. [45], the author proposed an enhanced VANet algorithm. The cluster-based proposal is helpful for data communication in VANET. The CH selects the algorithm by considering the node scale, resource availability of the candidate CHs, and Cluster Member. According to the author in ref. [46], proposed a hybrid backbone-based clustering algorithm for the VANET (i.e. a new CBR protocol in VANET is called *EECBLTR* protocol). This protocol shows an essential enhancement in expressions of throughput and lifetime. Location Aided Routing lacked in showing that nodes in VANET have random movement. According to ref. [47], proposed Rectangle-Aided LAR based protocol on the shaped zone of the mobility of node model. Moreover, before selecting the route location, this protocol utilises the location of the destination node. The proposed work also optimised the Genetic algorithm by selecting time-out variables. Moreover, according to a researcher in ref. [48], a multipath scheme in mobile ad-hoc networks was introduced, which is residual-battery aware. In the same scheme, the traffic load is redirected from the low-energy node to the high-energy node. Various other routing protocols in VANET are discussed. According to the survey paper [49], a detailed survey and comparison among the routing protocols are made between position-based, topology-based, cluster-based, broadcast-based, and geocast based. The author explains each routing protocol that is already introduced. The author in ref. [50] proposed another comparative study regarding two existing routing protocols that were analysed. The protocols are Ad-hoc On-Demand Distance Vector and Dynamic Source Routing for the VANET.

According to the categorisation, many techniques, frameworks, and models have been recognised, and the idea, input parameters, pros, and cons have been discussed. Therefore, the detailed literature on the idea provides valuable data and clarity to the research to identify the problem and state its optimised approach. The detailed analysis highlights shortcomings of the previous work, takes it forward to work on it, and presents a better clustering result in routing protocol to cope with uncertainty using the Sugeno-based FIS model. Moreover, in ref. [51], a data dissemination model has been introduced in which roadside communication was time-dependent, and storage was observed for the communication. The status of communication is updated to improve VANET in this model. Mobile Ad-hoc Networks (MANETs) lack security due to the random movements of nodes and multi-hop architecture. To improve this security, a sequence number-based scheme was initiated in ref. [52] to overcome the Grayhole Attack. The idea introduced was to stop the movement of the nodes. The results proved its efficient performance. Moreover, a routing scheme was introduced in ref. [53] to detect sequence number attacks. A comparison was made with the previously proposed schemes. This scheme detected all the misbehaving nodes in the routing path to overcome the attack. The enhancements were made in the distance vector routing protocol. Researchers all over the globe are working on the advancement of networks. A survey on 6G is conducted in ref. [54], which discusses the key performance indicators, services, and applications. Moreover, the survey paper discusses the challenges faced in 6G Networks. Networking is one of the most advancing areas nowadays, and studies are being carried out to improve communication among devices for better routing and information transferring. Table 1 presents the relevant work and its limitations.

3 | PROPOSED SOLUTION

The proposed solution is the Enhanced Cluster-Based Lifetime Protocol. It improves routing stability in a bidirectional way and increases the average throughput. The steps included are shown in Figure 3. In the first step, the segment is split into clusters. After forming clusters, the CH is selected through the fuzzy system based on inputs that pass through the system and select CH. Finally, the proposed routing protocol decides the most appropriate routing path based on the CH neighbours and the destination's location.

3.1 | Cluster dividing

In this first step, the vehicles are divided into different clusters. The dimension of each cluster would be equal to half of the transmission range of the designated vehicle. For example, if we want to make two clusters, then the centre position of one of the clusters will be fixed after division. The assumptions can be taken as follows: radius as r, length of each cluster is l, and the width of half highway is said to be w. Since $d > w$, d will be equal to $r/2$. In IEEE 802.11p, the radius is 1000 m, so it is calculated that the length of every cluster is 500 m. So this is how the dimension for each cluster can be calculated. Each segment is a road in both directions and is divided into different clusters, equivalent to half of the transmission range (of the standardised vehicle). It is assumed that every vehicle knows cluster-ID and synchronisation. Every vehicle is assigned to any cluster based on the vehicle's location at each unit. Every Cluster and Vehicle is assigned a unique ID that differentiates each other. A segment with two clusters is shown in Figure 4. When a vehicle enters any one of the clusters simultaneously, it becomes part of that cluster. The Algorithm 1 for cluster dividing is given below in which the vehicle enters the cluster and becomes part of it, here ST is the stimulation time, N stands for the total amount of vehicles in the segment, CID stands for Cluster ID, NCL is the total number of clusters in the segment, and MCID is the members of CID including the time. The evaluation measures taken are accuracy and precision concerning the division of clusters.

TABLE 1 Related work on clustering-based routing protocol in vehicular ad-hoc networks (VANET)

References	Focus	Limitation
[37]	Data routing for urban VANET	Enhancing network lifetime and stability
[51]	Date communication in autonomous vehicles	Maximising network lifespan
[38]	Increasing QoS in VANET using fuzzy logic	Network stability
[55]	Routing for VANET in real geographic scenario	Efficient cluster head (CH) selection and maximising average throughput
[36]	Geographical routing protocol for intelligent vehicles	Network stability
[45]	Learning-based protocol for clustered EV-VANET	Efficient cluster and CH formation

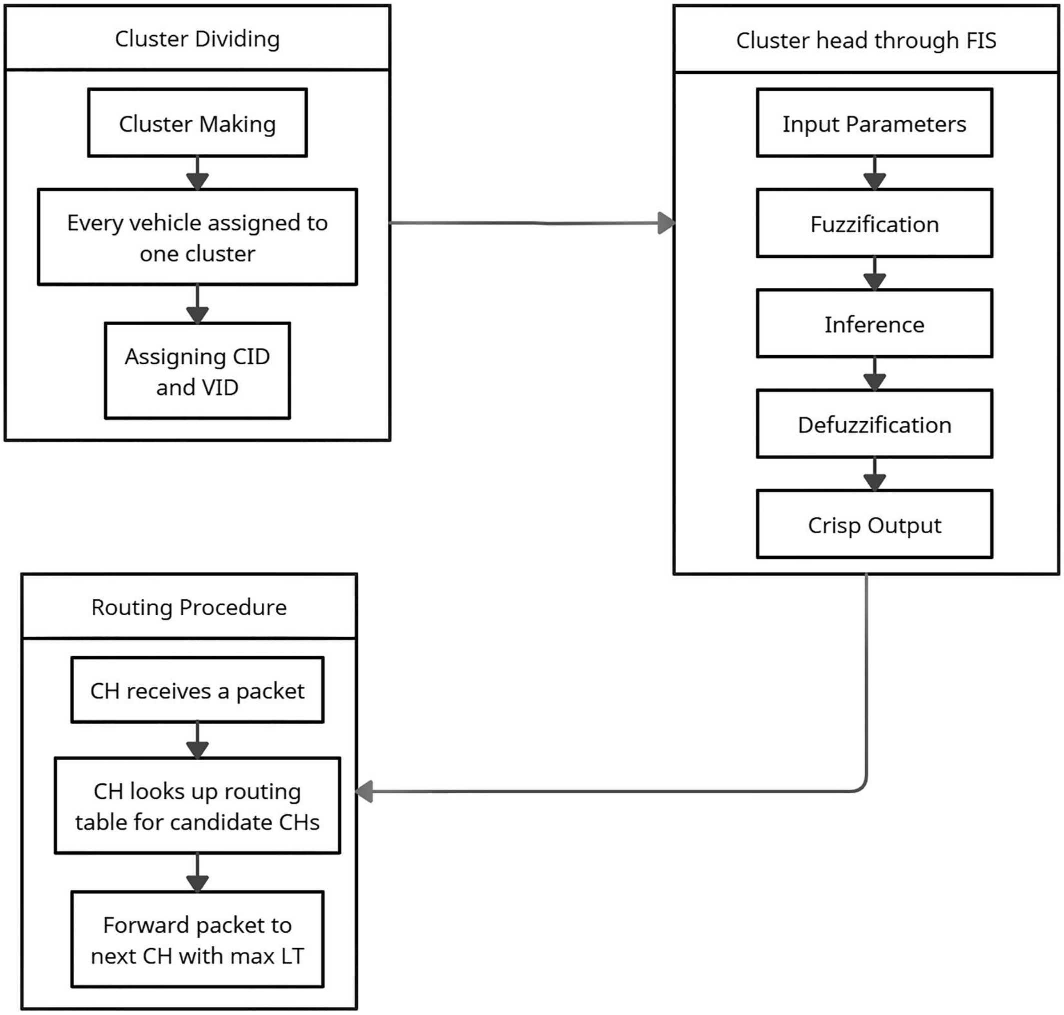

FIGURE 3 Proposed solution. CH, cluster head

Algorithm 1 Cluster dividing

```
Input: Cluster ← Vehicle
Output: Divided Clusters
    Evaluation Measures: Accuracy,
    Precision
ST ← [] {Stimulation Time}
N ← [] {Total Vehicles in Segment}
CID ← [] {Cluster ID}
NCL ← [] {Total Clusters in segment}
MCID ← [] {Members of CID including time}
for i = 1, …, ST do
   for x = 1, …, N do
      for CID = 1, …, NCL do
         if (loc(x) withinloc(CID)) then
            MCID = x + MCID
         end if
      end for
   end for
end for
return Output
```

3.2 | Cluster head selection

The clusters are assigned a CH responsible for collecting data from all the nodes and sending it to the sink node [12, 56]. The selection of CHs has a significant effect on the lifetime of WSN. The specifications of an ideal CH include a maximum number of neighbour nodes, the smallest distance from the BS, and the highest residual energy. To enhance the clustering-based protocol, a fuzzy system is implemented to select CHs.

A FIS is used, which does not use a probabilistic scheme. The parameters, that is, node degree, local distance, residual energy, concentration, and distance from the BS, are responsible for the CH selection. Moreover, it is fully localised as it does not involve a BS. A fuzzy system minimises the cost of CH selection. Figure 5 shows the model for choosing a CH through the FIS. The fuzzy system is implemented, and the inputs are sent through the fuzzy system. Five input parameters are taken:

1. Residual Energy
2. Node Degree

3. Local Distance
4. Concentration
5. Base Station Distance

A FIS consists of three steps fuzzification, knowledge base, and defuzzification. The FIS Sugeno model is developed in which residual energy, node degree, local distance, concentration, and BS distance are used as input parameters, as shown in Figure 6. The Sugeno model selects the CH according to the input parameter in this paper.

CH selection is used as an output parameter. The Sugeno model used for implementing the format of the Sugeno rule is given in Equation (1):

$$(If\ x\ is\ A)\ AND\ (y\ is\ B),\ THEN\ (z\ is\ f\ (x,\ y)) \quad (1)$$

The linguistic variables in this equation are x, y, z, A, and B, which are fuzzy sets, and $f\,(x,y)$ is a function. BS distance, local distance, node degree, residual energy, and concentration are the input variables, and CH selection is the output variable. The fuzzy proposition holds t as given in Equation (2):

$$t = (BSD)(LD)(ND)(RE)\ Concentration \rightarrow CH\ selection \quad (2)$$

In the second step, membership functions are defined. Triangular functions select the CH. The Fuzzification of the rule base and defuzzification are significant parts of the ANFIS model. The steps that follow in the ANFIS are as follows.

- Take input data

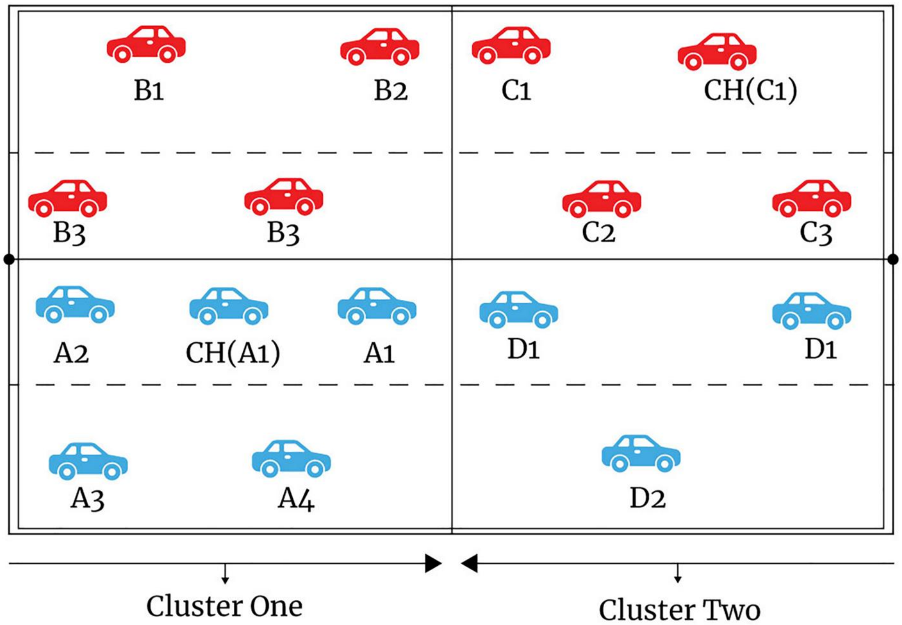

FIGURE 4 Segment with two clusters.

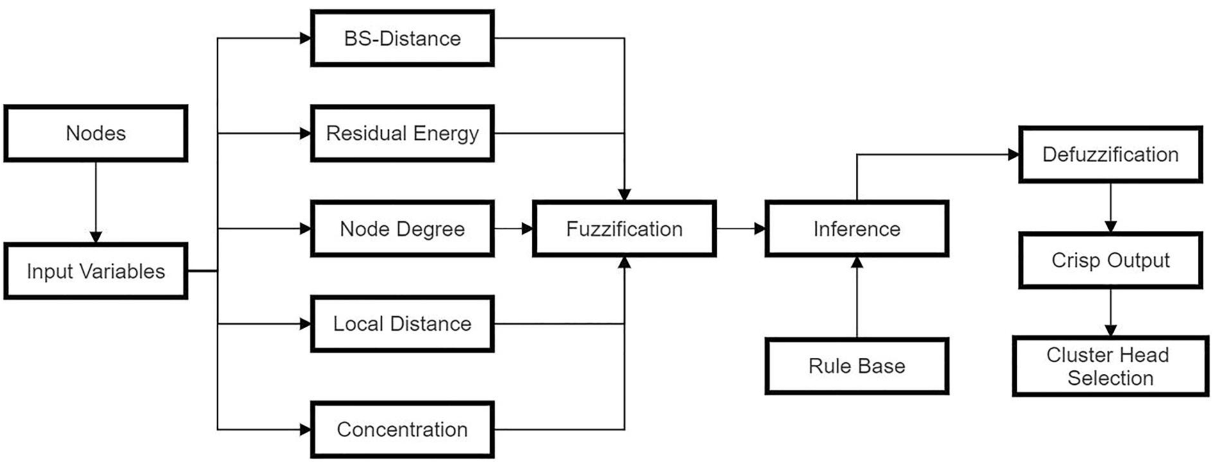

FIGURE 5 Cluster head through fuzzy.

- Make membership functions
- Define Rules
- Values convert into the output

Figure 6 shows the input parameters taken for the FIS, and Figure 7 shows the plotting of the FIS.

Figure 8a–e shows the membership function for the input variables. The membership functions are suitable for low, medium, and high ranges. Three ranges are taken for each of the inputs.

A proposed method is applied to plan a model used to select the CH selection in VANET.

Residual energy: In the self-organising scheme, CH consumes more power than the member nodes because CH is responsible for aggregating data and processing and routing data. The range of MF for residual energy is given below as Equation (3):

$$\mu(ResidualEnergy) = 0 < x < 0.4 = low, \\ = 0.1 < x < 0.5 = medium, \\ = 0.6 < x < 1 = high \tag{3}$$

Node degree: The connection each node has with the other node is called node degree. Any node having a degree greater than six is considered strong. The range of MF for node degree is given below as Equation (4):

$$\mu(NodeDegree) = 0 < x < 0.4 = low, \\ = 0.1 < x < 0.5 = medium, \\ = 0.6 < x < 1 = high \tag{4}$$

Local distance: It is the total amount of distances from node A to the nodes within a defined distance *r*. The range of MF for local distance is given below as Equation (5):

$$\mu(LocalDistance) = 0 < x < 0.4 = low, \\ = 0.1 < x < 0.5 = medium, \\ = 0.6 < x < 1 = high \tag{5}$$

Concentration: Concentration is a direct relationship between CH and member nodes. The range of MF for concentration is given below as Equation (6):

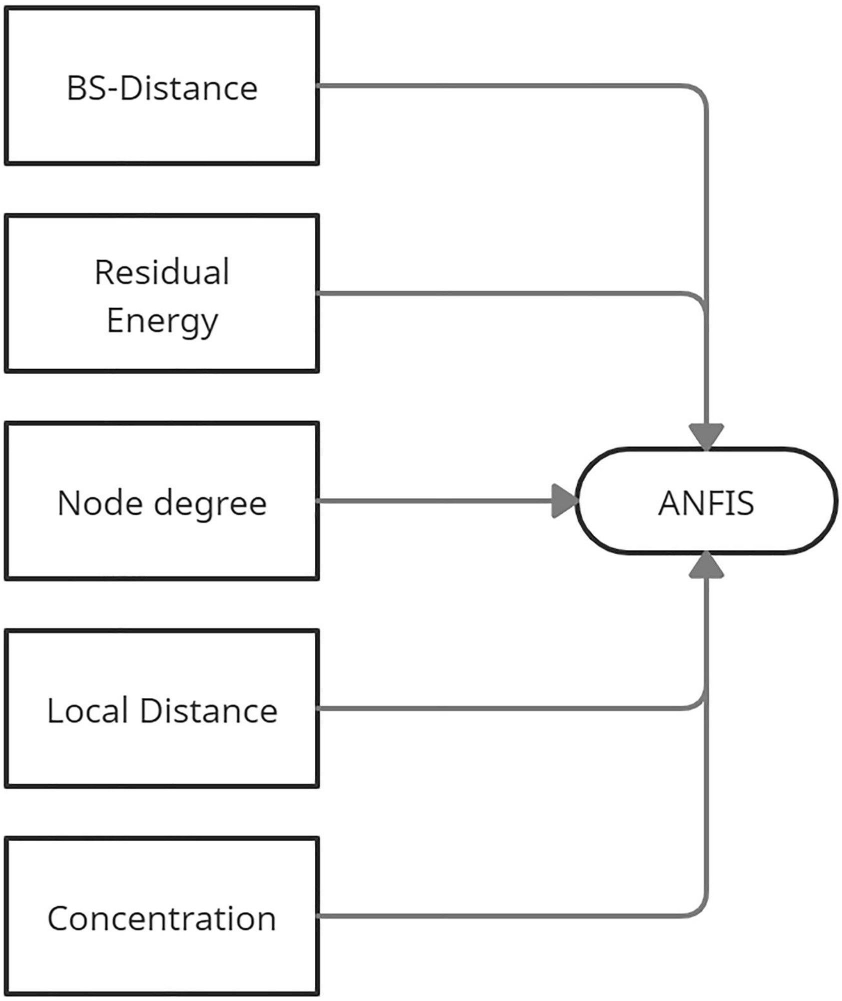

FIGURE 6 Input parameters.

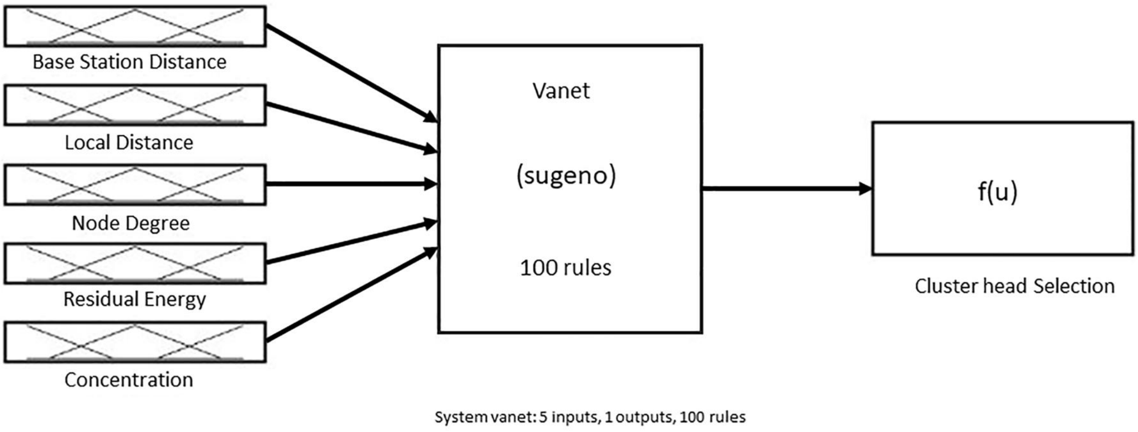

FIGURE 7 Input and output parameters.

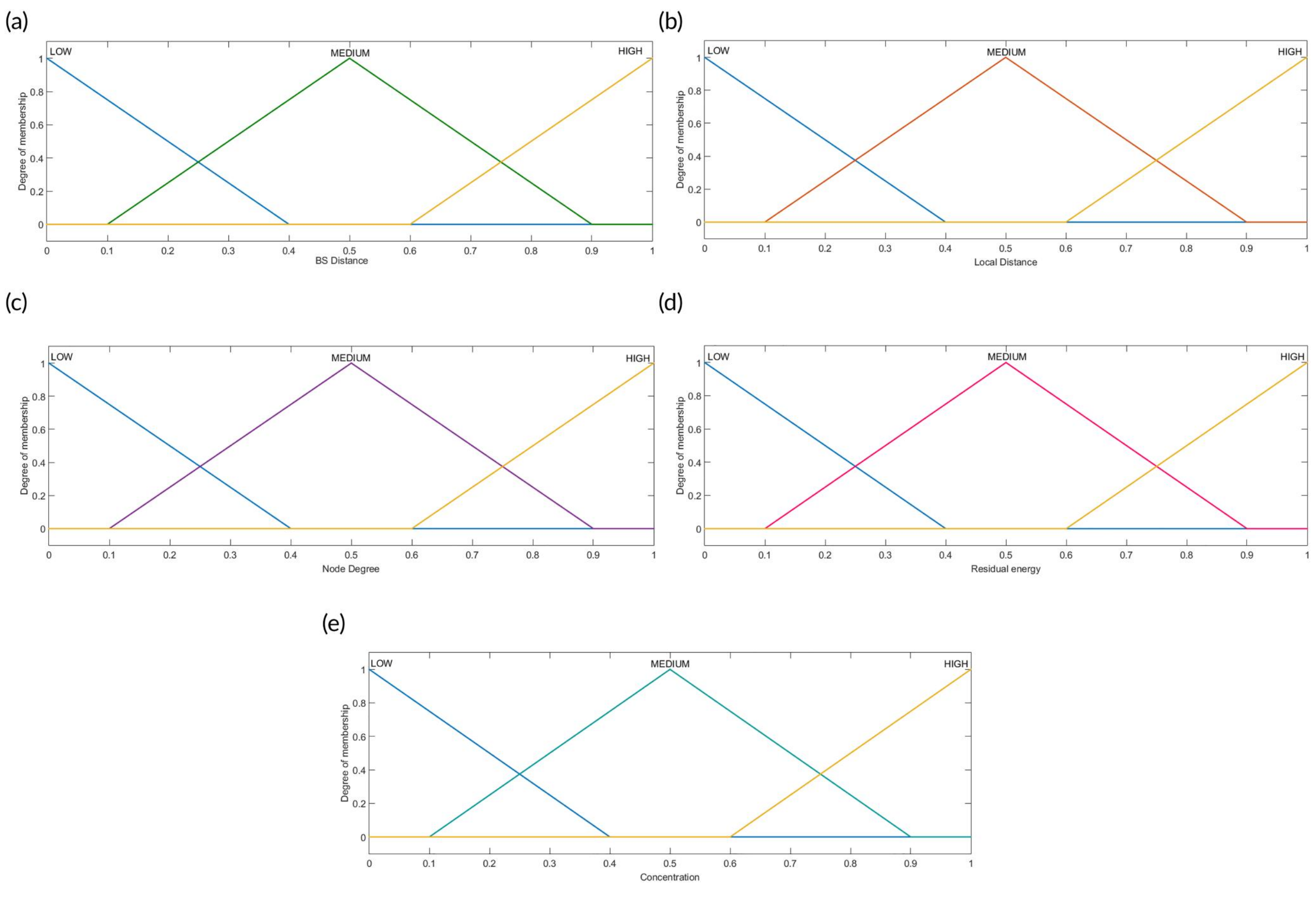

FIGURE 8 Membership functions. (a) Base station distance. (b) Local distance. (c) Node degree. (d) Residual energy. (e) Concentration.

$$\begin{aligned}\mu(Concentration) &= 0 < x < 0.4 = low,\\ &= 0.1 < x < 0.5 = medium,\\ &= 0.6 < x < 1 = high\end{aligned} \quad (6)$$

BS-Distance: Base Station Distance is the distance between CH and the BS. The range of MF for BS distance is given below as Equation (7):

$$\begin{aligned}\mu(BS - Distance) &= 0 < x < 0.4 = low,\\ &= 0.1 < x < 0.5 = medium,\\ &= 0.6 < x < 1 = high\end{aligned} \quad (7)$$

A FIS labels the input and defines the membership function. Rule base makes some new rule according to variation in the input parameter and then selects the CH. Then rules are sited into multiple if-then rules, that is, fuzzy rule base. The rules are presented as follows:

1. If (BS distance is low), and (local distance is low), and (node degree is low), and (residual energy is low), and (concentration is low), then (CH selection is low)
2. If (BS distance is medium), and (local distance is low), and (node degree is low), and (residual energy is low), and (concentration is low), then (CH selection is low)
3. If (BS distance is low), and (local distance is low), and (node degree is low), and (residual energy is high), and (concentration is low), then (CH selection is medium)
4. If (BS distance is low), and (local distance is medium), and (node degree is low), and (residual energy is high), and (concentration is medium), then (CH selection is high)
5. If (BS distance is high), and (local distance is low), and (node degree is low), and (residual energy is medium), and (concentration is low), then (CH selection is medium)

3.3 | Routing procedure

Each cluster is assigned a CH responsible for transmitting data to the BS. The following Algorithm 2 is used for the routing procedure. This protocol intends to send the packets within the segment through the selected CH. Every CH builds a routing table that stores Lifetime (LT), Expiry time, associated locations, and CHID. The table's expiry time keeps updating the contents of the routing table. Whenever a CH receives a packet, it searches the routing table to find the candidate CHs located towards the destination regardless of the direction. The packet is then transferred to the next CH having a maximum lifetime. If two candidate CH in the routing table have the same LT, then the CH has the same moving direction as the previous CH selected. Moreover, if there is no CH to pass on the packet, CH performs the store and forward process. That packet is stored in a buffer and keeps it moving until a relaying CH is found.

Algorithm 2 ***ECBLTR*** **protocol**

```
Input: CH ← Packets
Output: Routing Path
Evaluation Measures: Accuracy, Precision,
Maximised Routing Stability, Maximised
Average Throughput
RT ← [] {Routing Table}
ST ← [] {Simulation Time}
PR ← [] {Packets Received}
for t = anytime and t ≤ ST do
if (PR by CH = t) then
    Check RT of the CH
    if (RT ≠ empty) then
        Store closest CHs to destination
        in CandiCHtable
    else if (CandiCHtable ≥ 2CH with
    same maximum LT) then
        CH = CH closest to destination
    else
        CH = CH with maximum LT
    end if
else
    Store and Forward
end if
end for
return Output
```

4 | RESULTS AND DISCUSSION

Based on the proposed protocol, the routing in VANET can be assessed. MATLAB was used to analyse the results and visualise the outcomes. The configuration of the model implemented in fuzzy logic is shown in Table 2.

Table 3 showed the fuzzy If-Then Rules when the CH selection remained low. Table 4 showed the fuzzy If-Then Rule when the CH selection remained medium, and Table 5 shows the If-Then Rule when the selection of CH is high.

Different values were taken and passed through the system (for training purposes). A total of 60 values are taken for the testing, and 40 values are taken to train the system. The results (after loading the file of training values) are shown in Figure 9a, and the results (after loading the file of testing values) are shown in Figure 9b.

The surface viewer shows the relation between the input and output variables. A 3D plot is obtained after training & testing of data in which two axes show the input parameter, and the third axis shows the output parameter. The surface viewer observes at different angles.

Figure 10a x-axis shows the input parameter base-station-distance, and the y-axis shows the input parameter's local distance. Z-axis shows the output parameter cluster-head-selection. The surface plot shows the relationship between input and output parameters. 3D plot in Figure 10b shows the BS's distance and node degree as the input parameters and CH selection as the output. Figure 10c shows two input parameters BS's distance and residual energy (marked at the x-axis and y-

TABLE 2 Fuzzy implementation

Name	Cluster-based routing in vehicular ad-hoc network (VANET)
Type	Sugeno
Num inputs	5
Num outputs	1
And method	prod
Or method	probor
Implications	min
Aggregation	max
Defuzzification	wtaver

TABLE 3 Fuzzy If-Then rules when output is low

Residual energy	Node degree	Local distance	Concentration	BS distance	CH selection
L	L	L	L	H	L
L	L	Medium	Medium	H	L
L	Medium	Medium	L	Medium	L

Abbreviations: BS, base station; CH, cluster head; H, high; L, low; M, medium.

TABLE 4 Fuzzy If-Then rules when output is medium

Residual energy	Node degree	Local distance	Concentration	BS distance	CH selection
M	M	L	L	L	L
M	M	M	M	M	L
M	M	M	M	L	L

Abbreviations: BS, base station; CH, cluster head; H, high; L, low; M, medium.

TABLE 5 Fuzzy If-Then rules when output is high

Residual energy	Node degree	Local distance	Concentration	BS distance	CH selection
H	H	Low	Low	Low	H
H	M	Low	M	Low	H
H	H	M	M	Low	H

Abbreviations: BS, base station; CH, cluster head; H, high; M, medium.

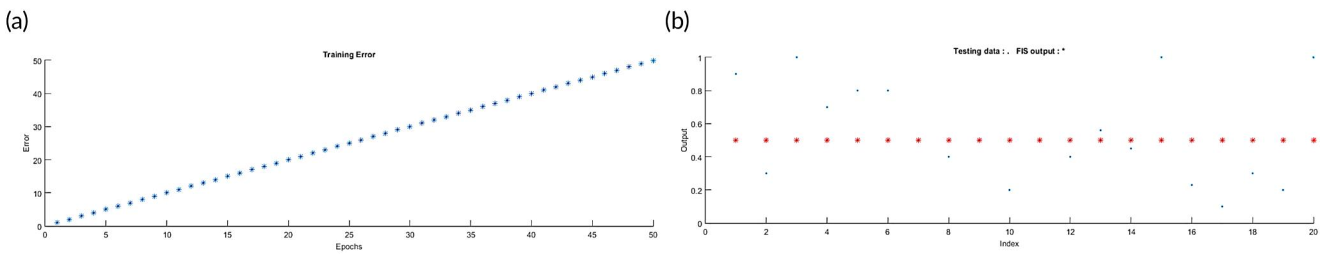

FIGURE 9 Performance of the system. (a) Training. (b) Testing.

axis), and CH selection is placed on the *z*-axis output parameter. In Figure 10d, the surface viewer shows the BS's distance and concentration as input parameters and CH selection as the output parameter. These surface viewers were viewed from various angles to generate the results. Comparative analysis is carried out between cluster-based lifetime routing protocol (CBLTR) and ECBLTR to verify the results of our proposed protocol. To analyse the lifetime of the network, bar graphs were demonstrated. Figure 11 shows their comparison for 8000 rounds. The results clearly show that ECBLTR enhances the network's lifetime. The number of alive nodes remained high, and the number of dead nodes was less than CBLTR. Moreover, our proposed protocol also improves the average throughput and stability. Another comparison was made for both CBLTR and ECBLTR for 1000 rounds, as shown in Figure 12. The result shows an increase in alive nodes and decrement in dead nodes. Overall, there was a 10% increase in network lifetime, and the stable period and average throughput were improved.

The figures and tables discussed above show the result of the proposed protocol. The previous routing protocol had some limitations regarding selecting CHs for each cluster. There was a need to bring forward a methodology that helps select CH efficiently. CH selection is one of the most important aspects for efficiently transferring data from the nodes to the BS. In CBLTR, the CH selection was implemented using an algorithm considering the vehicles' calculated lifetime in their associated cluster at a specific time. While in our proposed protocol, that is, *ECBLTR* Protocol, a FIS is used instead that takes in several input parameters and selects an appropriate CH as an output. Our protocol considers the FIS because all non-linear data can be presented linearly with a high accuracy rate. Moreover, our

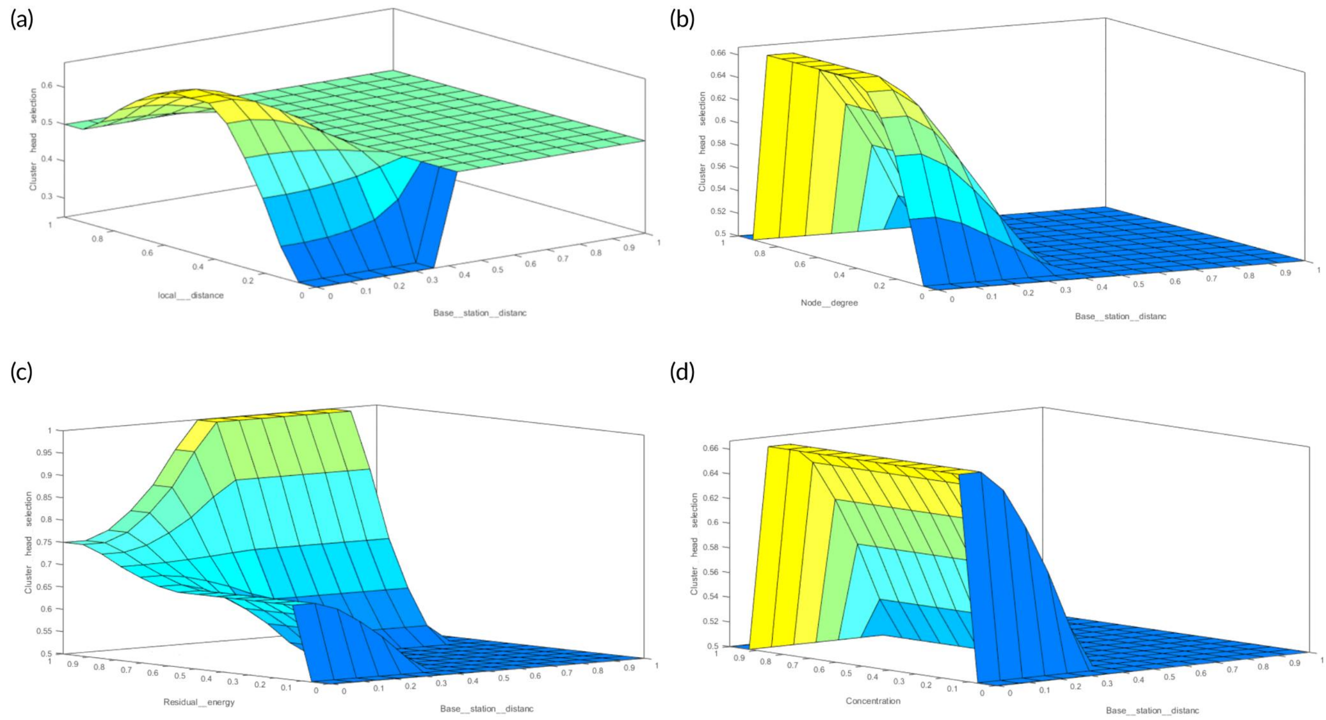

FIGURE 10 Membership functions. (a) Base station distance. (b) Local distance. (c) Node degree. (d) Residual energy.

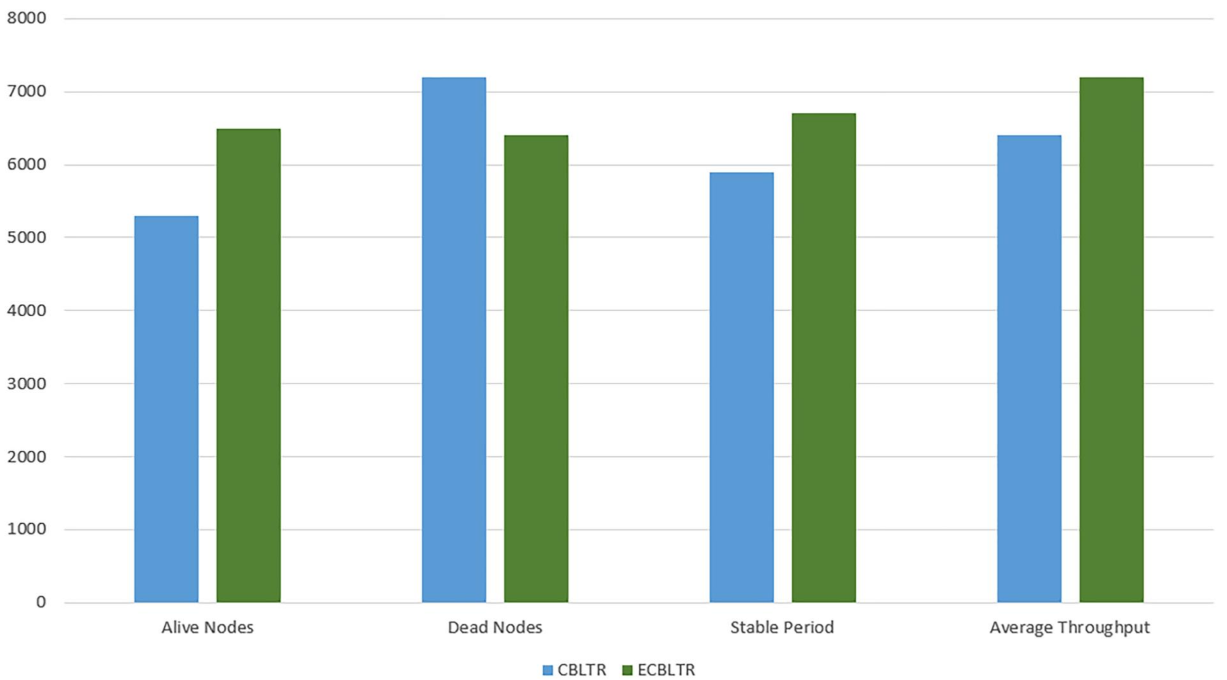

FIGURE 11 Comparison of cluster-based lifetime routing protocol (CBLTR) [57] with proposed ECBLTR for 8000 rounds.

enhanced algorithm for routing protocol generates better results than CBLTR in terms of network lifetime that depends on various factors, for example, alive nodes, dead nodes, stable period, and average throughput. So this enhancement in CBLTR provides considerable results for the routing purpose in the Vehicular ad-hoc network.

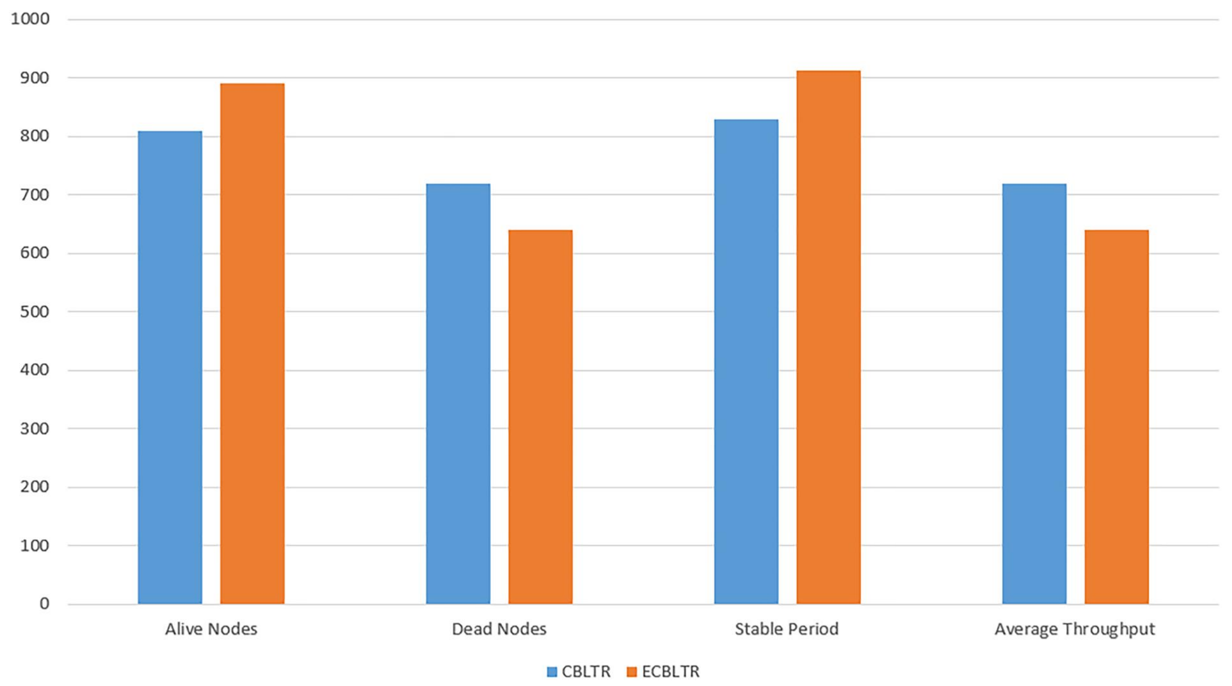

FIGURE 12 Comparison of cluster-based lifetime routing protocol (CBLTR) [57] with proposed ECBLTR for 1000 rounds.

5 | CONCLUSION

Vehicular Ad hoc Networks are among the most potent emerging networks used in many applications, along with emerging 5g technologies in VANET to increase the stability and efficiency of communication. This network dynamically exhibits the changing topology. Routing protocols must acknowledge all the changes rapidly to send the packages' actual routing towards their final station. Clustering is one of the efficient techniques that stabilise and manages the system. A new clustering-based protocol is proposed for VANET. In contrast to the other already proposed protocols, the results show improved routing. Our results show and verify that the proposed protocol minimises the chance of road accidents. CH selection is made through the Sugeno fuzzy system, which handles the uncertainty, thus selecting an optimal CH to transfer packets efficiently. Moreover, our graphs depict the practical training for CH selection by providing input parameters. Efficient cluster-based routing is carried out after the CH selection. In the future, we will research the clustering node for better power management, sensing function, and connectivity of nodes with a 5g networking connection to make the CH of nodes active and efficient. Furthermore, this research aims to work on the cluster technique by choosing an efficient node deployment and cluster formation to improve network transmission. Moreover, it will focus on making zones for clusters and then splitting nodes into zones precisely to improve the network's coverage.

AUTHOR CONTRIBUTIONS

Afia Naeem: Conceptualisation; Investigation; Methodology; Writing – original draft. **Muhammad Rizwan**: Conceptualisation; Formal analysis; Supervision. **Shtwai Alsubai**: Resources; Validation. **Ahmad Almadhor**: Conceptualisation; Data curation; Project administration. **Hameedur Rahman**: Validation; Visualisation.

ACKNOWLEDGEMENTS

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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How to cite this article: Naeem, A., et al.: Enhanced clustering based routing protocol in vehicular ad-hoc networks. IET Electr. Syst. Transp. e12069 (2023). https://doi.org/10.1049/els2.12069