

Location-Aware Distributed Clustering with Eliminating GPS in Vehicular Ad-hoc Networks

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Abstract— Vehicular ad-hoc network (VANET) is a type of mobile network which is used for establishing connection between vehicles (M2M) and also between vehicles and nearby stationary equipment which are often road-side equipment. The main target of VANET is to provide security and convenience for the passengers. In order to achieve this goal, a special electronic device called OBU (On-Board Unit) is embedded in each vehicle which makes the connection between vehicles and between the vehicles and the road-side equipment possible. In this paper, the Location-Aware Clustering in Vehicular Ad-hoc Networks (LAC-VANET) is proposed. We try to achieve the main and major goal in VANET networks, i.e. fast propagation of security and urgent messages in ITS systems, using clustering and selecting the best cluster head based on Fuzzy logic such that the cluster head can transfer important information such as the obstacles and accidents detected on the road with a suitable speed and without creating a large traffic load in the vehicle network in order to notify other vehicles and prevent the danger and vehicle accidents. Moreover, LAC-VANET method is evaluated here via extensive simulations carried out in NS-2. The simulation results indicate that the VANET network performance metrics are improved in terms of average throughput, Packet Delivery Ratio (PDR), end to end delay, and packet loss rate.

Keywords- Vehicular ad-hoc network (VANET); M2M; Fuzzy logic; ITS; LAC-VANET

I. INTRODUCTION

Vehicular Ad Hoc Networks (VANETs) are special class of Mobile Ad Hoc Networks (MANETs). Unlike the MANET nodes, VANET nodes move very fast. Maintaining a steady and stable path for the release of urgent and alert messages from a danger zone is a very challenging task. The main target of VANET is to provide security and convenience for the passengers. In order to achieve this goal, a special electronic device called OBU (On-Board Unit) is embedded in each vehicle which makes the connection between vehicles and between the vehicles and the road-side equipment possible. Such a network must be implemented without the limitations of client-server network connection structures [1]. Each vehicle equipped with a VANET device is similar to a node in Ad-hoc networks and will be able to send and receive others' messages through the wireless network. Traffic alerts, road signs, and online traffic monitoring which can be transferred through such a network give the driver the tools needed

for making decisions about the best route. Since creating an inter-vehicle ad hoc network is associated with deadly and vital conditions, the quick transmission of security messages in this network is of utmost importance. Therefore, intelligent transportation systems (ITS) were created. The ITS system is a distributed system which is connected to the vehicles, road-side-units (RSU), and the user's mobile phone and together they run the application services developed and managed by the software providers. All of the computational and control functions of the vehicle are managed by displaying information on a display or changing the speed of the vehicle. Therefore, communications in a vehicle are a necessary and important part of ITS. In its simplest format, vehicles are connected to the servers remotely and there must be a wireless interface like mobile network or satellite connection for establishing the connection remotely. Data propagation in VANETs is used for improving the driving quality in terms of time, distance, and safety. There are various methods for optimizing V2V

connections. Clustering is one of them. In clustered vehicles, the same vicinity gets grouped together in order to establish an efficient connection. Clustering can be used for improving scalability and routing reliability in VANETs. A sample vehicular ad-hoc network is shown in Fig. 1.

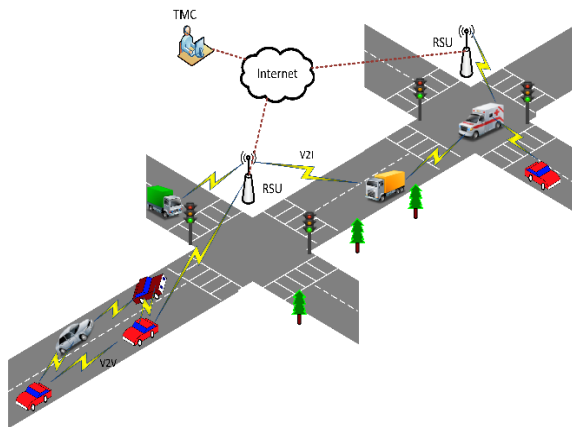


FIGURE I. VEHICULAR AD-HOC NETWORK.

In this paper, we try to achieve the main and major goal in VANET networks, i.e. fast propagation of security and urgent messages in ITS systems, using clustering and selecting the best cluster head based on Fuzzy logic such that the cluster head can transfer important information such as the obstacles and accidents detected on the road with a suitable speed and without creating a large traffic load in the vehicle network in order to notify other vehicles and prevent the danger and vehicle accidents.

The paper presented here is organized as the following. Section II presents the related works on location-aware distributed clustering. In Section III, the details of our proposed LAC-VANET method is discussed. Moreover, parameters utilized for performance evaluation are investigated and simulation results are discussed in Section IV. Finally, in Section V, the paper is concluded.

II. RELATED WORKS

One of the most challenging issues of VANETs is routing. The dynamic nature of VANETs, which is due to high velocity and movement limitations (due to special traffic conditions on the road) of vehicles, has led to the fact that MANET's routing protocols have been proven useless and insufficient for VANETs. Some of the researches activities in the context of developing a routing algorithm for VANETs are presented in this section. The work presented in [2] proposes an efficient routing protocol named AHP-based Multi metric Geographical Routing Protocol (AMGRP) as it adopts an Analytical Hierarchical Process (AHP) while considering multiple routing criteria such as mobility metric, link lifetime, node density and node status which have been accepted as crucial factors for better performance of a protocol. The protocol implements the computed single-weighting function to identify a next hop node within a defined range which can ensure an enhanced forwarding process.

The work presented in [3] introduces a Reliable Routing Protocol (R2P) for Vehicular Ad-hoc Networks (VANETs), which divides the network into overlapping zones. For each zone, a special node is promoted to be the Master Node (MN), which maintains an up-to-date routing boards for inter/intra-zone communication. R2P depends on two types of boards, namely; Internal Routing Board (IRB) and External Routing Board (ERB). Two types of IRB are used, namely; Zone Routing Board (ZRB) that is maintained by MNs, and Private Routing Board (PRB) that is maintained by each network node. Both ZRB and PRB register routes among zone nodes, while ERB, which is maintained by MN, registers available gateways to neighboring zones.

In [4], a reliable multi-level routing protocol based on clustering, RMRPTS has been introduced in VANETs. Even if this topology constantly changes, clustering based multi-level routing will create the possibility of self-organization and route maintaining; moreover, it will solve the problem of developing a trap in the local optimum using TABU search. At the first level, the proposed protocol is an extension of AODV routing protocol that has been improved using fuzzy logic in order to create reliable routing between cluster members. TABU search has been used at a higher level for routing between cluster heads and destination. TABU search is a meta-heuristic improved learning method used for solving hybrid optimization problems, and it uses cost function to select a solution among a set of possible solutions. The effective parameters used in the proposed method to select the best path include nodes distance, the velocity of nodes, node's angle, link stability, and link reliability.

In [5], authors proposed PFQ-AODV, which is a portable VANET routing protocol that learns the optimal route by employing a fuzzy constraint Q-learning algorithm based on ad hoc on-demand distance vector (AODV) routing. The protocol uses fuzzy logic to evaluate whether a wireless link is good or not by considering multiple metrics, which are, specifically, the available bandwidth, link quality, and relative vehicle movement. Based on an evaluation of each wireless link, the proposed protocol learns the best route using the route request (RREQ) messages and hello messages. The protocol can infer vehicle movement based on neighbor information when position information is unavailable. PFQ-AODV is also independent of lower layers. Therefore, PFQ-AODV provides a flexible, portable, and practicable solution for routing in VANETs.

In [6], a graph-based reliable routing scheme for VANETs has been proposed to facilitate QoS support in routing process. In this routing development graph, Dijkstra's algorithm was expanded to find the most reliable path in the VANET-oriented evolving graph.

In [7], a link reliability mathematical model, which considers not only the impact of the link duration, but also traffic density, was designed and presented. The aim of DeReQ algorithm is to find a route which is not only reliable, but also compliant with delay requirements. Adaptive QoS-based routing for VANETs using ACO sought to set up the best QoS route with a delay constraint from a source vehicle to

its destination in terms of three QoS metrics, namely, connectivity probability, packet delivery rate and delay.

In [8], an ACO and fuzzy logic-based approach has been proposed for enhanced framework in vehicular ad-hoc networks, which can present a high data packet delivery ratio and low end-to-end delay.

Souze et al. [9] have proposed the multicast with ant colony optimization for VANETs based on MAODV (MAV-AODV) protocol. This protocol, which inspired the principles of the ant colony optimization, builds stable trees base on vehicular mobility information. MAV-AODV protocol evaluates the route stability and estimates the link lifetime by using beacon messages. This mobility information is used to define the procedures for the route request to the multicast tree and for the multicast route reply. This protocol uses two types of messages: route request message (Ant-RREQ-J) and reply message (Ant-RREP) and builds the multicast tree by using paths with longer lifetime and smaller hop counts. Choosing these paths depends on the number of pheromones deposited by routing messages that function as ants. The simulation results represented that MAV-AODV is better than MAODV in terms of several metrics such as packet delivery ratio, maximum end-to-end delay and routing overhead.

III. THE PROPOSED LAC-VANET METHOD

In the following section, we design a Location-Aware Distributed Clustering schema by employing the Fuzzy Logic System. The proposed system consists of three steps, such as the assumptions in the LAC-VANET method is discussed in Sect. A. Next section defines the steps of the proposed LAC-VANET method. Section C describes performing re-clustering and selecting the new cluster head.

A. The Assumptions in the LAC-VANET Method

The proposed method is for urban areas and non-urban areas which have inter-vehicle facilities. Some of the assumptions of the proposed method are presented below:

- In the proposed LAC-VANET method, it is assumed that the vehicles are not equipped with GPS.
- In the proposed LAC-VANET method, it is assumed that the vehicles are equipped with OBU.
- Each vehicle sends its location in a HELLO message after discovering its information so that the vehicles in the cluster send the packets to each other.
- Each vehicle has a specific transmission range and can receive a data message from another vehicle only in case it is in the range of that vehicle. Range of each vehicle is presented with a green circle in Fig. II.

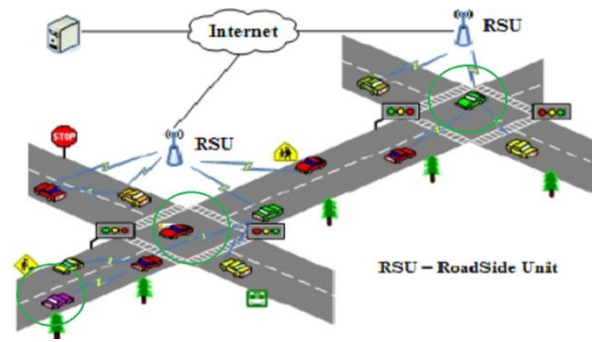


FIGURE II. TRANSMISSION RANGE IN THE PROPOSED METHOD

B. Steps of the Proposed LAC-VANET Method

Our proposed LAC-VANET method consists of three phases: the first phase is the acquisition of the location information of each vehicle, the second phase is the propagation of information to neighboring vehicles in the network, and the third phase is selecting the cluster head and transmitting data using Fuzzy logic. The formation of the network in the proposed method in the ITS system is presented in Figure II. The green circle around each vehicle shows the transmission range of the vehicles. We mentioned that the vehicles are not equipped with a global positioning system (GPS) device. Therefore, we act as phase one in order to obtain the location of each vehicle.

1) Phase One: Discovering Vehicle Position

In the proposed method, the vehicles are not equipped with GPS. Therefore, each vehicle obtains its position from RSU based on the received signal strength (RSSI). The procedure is such that periodic messages are exchanged between the OBU device on the vehicle and the RSUs on the road. An OBU device scans all the messages in the range it can detect. Then, selects one of the RSUs for joining. In fact, RSU collects the RSSI values and generates the RSSI data according to the current location of the vehicle. All of the measured radio signal strength values and also the radio signal propagation loss model are used while calculating RSSI for obtaining the correct position. Assuming the transmitted signal strength to be P_{TX} and the route drop model to be C and the route drop coefficient to be α , the receiving RSU can use the received signal power (P_{RECV}) to calculate the distance (D_{i_v}) between itself and the transmitter vehicle. The calculation can be carried out using Eq. (1).

$$P_{RECV} = c * \frac{P_{TX}}{D_{i_v}^{\alpha}} \leftrightarrow D_{i_v} = \sqrt[\alpha]{\frac{cP_{TX}}{P_{RECV}}} \quad (1)$$

This method does not need any extra hardware and also the distance is obtained easily and without the need for coordination and transmission of extra signals. Therefore, it seems to be a suitable method. Although RSSI values are not constant and the received power value is variable, but the error can be reduced by sending the message repeatedly. Therefore, the RSU can calculate the position of the vehicle using Eq. (2) with respect to its fixed position (X_i, Y_i) and inform the OBU.

$$D_{i_v} = \sqrt{(X_i - X_j)^2 + (Y_i - Y_j)^2} \quad (2)$$

2) Phase Two: Propagating the Information to Neighboring Vehicles

After the OBU has received the position of the vehicle from the RSU according to the previous phase, all the nodes in the network try to connect to a cluster. The scenario is considered this way that a vehicle starts looking for a cluster by broadcasting a membership request message immediately after arrival. If it does not receive an acceptance message during the predicted period, the aforementioned vehicle starts the cluster creation process in its vicinity. Therefore, it starts establishing connections with other vehicles. Communication between vehicles is done by sending HELLO messages. In the proposed method, each vehicle has two information tables. One of the tables contains the information obtained by the vehicle itself while the other table stores the neighboring vehicles' information. The format of these two tables is as presented in Tables (I) and (II).

TABLE I. VEHICLE INFORMATION

ID	Position (X_i, Y_i)	Speed (V)	Direction (θ)	Density	Transmission Range(TR)
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TABLE II. NEIGHBORING VEHICLE INFORMATION

Position (X_j, Y_j)	Speed ($Speed_v$)	Direction (θ_m)	HopCount (t)	Transmission Range(TR)
Delay (T_v)	Density	Distance (DI_v)	LinkExpirationTime(LET)	

In order to obtain the information of other vehicles and fill the neighbors' table, we act this way each vehicle sends its information table which includes the information presented in Table I to all of its neighbors in the form of a flooding HELLO message. The declarative HELLO message includes the vehicle ID, vehicle position, speed, vehicle direction, transmission range, and vehicle density. Some of this information is obtained from the RSU and we describe the steps to obtaining the density in later sections. In the proposed method, the delay, density, distance, and link expiration time criteria are used for choosing the best vehicle to become the cluster head using Fuzzy logic. Each vehicle can use the HELLO message for saving the table containing the list of its one-hop neighbors. Take Figure III and Figure IV for example, where how the HELLO message is sent and how the location information is received from RSU are presented.

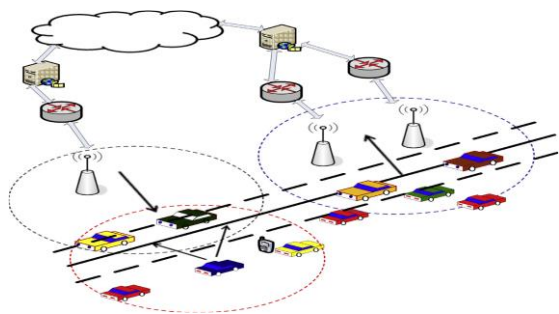


FIGURE III. SENDING THE MESSAGES IN THE PROPOSED METHOD

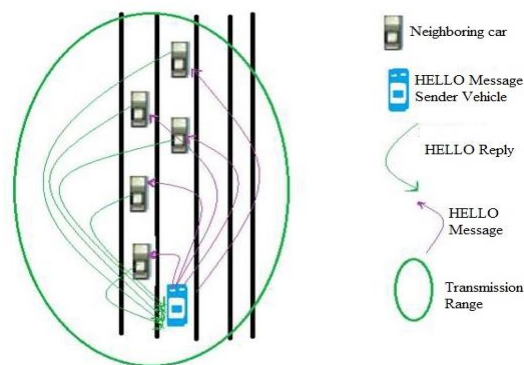


FIGURE IV. THE VEHICLE BROADCASTS THE HELLO PACKET AND RECEIVES THE NEIGHBORS' CONDITION

It is obvious that at the beginning of establishing the connection by the vehicles, the number of the neighbors and therefore density, delay to the neighboring vehicle, link expiration time, distance, and other information regarding the neighbors do not have a value. Each vehicle updates these values after identifying its neighbors and calculates these values using the vehicles transmitted information and sends the density to its neighbors in later messages.

After receiving the message from other vehicles, the message creation time is checked first and since one of the applications of clustering is for security tasks where messages must be sent quickly, we consider the maximum message delay for security messages to be 50. Therefore, in case the delay of the received message is more than 50, these messages will be discarded and get removed. However, in case the message creation time is valid, the direction of the vehicle which sent the message is also checked and if the directions don't match, the message will not be considered and gets removed. In fact, the messages received from the vehicles which move on the opposite side will be removed. After receiving a valid message, each vehicle updates the information table of its neighbors and also the information in its own tables by calculating delay, density, link expiration time, and distance immediately after receiving a message from other vehicles.

In order to update the neighbors' information table, we act this way that first, the neighbors' information table is reviewed. In case the vehicle information is present in the neighbors' tables, the new information replaces the old one and vehicle information update time also changes. In case the vehicle information is missing the neighbors' information table, a new record gets added to the information table of the neighbors and the information received from the neighbor gets stored in it. Then, vehicle density is added.

3) Phase Three: Selecting the Cluster Head using Fuzzy Logic

In the LAC-VANET routing method, the appropriate vehicle gets selected as a cluster head based on minimum delay and distance to neighboring vehicles and higher link expiration time and density. As we mentioned, in the ITS system, each vehicle

seeks its current location information from RSU using OBU. This information is calculated using RSSI and using the information received from the neighbors, it calculates the density, distance, delay, and link expiration time between itself and the neighbor. In the proposed LAC-VANET method, the cluster head gets selected as the most appropriate cluster head for transmitting the information packet based on criteria like lower delay, shorter distance to the neighbors, higher density, and link with longer expiration time. After receiving the reports, the condition of the neighbors, and receiving the information of neighboring vehicles, each node calculates the delay T_v , distance (Di_v), link expiration time (LET), and density for each neighbor as follows (V is short for Vehicular meaning a vehicle)

Delay: Represents the time required for a vehicle with a unique identification number for packet delivery to the intended destination, calculated using Eq. (3). Distance indicates the distance between the neighbor vehicle and the destination which is obtained using Eq. (2) and is also the speed related to neighboring vehicles.

$$P_{RECV} = c * \frac{P_{TX}}{Di_v} \leftrightarrow Di_v = \sqrt{\frac{cP_{TX}}{P_{RECV}}} \quad (3)$$

Table III, for example, presents the condition where a vehicle has five other vehicles in its communication range. Vehicles A, B, C, D, and F for example. Delay for each vehicle is calculated in Table III. In the proposed LAC-VANET method, unlike other methods where only the vehicle speed is used as the criterion for choosing the vehicle, the criteria for selecting the cluster head for quick propagation of information is the delay to the destination, density, distance, and link expiration time between neighboring vehicles. The lower the delay of a node is, that node is more suited for becoming the cluster head.

TABLE III. CALCULATING THE DELAY

Vehicle	Distance(m)	Speed(m/sec)	Delay (T)
A	550	50	11
B	600	50	12
C	500	45	11
D	700	50	14
F	400	40	10

Link Expiration Time (LET): the next criterion used as an input for the Fuzzy logic is the link expiration time (LET). The link expiration time is the amount of time when two mobile nodes can stay in touch with each other. In order to evaluate LET in the proposed method, we use important criteria used in inter-vehicle like speed, movement direction, position, etc. This information is obtained using the information exchanged in the HELLO message and are available in the neighbors' table. LET is calculated using Eq. (4).

$$LET = \left(\frac{-(ab + cd) + \sqrt{(a^2 + c^2) * r^2 - (ad - bc)^2}}{a^2 + c^2} \right) \quad (4)$$

LET is the link expiration time and parameters a , b , c , and d in Eq. (4) are obtained as follows:

$$a = V_i \cos \theta_i - V_j \cos \theta_j$$

$$b = x_i - x_j$$

$$c = V_i \sin \theta_i - V_j \sin \theta_j$$

$$d = y_i - y_j$$

i and j are two moving vehicles which have a transmission range of (TR) meters. V_i and V_j are these two vehicles' velocities while θ_i and θ_j represent their movement direction. Also, X_i , X_j and Y_i , Y_j represent their position. The higher the link expiration time between two nodes is, the more suited that node is because its connection links get destroyed later.

Distance (Di_v): the distance parameter presents the overall distance of a node with its neighbors. The lower this distance is, the node is more appropriate for becoming the cluster head because it leads to a decrease in delay and faster transmission of packets to its neighbors. The distance criterion is described based on the information in the neighbors' table obtained from the neighbors and the position of the vehicle, using Eq. (2).

Density: Displays the number of neighbors in the transfer range at the time the current HELLO message is sent. The density is meant to be the number of vehicles that are located in the neighborhood of the node when HELLO message is sent, which is calculated as the number of vehicles in the neighborhood list of each node at the moment of sending a HELLO message, divided by the transfer range of the node. The neighbors list is made up of vehicles in the transfer range that send HELLO packets with high power, which these neighbors are considered as stable neighbors. Each node calculates its current density and puts it in the next HELLO message. The Density is calculated in Eq. (5) follows:

$$Density_{id}(t) = \frac{Nnig(t)}{TR_{id}} \quad (5)$$

Based on Eq. (5), when a node has a higher density than other nodes, it is better option to choose, because nodes with a denser region in the transfer range have the potential for better sending the packet to the next node.

By obtaining this information, each node calculates the delay (T_v), distance (Di_v), link expiration time (LET), and density ($Density_{id}$) for all of its neighbors and the best vehicle gets selected as the cluster head using Fuzzy logic.

Figure V presents the Fuzzy logic system with four delay (T_v), distance (Di_v), link expiration time (LET), and density ($Density_{id}$) input variables.

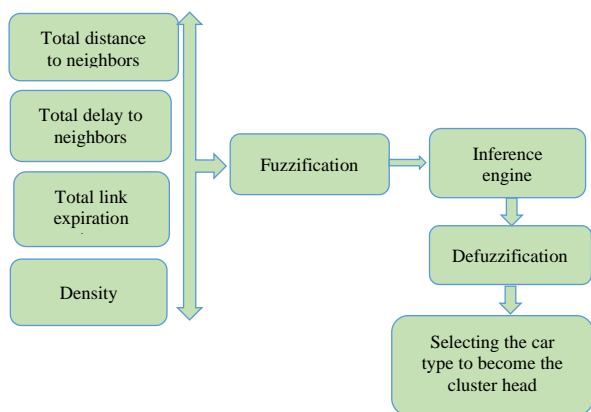


FIGURE V. THE STRUCTURE OF THE FUZZY LOGIC FOR DISCOVERING THE CLUSTER HEAD

Three main procedures in the fuzzy logic include fuzzification, fuzzy inference, and defuzzification. In this section, the fuzzification step is run in the fuzzy logic system where numerical values get converted to fuzzy values using the fuzzy membership function. As mentioned above, the input of the fuzzy logic includes delay (T_v), distance (D_{i_v}), link expiration time (LET), and density ($Density_{i_v}$). The function diagram of these parameters is presented in Figures VI through IX.

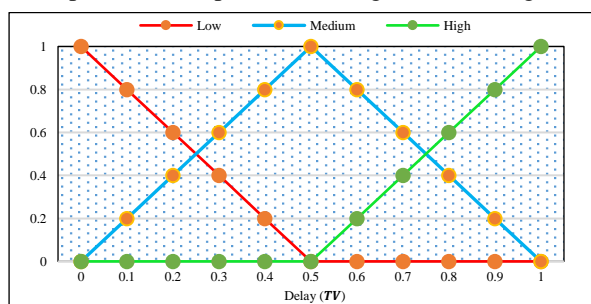


FIGURE VI. FUZZY LOGIC DIAGRAM OF DELAY

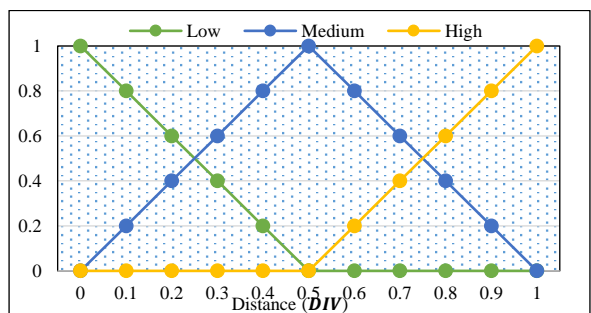


FIGURE VII. FUZZY LOGIC DIAGRAM OF DISTANCE

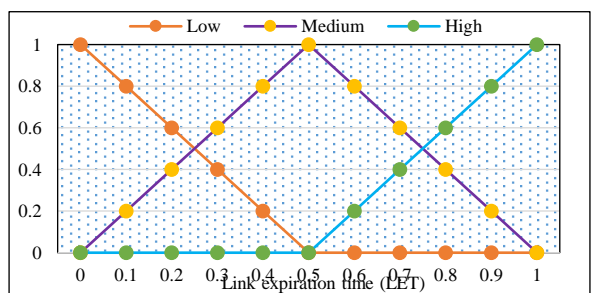


FIGURE VIII. FUZZY LOGIC DIAGRAM OF LINK EXPIRATION TIME

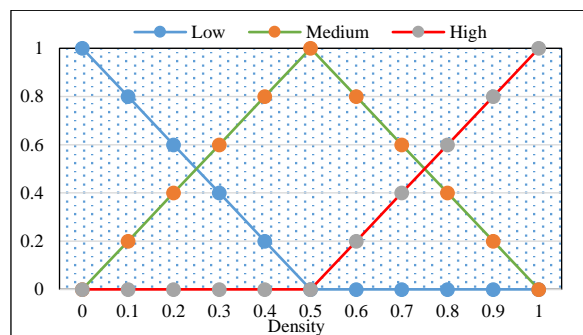


FIGURE IX. FUZZY LOGIC DIAGRAM OF DENSITY

After determining the fuzzy logic input parameters, we performed the fuzzy inference phase and developed a rule set using expert knowledge. The fuzzy-rules-based knowledge is designed to integrate the input and output variables; this is done based on the criteria expressed by the origin. Since we have four criteria that each has three levels (low, intermediate, and high), we will have 64 (43) fuzzy rules in the knowledge base to design the fuzzy inference by the decision-making system. The fuzzy rules have been written based on the If-Then law. Every fuzzy rule includes an “If” term and a “Then” term. Some of these rules are presented in Table IV.

TABLE IV. SOME OF THE FUZZY LOGIC RULES OF THE PROPOSED LAC-VANET METHOD

Rules	Delay	Distance	Density	LET	Fuzzy output
1	Low	L	H	H	Perfect
2	Low	H	L	M	Bad
3	Low	M	L	L	Bad
4	M	H	L	L	Bad
5	H	H	L	L	Very Bad
6	H	H	L	M	Very Bad
7	H	H	M	L	Very Bad
8	L	M	M	H	Good
9	M	M	H	H	Good
10	L	L	M	M	Good

Linguistic variables used for specifying the cluster head are organized in one of the four {Very bad, Bad, Good, Perfect} ranges similar to Figure X. A perfect node is a node which has a low delay and distance to other neighboring nodes and its density and link expiration time are high. A good node is a node which has a low delay or distance but average link expiration time or density. Bad and very bad nodes are nodes which are not suited for becoming the cluster head.

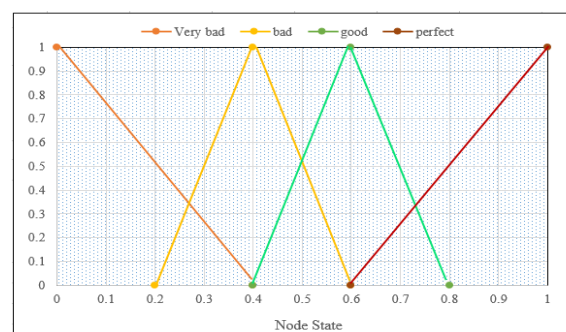


FIGURE X. NODE CONDITION DIAGRAM IN THE PROPOSED LAC-VANET METHOD

In the last phase, the results obtained in the two previous phases by the fuzzy system should be defuzzified in the defuzzification phase to make them understandable for the computer. In our proposed approach, we use the Centroid of Area (CoA) defuzzification method to defuzzify by Eq. (6) because the CoA defuzzification method has been widely used to defuzzify the Mamdani method.

$$\alpha = \left(\frac{\int_z \mu_A(x)zdz}{\int_z \mu_A(z)dz} \right) \quad (6)$$

In Eq. (6), α is the non-fuzzy output for the fuzzy system (z) and $\mu_A(z)$ is the aggregated output membership function. Based on the α output value, the node recognizes whether the node is suited to become the cluster head or not. The node which has the highest value and gets identified as perfect by the fuzzy logic is the best option for becoming the cluster head. After a vehicle is selected as the cluster head in each region, it sends its ID as the cluster head along with the fuzzy logic number to other members of the cluster. After receiving the announcement message, each vehicle compares its fuzzy logic number to its own fuzzy logic number. In case the fuzzy logic number of the received message is higher, it sends a connection request message to the cluster head vehicle.

After receiving the connection request message, first, the cluster head reviews the node's information in the neighbors' table and in case this node is in the allowed range, it reviews the direction, velocity, and position parameters of the request message. In case these parameters are allowable for connecting to this cluster, it accepts the cluster connection request and registers the vehicle in the cluster. The cluster head also sends its ID to the RSU in order to communicate to other cluster heads. After forming the clusters and specifying the cluster heads, the vehicles periodically send a message containing the vehicle information to the cluster head and the cluster head updates the vehicles' information table based on the received information. From this point on, each vehicle which is a member of the cluster and has new information sends the information to the cluster head to be broadcast on the network. The cluster head broadcast the information in its cluster and then transfers it to the RSU to provide it to other clusters.

C. Performing re-clustering and selecting the new cluster head

In any clustering method, it is essential to perform the clustering again and select a new cluster head after an amount of time has elapsed due to reasons like depletion of the cluster head's energy or other events. If the cluster head's energy gets depleted before the new cluster head is selected, the information sent to the cluster head will be lost. Therefore, clustering and selecting the cluster head must be done at the right time. Considering the movement of the nodes in this network and constant change in its topology, the proposed LAC-

VANET method performs re-clustering in case one of the following three conditions is met:

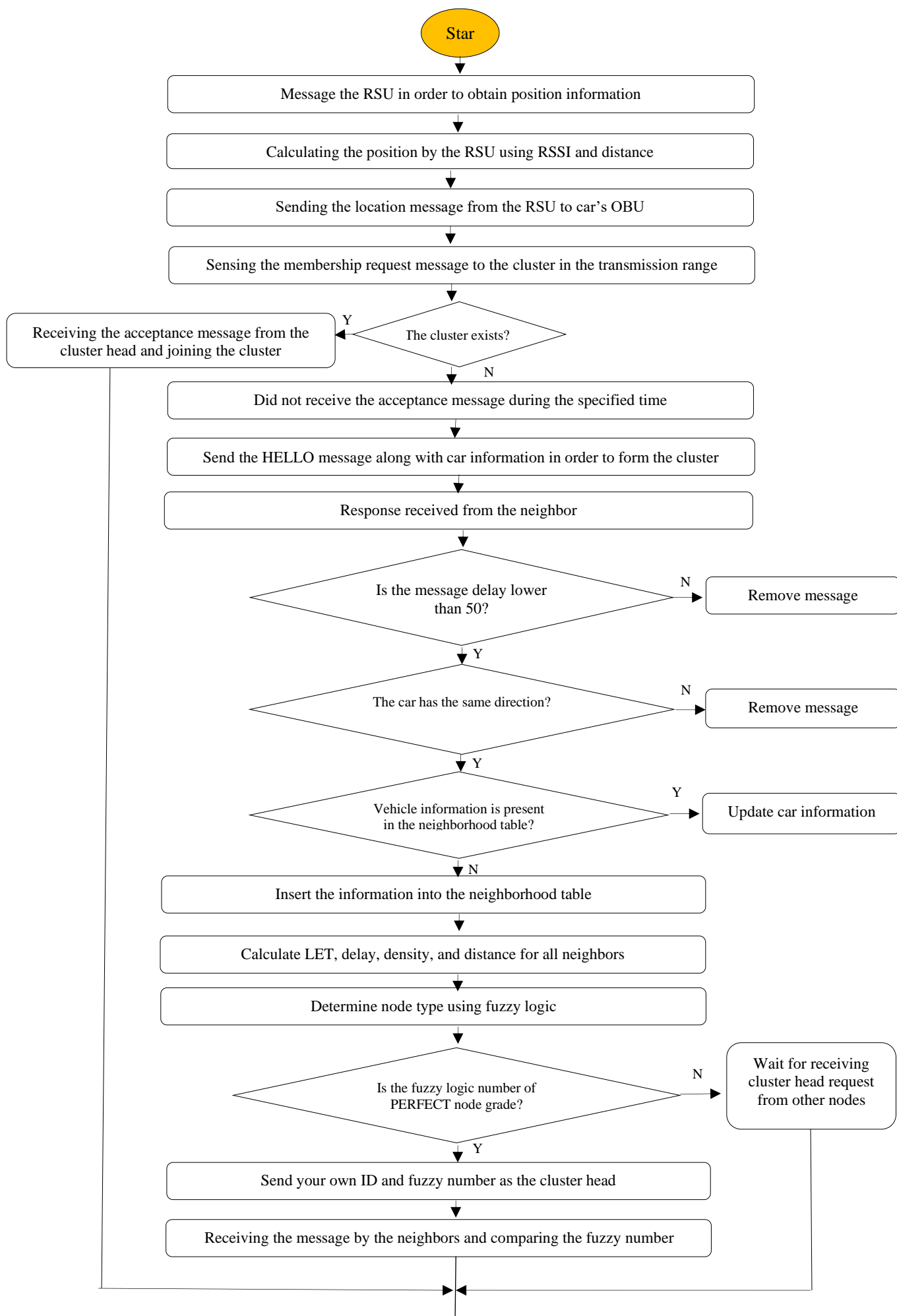
The amount of change in the battery level of the cluster head: if the energy level of the cluster head decreases after it has performed for a while, this node will not be able to work and therefore another node must be selected as the cluster head. In the proposed LAC-VANET method, if the energy level falls below 20 percent of the initial amount, this node must not be the cluster head anymore since its energy might get depleted during information transmission. For example, if the initial energy level of a node which has been chosen as the cluster head is 98 Joules, when its energy reaches 19 Joules it means that it has lost 80 percent of its initial energy and this node does not have the required capability to remain the cluster head. Therefore, it sends an energy reduction message to the members of its cluster in order to start the clustering and cluster head re-selection phase.

Cluster stability: another important factor in performing the clustering again is the stability of the nodes present in a cluster. In the intra-vehicle network, the stability of the clusters is hard to achieve due to the high mobility of the nodes in this type of network. If the number of new nodes added to the cluster is high or the number of nodes in the cluster decreases a lot, this cluster is no longer very suitable and cannot transmit all the information very well. In case the number of members is too high, the number of messages sent to the members of the cluster or the messages received from them increases and the cluster head might rapidly lose its capability. In the opposite case, if the number of cluster members is too few, cluster head stability with so few members is not so desirable. Therefore, in the proposed method, two threshold values are considered for this condition. The first threshold (TH_H) is the threshold on the growth of the number of nodes in a cluster. If the number of cluster members grows by a certain percentage, the clustering phases gets executed again. This threshold and its percentage value will be specified during the simulation. The next threshold is (TH_L) which if the number of cluster members decreases by a certain percentage, the clustering phases gets executed again. This threshold and its percentage will be specified during the simulation as well. Therefore, the cluster head sends the re-clustering message to cluster members in order to perform clustering again.

Not receiving the periodic message: if a vehicle does not receive any messages from its cluster head after a time interval, assumes itself to be free and enters the re-clustering phase. Also, if the cluster head does not receive any messages from a member of the cluster during an interval, assumes the vehicle to have left the cluster region and removes it from the list of members.

Therefore, in the proposed LAC-VANET method, the conditions of re-clustering and selecting the new cluster head gets determined according to these two criteria in order to prevent information from being wasted and packets from being lost.

Flowchart of the operation steps of the proposed LAC-VANET method is presented in Figure XX.



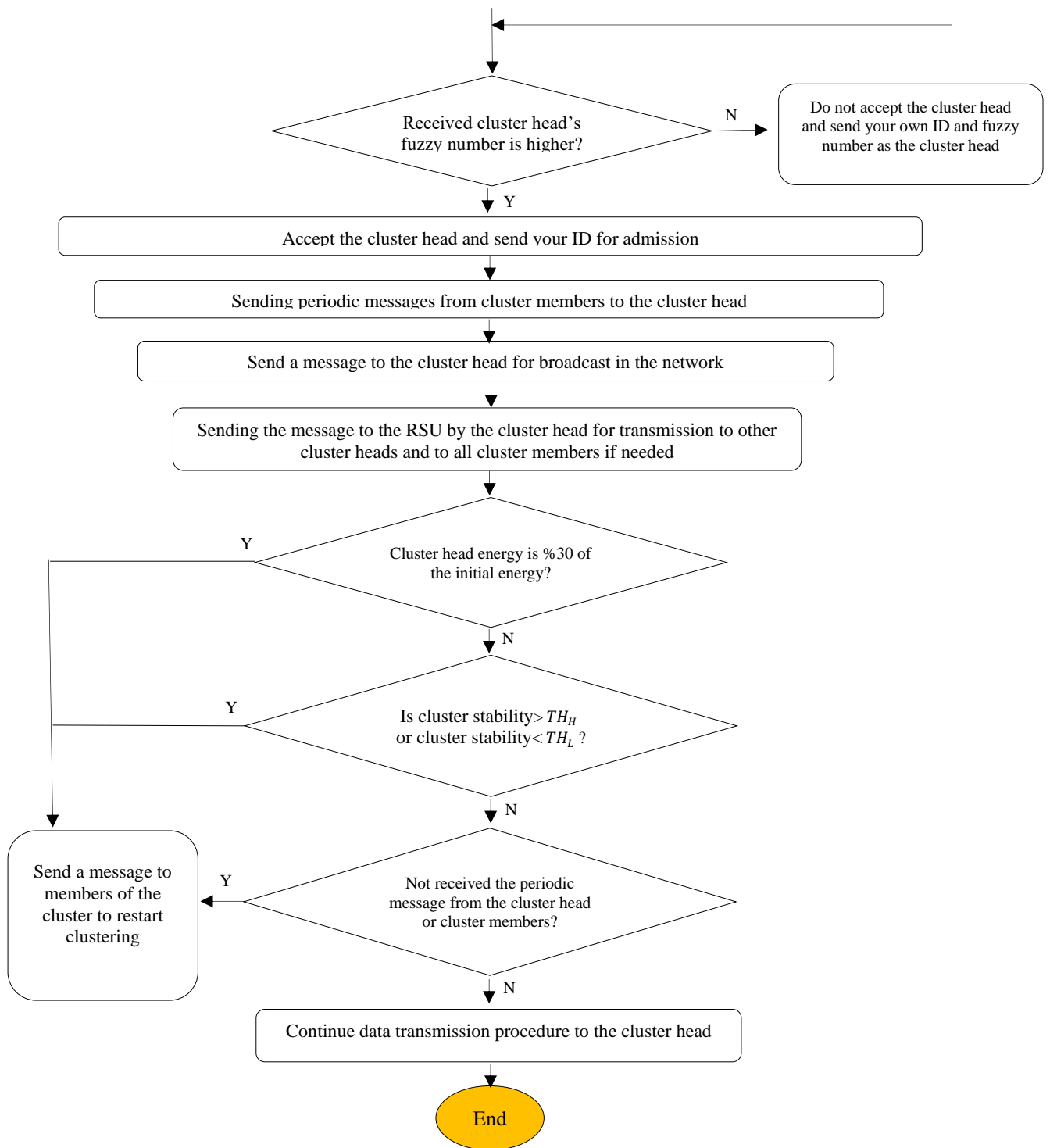


FIGURE XX. FLOWCHART OF THE PROPOSED LAC-VANET METHOD

IV. EVALUATING THE PERFORMANCE

In the following section, the performance of our proposed LAC-VANET approach is evaluated to location-aware distributed clustering.

A. Performance metrics

In this section, the effectiveness and performance of our proposed LAC-VANET approach is thoroughly evaluated with comprehensive simulations. The results are compared with VMaSc approach proposed in [10-17] respectively. The average throughput, Packet

Delivery Ratio (PDR), end to end delay, and packet loss rate are evaluated.

1) Average throughput

Average throughput is the division of the sum of packets sizes received at the destination sensor node, to the difference of simulation stop and start time. Eq. (7) obtains the average throughput for N experiments, and is calculated in Kilobits per second [18].

$$\text{Throughput} = \frac{1}{n} * \frac{\sum_{i=1}^n X_i * P_s}{S_p - S_T} * \frac{8}{1000} \quad (7)$$

2) Packet delivery ratio

PDR is the division of the total data packets received at the destination sensor node, to the total number of data packets transmitted by the source node, described in percentage. The average PDR obtained for experiments is demonstrated by Eq. (8) [19].

$$PDR = \frac{1}{n} * \frac{\sum_{i=1}^n X_i}{\sum_{i=1}^n Y_i} * 100\% \quad (8)$$

3) End to end delay

This is the average delay between the sending of packets by the source and its receipt by the receiver. This includes all possible delays caused during data acquisition, route discovery, queuing, processing at intermediate nodes, retransmission delays at the MAC, propagation time, etc. It is measured in milliseconds. The lower value of end-to-end delay means the better performance of the protocol [20-24]. The Delay is calculated in Eq. (9) follows:

$$Delay = \left(\frac{\sum_{j=1}^n DeliveryTime - \sum_{j=1}^n ArrivalTime}{\sum_{j=1}^n ReceivedPackets} \right) \quad (9)$$

4) Packet loss ratio

PLR occurs when one or more packets of data traveling across a computer network fail to reach their destination. PLR is typically caused by network congestion. Packet loss is measured as a percentage of packets lost with respect to packets sent. The lower value of the packet loss means the better performance of the protocol. The PLR is calculated in Eq. (10) follows:

$$PLR = \left(\frac{\sum_{j=1}^N Number\ of\ sent\ packets}{\sum_{j=1}^N Number\ of\ recieved\ packets} \right) * 100 \quad (10)$$

B. Simulation Setup and Comparing Algorithms

The difficulties in implementation and debugging routing protocols in real networks, raises the necessity to consider simulations as a fundamental design tool. The main advantage of simulation is simplifying analysis and protocol verification, mainly in large-scale systems [25-30]. It is possible to employ a NAM in the NS-2 to visualize the results. In this section, the performance of our proposed approach is evaluated using NS-2 as the simulation tool, and the results are discussed further. Moreover, the proposed LAC-VANET are compared with VMaSc model. It is worth mentioning that all LAC-VANET and VMaSc parameters and settings are considered to be equal.

C. Simulation results

We have simulated LAC-VANET approached in the NS-2 on Linux Fedora 10. The setting of simulation parameters is given in Table V.

TABLE V. SETTING OF SIMULATION PARAMETERS

Parameters	Value
Simulator	NS-2 (Version 2.34)
Channel type	Wireless channel
Radio propagation model	Propagation/Two ray ground
Application Layer Protocol	Constant Bit Rate (CBR)
Transport Layer Protocol	User Datagram Protocol (UDP)
Simulation time	400 Second
Number of nodes	50
Topographical area	1000 x 1000 m ²
Transmission range	250 m
Mobility	Random waypoint
MAC layer	IEEE 802.11
Max. node movement speed	20 m/s
Pause times	100, 200, 300, and 400 second
Packet size	512 Bytes

Tables VI-XX compares the performance of LAC-VANET with that of VMaSc in terms of average throughput, Packet Delivery Ratio (PDR), end to end delay, and packet loss.

TABLE VI. AVERAGE THROUGHPUT OF TWO APPROACHES WITH VARYING DEGREE OF VEHICLE NODES

Vehicles	VMaSc	LAC-VANET
30	121.77	370.55
40	121.82	364.68
50	125	372.01

TABLE VII. PDR OF TWO APPROACHES WITH VARYING DEGREE OF SIMULATION TIMES

Simulation times	VMaSc	LAC-VANET
100	45.5	94.08
200	46.04	93.42
300	43.46	96.23
400	41.49	95.95

TABLE VIII. PDR OF TWO APPROACHES WITH VARYING DEGREE OF VEHICLE NODES

Vehicles	VMaSc	LAC-VANET
30	40.63	92.87
40	41.31	95.7
50	40.89	94.74

TABLE IX. DELAY OF TWO APPROACHES WITH VARYING DEGREE OF VEHICLE NODES

Vehicles	VMaSc	LAC-VANET
30	5171	945
40	5149	923
50	5253	1028

TABLE X. DELAY OF TWO APPROACHES WITH VARYING DEGREE OF SIMULATION TIMES

Simulation times	VMaSc	LAC-VANET
100	1228	331
200	2435	473
300	3739	685
400	5188	931

TABLE XX. PACKET LOSS RATE OF TWO APPROACHES WITH VARYING DEGREE OF VEHICLE NODES

Vehicles	VMaSc	LAC-VANET
30	18.75	3.03
40	15.52	4.65
50	13.24	2.83

Figure XXX, demonstrates the comparison between our proposed LAC-VANET scheme, and VMaSc model in terms of throughput. Since throughput is a vital parameter in VANETs, we evaluated this parameter to evaluate our method. As shown in Figure XXX, LAC-VANET increases the throughput by more than 45% those of VMaSc model.



FIGURE XXX COMPARISON OF THE LAC-VANET PROPOSED SCHEME AND VMaSc MODEL IN TERM OF AVERAGE THROUGHPUT.

Figure XL and L demonstrates the relationship between PDR, number of vehicles, and Simulation times. With 200 active vehicles, the PDR is relatively low for the VMaSc method. The reason for this is the fact that in such conditions, some packets fail to reach destination in the designated timeframe. However, since increasing the number of vehicles results in more packets being delivered to the destination, using more

vehicles would slightly improve the PDR. As shown in the Figure XL and L, LAC-VANET increases the PDR by more than 43.5% those of VMaSc model.

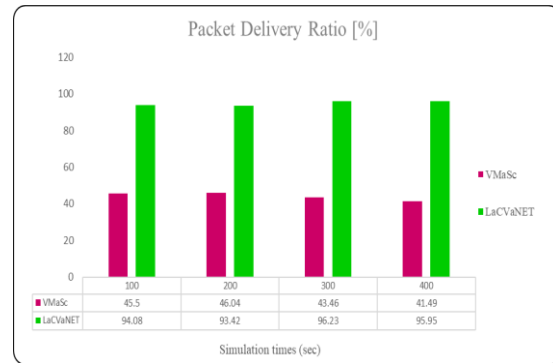


FIGURE XL COMPARISON OF THE LAC-VANET PROPOSED SCHEME AND VMaSc MODEL IN TERM OF PDR.

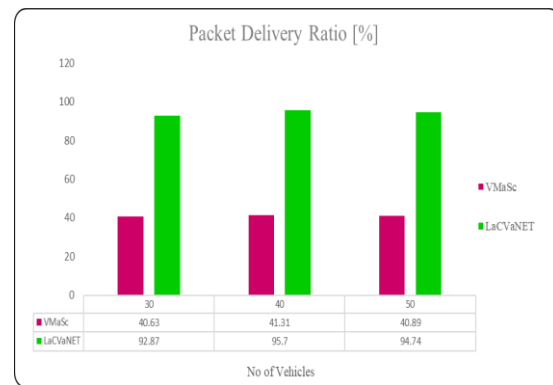


FIGURE L COMPARISON OF THE LAC-VANET PROPOSED SCHEME AND VMaSc MODEL IN TERM OF PDR

Figure LX and LXX, shows end-to-end delay against the simulation time and number of vehicles. From the following graph, we can say that value of end-to-end delay for VMaSc is increasing but not constantly when we vary time of pause time from 100 to 200, end to end delay increases sharply for 300 until 400 pause time. In proposed approach at pause time 100 to 400, end-to-end delay is improved compared to VMaSc when we vary time of pause time from 100 to 200, end to end delay decreases minor for 300 until 400 pause time.



FIGURE LX COMPARISON OF THE LAC-VANET PROPOSED SCHEME AND VMaSc MODEL IN TERM OF DELAY.



FIGURE LXX COMPARISON OF THE LAC-VANET PROPOSED SCHEME AND VMaSc MODEL IN TERM OF DELAY.

The number of lost packets in the network of VANET is always high due to the existence of security attacks. So, we also consider the number of lost packets as a criterion to evaluate the proposed method. Figure LXXX indicates that the proposed method reduces the number of lost packets in different numbers of vehicles. We try to achieve the main and major goal in VANET networks, i.e. fast propagation of security and urgent messages in ITS systems, using clustering and selecting the best cluster head based on Fuzzy logic such that the cluster head can transfer important information such as the obstacles and accidents detected on the road with a suitable speed and without creating a large traffic load in the vehicle network in order to notify other vehicles and prevent the danger and vehicle accidents.

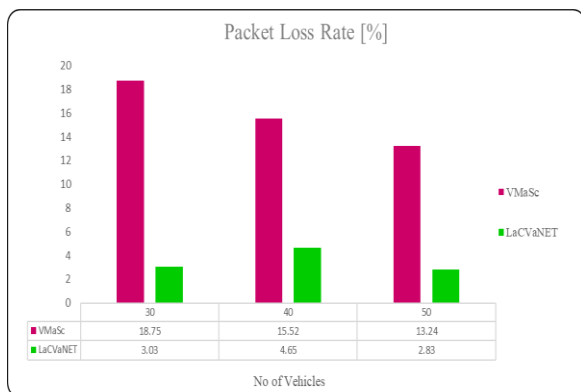


FIGURE LXXX COMPARISON OF THE LAC-VANET PROPOSED SCHEME AND VMaSc MODEL IN TERM OF PACKET LOSS RATE.

V. CONCLUSIONS

In this paper, a new clustering algorithm called LAC-VANET which is based on the score values considering delay, distance, LET and density, is proposed. We try to achieve the main and major goal in VANET networks, i.e. fast propagation of security and urgent messages in ITS systems, using clustering and selecting the best cluster head based on fuzzy logic such that the cluster head can transfer important information such as the obstacles and accidents detected on the road with a suitable speed and without creating a large traffic load in the vehicle network in order to notify other vehicles and prevent the danger and vehicle accidents. In our

analysis, the performance of our proposed LAC-VANET scheme is evaluated using NS-2. The results confirmed that our scheme is capable of exhibiting high-levels of security and high average throughput (exceeding 350 kbps). In addition, our proposed scheme has high PDR (more than 95.41%), low Delay (less than 1000 sec), and low Packet loss rate (less than 4.1%), in comparison with the other approach currently being employed.

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