IEEE Access
Multidisciplinary ⁞ Rapid Review ⁞ Open Access Journal

Received July 20, 2021, accepted August 1, 2021, date of publication August 3, 2021, date of current version August 16, 2021.
Digital Object Identifier 10.1109/ACCESS.2021.3102216

Reliable Group of Vehicles (RGoV) in VANET

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ABSTRACT Nowadays vehicles on the roads can communicate using a special type of wireless network called Vehicular Ad-hoc Networks (VANETs). It has been demonstrated by the researchers that because of the unique features such as high density of vehicles and frequent change of network topology, VANETs are not supported by the traditional routing protocols. The routing consistency of such highly dynamic networks must be taken into account in VANETs as communication links are disintegrated in VANETs more often than Mobile ad-hoc Networks (MANETs). The nature of VANET communication can bring extreme routing overhead to the network, therefore to increase network performance, the overhead issue must be tackled. The proposed protocol is focused on reducing the overhead to get the improved PDR performance of the network. The improvement is achieved by permitting communication amongst only those nodes which are considered reliable in terms of availability and geographical position. The reliability factor simply reduces unnecessary nodes from the communication process and selects a set of reliable nodes that are discovered with the help of clustering technique throughout the routing process. Simulation experiments using the network simulator are presented to demonstrate the efficacy of the proposed protocol. The results show that the proposed protocol has enhanced network performance effectively compared to prior approaches.

INDEX TERMS Ad-hoc networks, reliable VANET, K-means.

I. INTRODUCTION

Traffic accident is a very common cause of many deaths and injuries happening in the world on a daily basis. The reason for the designing of VANETs is to prevent these deaths and injuries and to improve the road safety information. VANET has an enormous support capacity for Intelligent Transportation Systems (ITS) applications that is why the researchers are attracted towards it [1]–[4]. VANETs are a favorable technique in order to permit communications connections in between automobiles. VANETs are a divergent type of MANETs that offers vehicle-to-vehicle connections that result into proper communications i.e., transmission of a signal between each other. Mainly, it is expected that every automobile has a facility of wireless communication in order to provide ad-hoc network inter-connectivity. They have a tendency to function even with a deprived substructure; every vehicle could relay, send, and receive messages from other vehicles in the wireless network. Thus, vehicles can interchange present information, and drivers will keep on updating the conditions of road traffic and other information related to travel. They have a very fascinating and inimitable specification that differentiate VANETs from MANETs: greater computational capability, higher transmission power, and certain type of foreseeable motion in contrast to common mobile ad-hoc networks. Their performance and characteristics raise significant encounters in a technical system and that must be measured to effectively arrange these sorts of connections. The most challenging problem is possibly the frequent changes and the greater mobility of the network topology [5]. In VANETs, when vehicles alter their data rates and/or tracks, the network topology may vary. Normally, the above stated alterations are not planned in advance, but truly depend on the road conditions and drivers. The recent advancement in VANET, i.e. IoV (Internet of Vehicle), is nothing but a combination of VANET and IoT (Internet of Things). As IoV produces immense sensing data for a large number of sensors, intelligent vehicles face enormous computing constraints. In Mobile Edge Computing (MEC) [6], additional data computation and storage sinks at a location next to data source from core to edge network is installed. Some data need not be processed over the network to the cloud to decrease time and network loads and increase privacy and data security. It is highly vital that enormous amount of sensor data be sent to the edge nodes for computation for automatic driving, which involves a large latency, data processing and storage. This research is primarily intended to recommend a routing mechanism for VANETs that should be reliable and that reflects the

The associate editor coordinating the review of this manuscript and approving it for publication was Lorenzo Mucchi.

topological specifications of VANET communication via the position of the nodes. Since, vehicles travel at high speed on the roads, they could encounter diverse interruptions in terms of data distribution facility because of recurrent breakages in connection. While building a route, it is vital to guarantee that the utmost consistent network paths are opted. The rest of this article is structured as follows: The related work is presented in Section 2. Section 3 and Section 4 contains background information and vehicular mobility respectively. Section 5 discusses the proposed routing scheme RoGV. Based on comprehensive simulation, the performance of proposed protocol RoGV is assessed in Section 6. Finally, Section 7 concludes the paper.

II. RELATED WORK

The literature on routing stability is stated primarily on MANETs [7]. VANETs, establish a system which can predict a network breakage even before it occurs and it is because VANETs have a system to analyze those breakages, according to velocities of vehicles. A vehicle shifts from one group to another group and onto different road causing it to part from its group so the system looks for a greater stable path that would comprise of different vehicles from a similar cluster. In [8], the authors tackled the issue of frequent link disconnections and improved End-to-End delay by selecting the next forwarding node from the border area of its communication zone, and the vehicle direction plays an important role in improving the performance. A speed-assisted routing protocol has been suggested in [9] to use the packet forwarding scheme between the advancing node and destination. The packet transmission area is defined by estimating the future route of the target node based on its speed and location data. The authors in [10] presented protocol for VANETs which is Prediction Based Routing (PBR) protocols. Specifically, it is established to take the benefit of the predicted motion patterns of automobiles on roads and also for mobile gateway situations. PBR is mainly depended on two protocols, i.e. to predict the lifetimes of routes and produced a new pattern of routes if the existing route gives a signal of failure. The lifetime link estimate and establishment is dependent on related speeds, the communications range and the position of vehicles. The lifespan of a route is the least of its links, as a road may consist of more than one link. PBR enables the management of multiple routing requests for seeking full usable routes to the ending point. The highest-estimated route lifetime can be used when the origin node gets numerous responses. In [11] the author proposed a novel way of selecting reliable routes which minimizes routing failure to get improved routing mechanism.

The use of clustering techniques where vehicles are classified into groups or clusters, is considered to be a viable solution to address the scalability issue of VANET [12], [13]. Each cluster contains multiple nodes that can communicate with other cluster members by means of their respective cluster Head (CH) [14]–[16] because CH uses the data aggregation technique to eliminate redundancy of data [17]. The authors of [18] broadened the OLSR protocol by adding different metrics to pick CH and Multi-Point Relay (MPR) that minimize disconnection. Tracking the quality involves a distance of communication range, speed and the bandwidth between the potential MPR that is available and the vehicle. In [19] the authors suggest OLSR's MPRs to increase routing capabilities by reducing the control overhead architecture. The fundamental notion for MPR operations is in the selection of a cluster head, which separates each group into clusters, on the basis of the heuristic selection process. Once the message is received, each node regularly generates and maintains its neighbor's set on the basis of a one-hop and two-hop connectivity measure. Then these heads choose a specific MPR relay node. This approach decreases control overhead messages in the same area by reducing redundant transmissions. With the objective of decreasing the number of native MPR clusters, author [20] reduces the number of relaying nodes locally only when all the neighbouring two-hop nodes are integrated. The authors of [21] have created a novel routing method based on the accessibility of link and the selection need to address the relay selection problem. The MPR set might take a long time to calculate and entail significant additional overhead cost. In [22] the proposed protocol reduces the total number of MPR relay nodes to decrease topology control overheads. The approach minimises the number of head clusters locally, takes into account the level of collaboration and the degree of connectivity. The authors [23] allocated weights to the various links in order to make the ideal MPR choice. The average bandwidth and delay measures taken for the optimum MPR selection. QoS helps OLSR to achieve greater performance, particularly when compared to the best OLSR effort in terms of decreased topology control overhead. However, for MANET, this protocol was built. In [24] the authors optimized their routing decisions by considering the quality of the link while selecting MPR settings based on QoS restrictions. In [25], a chosen node group as a relevant member nodes were established utilizing the GSA-PSO optimization to monitor the signaling approaches. This approach used the MPR-OLSR to use the available bandwidth efficiently. An algorithm is proposed [26], which is termed as Dynamic Trilateral Enrolment (DyTE), that minimizes the broadcast storm by using the location of the source and destination vehicle. The route discovery mechanism is minimized by creating trilateral zone membership, therefore only those nodes which have the membership of that zone can participate in the route discovery process. An algorithm was proposed [27], which is termed as Movement Prediction-based Routing (MOPR), that actually determine a reliable route and forecast the location of a vehicle. If there are a variety of possible ways amid the source and the target vehicle are available, MOPR selects the most reliable path by looking at the mobility circumstances of the middle nodes with regard to the origin and terminal nodes. The process is so far accompanied via direction, velocity information, the location of every individual vehicle. In every node, an extension is added to the route request packet to achieve the requirements of the algorithm described above.

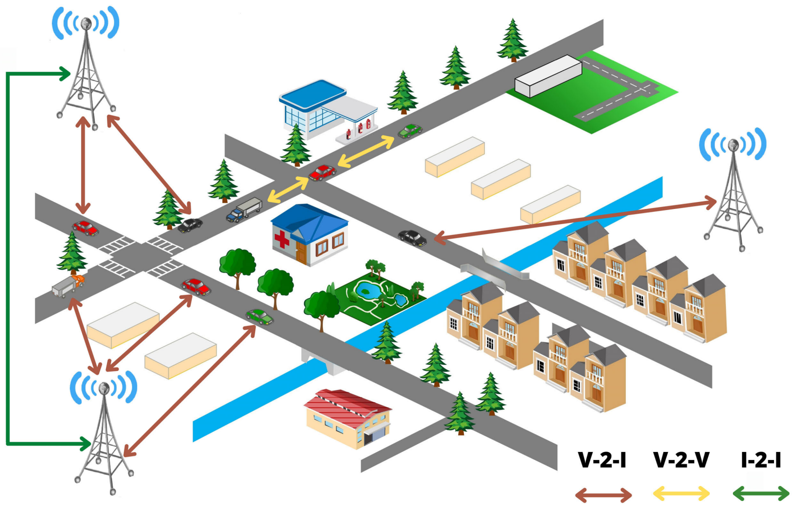

FIGURE 1. VANET's architecture.

III. BACKGROUND

An ad-hoc network forms temporary network using certain topology which is nothing but a combination of mobile nodes with wireless networks [28], where no specific infrastructure or centralized administration is present. The VANET is a modern way that offers wireless networks to vehicles of a new generation [29]. It has research significance because it provides an opportunity for a major shift in the transportation system through ITS [30]. The primary aim of the technique is to facilitate the vehicles with effective connectivity [31], enabling a more reliable and secure transportation system.

The VANET's development has been inspired to exchange information on the road between vehicles to avoid accidents, therefore enhancing safety for vehicles and drivers. All data from vehicle sensors can be viewed on the driver or transmitted to an on-road unit (RSU) or transmitted into surrounding vehicles depending on certain requirements. Apart from road safety information, there is a wide range of different applications mentioned for vehicular networks, i.e. gaming based, travel / tourism based, multimedia based, access to the internet, etc.

A. ARCHITECTURE

VANET architecture can be categorized in three categories as shown in Fig. 1

1) Vehicle-to-Vehicle (V-2-V) communication - The communication takes place among vehicles without any infrastructure, this means neighbor vehicles can talk to other vehicles directly.
2) Vehicle-to-Infrastructure (V-2-I) - These applications of vehicular network is facilitated by using local network access points and cellular network towers.
3) Infrastructure-to-Infrastructure (I-2-I) - To pass on the information to distant or sometimes multiple locations, communication takes place between peer-to-peer infrastructure [32].

B. SPECIAL CHARACTERISTICS OF VANETs

Communication in VANETs is unique because it possess no centralized server to define rules for communication [33]. This means that vehicles can have both roles either server or client to exchange information with other nodes at the same time. When compared VANETs with MANETs, following characteristics of VANETs are found more attractive:

1) Power and Storage - In VANET, high power and storage are supplied for vehicles.
2) Computation - Vehicles have uninterrupted and unlimited power, therefore the capability of computation for sensing and communication is highly supported.
3) Movement Prediction - Velocity and coordinate information is used to predict the mobility pattern in VANET because vehicles are moving in a specific direction because of roads.

C. CHALLENGES IN VANETs

The routing process is a huge challenge and needs to be solved prior to implementing these networks because of the peculiar characteristics of VANETs. Data packets will be transmitted through the available vehicles as relays via the source node to the destination node. But owing to the high density of cars and the high dynamic and continual density fluctuations, even traffic signals and crossings might trigger a partition of network which is a serious problem for the routing process. In contrast, VANETs gets benefit from routing protocol design features such as mobility constraints and consistent road mobility. Additional information can also be made available such as geographical coordinates and city maps. The existing protocols of routing proposed to VANETs can be divided into following categories according to [34]; Mobility-oriented movement protocols in which information of relative mobility including distance, velocities, acceleration and directions can be utilized in predicting the lifetime and length of the routing path; Infrastructure-based routing protocols are used to ensure the robustness and security of VANET communication through infrastructure such as RSU and cellular base stations; Geographical location routing protocols where VANETs can search for paths closer to the target vehicle using Global Positioning System (GPS) coordinates; and the protocols based on probabilities where the probability rules are used for estimating events such as a breaking link and the estimated communication time.

IV. VEHICULAR RELIABILITY MODEL

High speed vehicles on highways make it very difficult for VANETs to have a stable routing scheme, since different dynamic aspects have an impact. The distribution of vehicles and mobility patterns are some of the factors which affect the stable routing system [35]. We are expected to identify the characteristics of vehicle traffic and mobility model to explain the vehicle reliability system. Moreover, by knowing the traffic characteristics of the vehicle stream, we can predict the duration of steady connectivity between vehicles.

A. MODELING THE FOUNDATIONS OF VEHICULAR TRAFFIC FLOW

The macroscopic and microscopic model traffic stream are two important ways of evaluating spatiotemporal movement in vehicle flows [36]. The first approach shows a physical fluid stream that traffic flows. The macroscopic model of traffic describes traffic dynamics as combined macroscopic quantities such as $q(x, t)$, mean speed $v(x, t)$, and traffic densities $p(x, t)$ as time t and space x as a function of partial differential equation. These factors may be combined using their average [37] values through the following relationships:

$$d_m = \frac{1000}{p_{veh}} - l_m \tag{1}$$

$$T_m = \frac{d_m}{v_m} = \frac{1}{v_m} \times \left(\frac{1000}{p_{veh}} - l_m\right) \tag{2}$$

$$q_m = \frac{1}{T_m} = v_m \times \frac{1}{(\frac{1000}{p_{veh}} - l_m)} \tag{3}$$

p_{veh}:Traffic Density (Vehicle/km)
d_m: Avg. gap between vehicles in terms of distance (m)
v_m: Avg. velocity of vehicles (Km/h)
T_m: Avg. gap between vehicles in terms of time (s)
q_m: Avg. traffic flow (Vehicle/h)
l_m: Avg. length of vehicles (m)

However, the later approach defines the mobility of every vehicle. Microscopic approach model activities like lane changes, deceleration, and acceleration, of each individual vehicle in reflection to the surrounding traffic. The former approach could also be used to clarify the status [38] of both individual cars and general traffic flow. The mathematical distinction of vehicular motions through the network of traffic. The macroscopic approach is then used for describing the flow of the vehicle and using the average speed. In the following component, a macroscopic perspective of the vehicle speed is taken into account to establish a link-reliability model. We look for the velocity distribution rather than vehicle traffic stream to find out the state of the network connectivity. The key parameter is the speed of cars to guide the dynamics of network topology. It also has a major effect on finding how long two vehicles can communicate.

B. FRAMEWORK FOR RELIABILITY OF LINK

It can be described as a probability of continuously providing communication between two vehicles for a certain period of time. Due to the continued availability interval T_p of a particular link l between two vehicles at t, the reliability values $r(l)$ for the connection are as follows:

$$r(l) = P\{\text{To remain available until } (t + T_p)|\text{available at } t\}.$$

The speed factor of a vehicle is used for calculating the reliability of the connection. Vehicle speed is supposed to have a [39] standard distribution. In this case, the corresponding distribution function of probability should be $G(v)$, and $g(v)$ should be the probability density function of the vehicle's velocity v;

$$g(v) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(v-\mu)^2}{2\sigma^2}} \tag{4}$$

$$G(v \leq V_0) = \frac{1}{\sigma\sqrt{2\pi}} \int_0^{V_0} e^{\frac{-(v-\mu)^2}{2\sigma^2}} dv \tag{5}$$

whereas, σ_2 and μ shows the variance of velocity and the average value [40]. By using the relative velocity Δv and the time duration T, i.e., $d = \Delta v \times T$, calculation of the distance between two vehicles can be accomplished. Since the random variables v_1 and v_2 are normally distributed then the difference of change in both variables Δv is also supposed to be normally distributed, therefore we can write $\Delta v = d/T$. Each vehicle has a communication range represented as H likewise the maximum possible distance is $2H$, where connectivity between two vehicles is still probable, i.e., when both vehicles adjust a relative distance between $-H$ to $+H$. The probability density function $f(T)$ of the communication duration T can be calculated as follows:

$$f(T) = \frac{4H}{\sigma_{\Delta v}\sqrt{2\pi} \times T^2} e^{\frac{-(\frac{2H}{T} - \mu_{\Delta v})^2}{2\sigma^2_{\Delta v}}} \quad for T \geq 0 \tag{6}$$

where, $\sigma^2_{\Delta v}$ and $\mu_{\Delta v}$ represents the variance of relative velocity Δv and average value, respectively. GPS device is supposed to be equipped with each vehicle in order to provide the velocity, direction information, and location. The continuity of the particular link "l" between the two vehicles i.e. i and j is described as available;

$$T_p = \frac{H - L_{ij}}{v_{ij}} = \frac{H - \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}}{| v_i - v_j |} \tag{7}$$

The distance between vehicle i and j is known as Euclidean distance and is represented by L_{ij}. $f(T)$ can be integrated in Equation 6 from time t to $t + T_p$ to identify the likelihood that the connection is reachable at time t for a duration of T_p.

Therefore, the link reliability value $r_t(l)$ at time t is calculated as follows:

$$r_t(l) = \begin{cases} \int_t^{t+T_p} f(T)dt & \text{if } T_p > 0 \\ 0 & \text{otherwise} \end{cases} \quad (8)$$

The integral in Equation 8 can be obtained by using the Gauss error function (Erf) [41],

$$r_t(l) = Erf\frac{(\frac{2H}{t} - \mu_{\Delta v})}{\sigma_{\Delta v}\sqrt{2}} - Erf\frac{(\frac{2H}{t+T_p} - \mu_{\Delta v})}{\sigma_{\Delta v}\sqrt{2}} \quad when \quad T_p > 0 \quad (9)$$

where Erf stands for;

$$Erf(T) = \frac{2}{\sqrt{\pi}}\int_0^T e^{-t^2}dt, -\infty < T < +\infty \quad (10)$$

C. RELIABILITY OF ROUTE

In VANETs there are multiple potential paths between the destination d and the source s vehicle, whereas every single route is a collection of links between the origin and the target node. The number of its established connections is indicated $c : l_1 = (s, n_1), l_2 = (n_1, n_2), \ldots, l_c = (n_c, d)$ on any given route without loss of generality. Every individual link $l_b(b = 1, 2, \ldots c)$, is represented by $r_t(l_b)$, the value of link reliability is interpreted in Equation 11. Route Q's reliability can be defined as follows:

$$R(Q(s, d)) = \prod_{b=1}^{c} r_t(l_b), \ where\ l_b \in Q(s, d) \quad (11)$$

The reliability of a route is classified as the multiplicative reliability product across the established links of such route. Assume that the source s to the destination d may have ω multiple routes. Based on the following criteria, at a source node, the best route is chosen from the set of all possible routes i.e. if $M(s, d) = Q_1, Q_2, \ldots, Q_\omega$ is the set of all possible routes:

$$arg\ max_{Q \in M(s,d)} R(Q) \quad (12)$$

i.e., you are supposed to opt the most stable route if various routes are present.

V. PROPOSED PROTOCOL

The proposed routing protocol operates in two ways. It first restricts nodes participation in the restricted trilateral zone only, as illustrated in Fig. 2 and then that zone is further suppressed to allow only reliable nodes for further communication. Because an excessive number of nodes generates an excessive amount of requests inside the network, therefore the reliability element is important to implement. Routing overhead during the route discovery phase is the major concern in VANETs because it is inversely proportional to the network's PDR performance. Therefore, in order to maximize the performance of a network in terms of PDR, the routing overhead must be controlled first. In the proposed routing protocol, we first reduce the region of communication by permitting only nodes that are located inside the trilateral zone. Suppressing the communication zone will result in limiting the nodes count because by default the communication zone is in circular shape where irrelevant nodes may also participate in the communication zone which are going in a different direction altogether with respect to source and destination node. Suppressed trilateral zone allows only relevant nodes to get participated and therefore the list of nodes are limited but since those limited nodes may still go out of the communication range therefore the selected relevant nodes are further scrutinized based on the clustering technique i.e. K-Means. K-means is one of the most basic and widely used machine learning algorithms. Unsupervised algorithms frequently generate data sets from input vectors (in our case its GPS coordinates) with no reference to previously known or determined outcomes. The goal of K-means is straightforward: gather similar datasets and identify important patterns. In order to achieve this goal, K-means searches for a given number of clusters, i.e. "k," in a dataset. A cluster is a collection of data points that share certain characteristics, in our case, it's the distance from the centroid to the target node. That means the K-means method finds the "k" number of centroids, then assigns each node to the next closest cluster while keeping the centroids small. We simply utilized the K-means to group the nodes such that only the most reliable group of nodes is chosen based on the shortest distance between the cluster's centroid and the destination node. Each time when a new member node $\beta_{x,y}$ is associated with a cluster, the centroid $\alpha_{x,y}$ of the cluster is updated using Equation 13 with the help of the selected node's GPS coordinate:

$$\alpha_{x(new),\ y(new)} = \left(\frac{\alpha_{x(old)} + \beta_x}{2}, \frac{\alpha_{y(old)} + \beta_y}{2}\right) \quad (13)$$

The major contribution of the proposed protocol is the suppression of the communication zone and then the selection of reliable nodes within the suppressed zone. Following are the two phases of the proposed protocol that makes this work different from existing work:

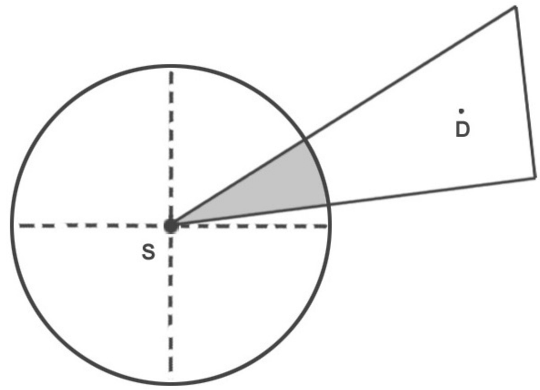

FIGURE 2. Limited trilateral zone.

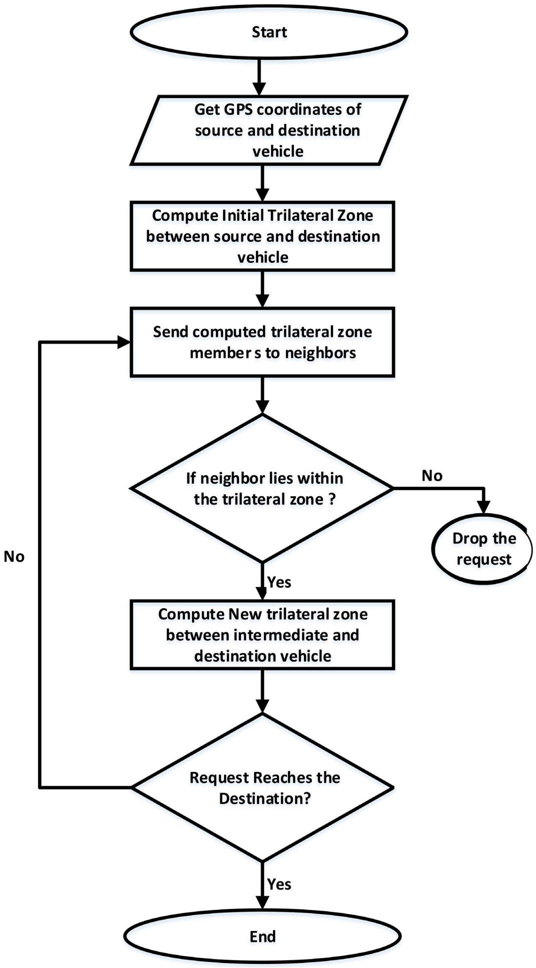

FIGURE 3. Flow of steps (Phase 1 and Phase 2 respectively).

First Phase - Limiting the Communication Zone: This phase is comprised of producing the restricted trilateral zone for communication by using the GPS coordinates of the nodes.

1) Get the source and destination node GPS co-ordinates, i.e. (x_S, y_S) and (x_D, y_D) respectively.
2) Calculate the trilateral zone to limit the broadcast of route requests within the network.
3) Generate a list of nodes that are within the trilateral zone; this list will then be suppressed further to obtain the most reliable nodes.

Second Phase – Finding the Reliable Set of Nodes Within the Limited Communication Zone: This phase is a continuation of the previous phase.

1) The reliable list of nodes for communication is calculated using K-Means. All list of nodes are further segmented into two groups by using the cluster's centroid calculations.
2) First two nodes in the list are considered as clusters and then the next node in the list will be part of only one cluster at a time.
3) Centroid coordinates will be updated only if the node is associated as a member of that centroid.
4) The above steps are repeated until the complete list is not processed.
5) When each nodes become the member of either of the clusters, the distance between the target node and the two centroids will be computed at the end.
6) The shortest distance from the centroid to the destination is selected for reliable members and then those reliable member nodes are included into the RREQ packet.

Each vehicle that receives the RREQ packet will check the list to see if it is a member of the trilateral region. If the recipient is within the trilateral zone, the packet can be processed further. Since K-Mean logic is primarily utilized for machine learning, this logic has been employed to improve the reliability of the communication process.

A. CONSTRUCTION OF TRILATERAL ZONE

In order to limit the communication zone, we need to construct the trilateral zone i.e. $\triangle AEF$. Initially, the source node

Algorithm 1 RGoV Communication Process

1: Get Source and Destination GPS coordinates (s,d).
2: Compute the trilateral zone using (s,d).
3: Get the list of neighbors lies within the trilateral zone.
4: Make groups for the list of neighbor based on the distances.
5: Select a particular group only which has the lowest distance to the destination.
6: Embed the selected reliable group with the list of neighbors to the RREQ packet and forward it.
7: Participation will be allowed only to those nodes which are present in the embedded list.
8: If the receiving node present in the list and it does not have information about the destination node then it will re-calculate a new trilateral zone and also associate a group before forwarding the packet further.
9: The above process is repeated until the destination is not found.

A uses the last known coordinate information of the destination node B and finds out the slope using the straight-line Equation 14 and also the distance between source and destination is calculated using the Euclidean distance formula Equation 15.

$$m_{straight} = \frac{\Delta y}{\Delta x} = \frac{y_D - y_S}{x_D - x_S} \quad (14)$$

$$dist(S, D) = \sqrt{(x_D - x_S)^2 + (y_D - y_S)^2} \quad (15)$$

After the above mentioned calculations the next step is to identify the next coordinate information i.e. C and D as illustrated in Fig. 4, for that we use perpendicular slope method Equation 16 and solve with Equation 15

$$m_{perpendicular} = -\frac{1}{m_{straight}} \quad (16)$$

After determining the perpendicular slope, we need to calculate the distance between $\overline{BC}$ and $\overline{BD}$ using the Euclidean distance formula. Likewise in order to get coordinate of E we first calculate the slope of the straight line $\overline{AC}$, since all three points lie within a straight line, therefore the slope of $\overline{AC}$ and $\overline{CE}$ will be equal and we find the coordinate of E. A similar process will be repeated for a point F by using the slope of $\overline{AD}$ we find out the point F because all points i.e. A, D and F lies within a straight line.

B. MEMBERSHIP PROCESS OF TRILATERAL ZONE

In order to take part in the routing process, the recipient node should be inside the trilateral zone of the sending node. After a trilateral zone has be established, a source node complements the list of each neighbour within the trilateral area by calculating the total area of that trilateral zone i.e. $\triangle AEF$ as shown in Fig. 5 and all possible combinations of coordinates with the arbitrary node T given in Equation 18.

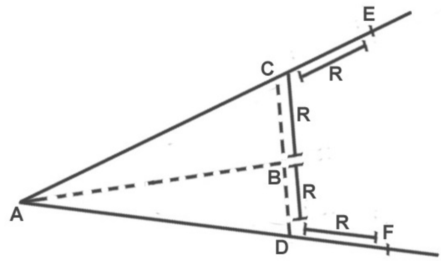

FIGURE 4. Trilateral zone.

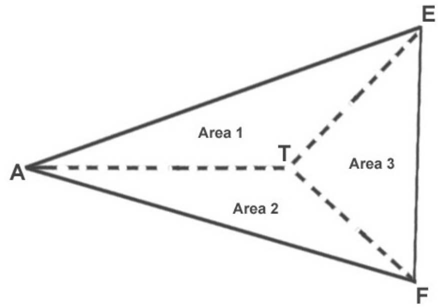

FIGURE 5. An arbitrary node inside the zone.

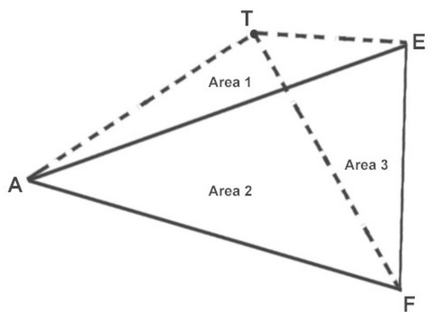

FIGURE 6. An arbitrary node outside the zone.

Calculating the area of the trilateral zone $\triangle AEF$.

$$Area_{\triangle AEF} = \left| \frac{x_A \times (y_E - y_F) + x_E \times (y_F - y_A) + x_F \times (y_A - y_E)}{2} \right| \quad (17)$$

In Fig. 5, the arbitrary node T lies within the trilateral zone whereas in Fig. 6, the arbitrary node T lies outside the zone. Following Equation 18 is used to get the information whether an arbitrary node lies inside or outside a trilateral zone:

$$Area_{\triangle AEF} = Area_{\triangle AET} + Area_{\triangle AFT} + Area_{\triangle EFT} \quad (18)$$

VI. SETTINGS FOR PERFORMANCE ASSESSMENT

This performance assessment primarily focuses on detecting the effect on the routing phase of highly complex topology. Moreover, we need to find the advantages of proposed RGoV that means what are the benefits if we pick the most relevant nodes during the route discovery phase. We carried out the

TABLE 1. Parameters of simulation.

Parameter	Value
Mobility	Manhattan
Channel Type	Wireless
Antenna	Omni-Antenna
Transmission Zone	250 m
Traffic Type	CBR
Protocol Type	UDP
Model	Two Ray Ground
Max. Speed	50 Km/h
Queue length	50 packets
MAC protocol	IEEE 802.11
Number of vehicles	25, 50, 75 and 100
Number of Simulations	15
Simulation Area	2500 m x 2000 m
Simulation Time	300 sec
Routing Protocols	COOP, NCA-MPR, NFA, UM-OLSR, QOLSR, CACA and RGoV

performance evaluation via NS-2 network simulator [42]. In order to achieve its actual outcome, we perform fifteen runs for every individual simulation experiment. The evaluation was conducted by comparing the proposed protocol with UM-OLSR [43], COOP [20], NCA-MPR [22], NFA [21], QOLSR [23] and CACA [18] algorithms. Thus, with the Simulation of Urban Mobility (SUMO) tool [44], we design realistic urban conditions to create models of the Manhattan Grid movement inside 2500 m × 2000 m. Simulation for traffic is demonstrated using SUMO to get the most frequently utilized information, such as road direction, edges, vehicle speed and traffic conditions. In addition, SUMO creates the mobility traces file that define the wireless mobile network, where the 100 nodes are randomly dispersed and also follow the road behaviour. At a maximum speed of 50 Km/s the cars move randomly in different directions. The cars exchange traffic related data packets that can generate a constant bit rate (CBR) with a size of 512 bytes of the data packet.

A. PERFORMANCE METRICS

For the simulation experimentation the below given metrics will be considered.

1) Packet delivery ratio (PDR): The proportion between the packets received at the destination to the packets sent from the source.
2) Normalized Routing Load (NRL): It corresponds to the proportion of all routing control packets transmitted over all the nodes to the number of data packets received at final nodes.
3) Average end-to-end (E2E) delay: It denotes the average period among the transmitting and receiving duration for the packets obtained.

In comparison to typical CACA, UM-OLSR, NFA, NCA-MPR, COOP, OLSR and QOLSR protocols, Fig. 7 indicates an improved packet delivery ratio of proposed RoGV algorithm. This is due to the selection of reliable next forwarding node in our algorithm which utilized to forward the packet to reach the destination with a lower chances of colliding or packet dropping due to the unreachability of intermediate nodes. Since the number of nodes are not only minimized but they are more reliable for the communication process, therefore the higher PDR is achieved.

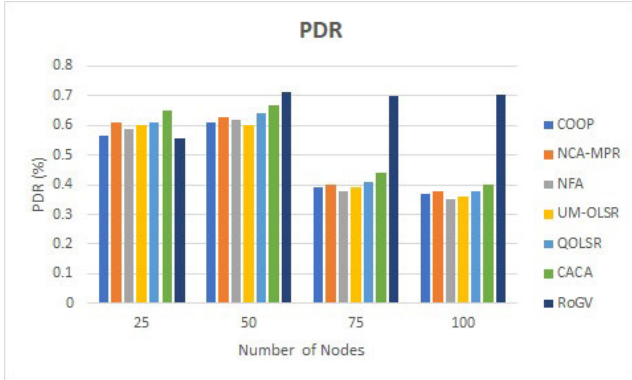

FIGURE 7. Packet delivery ratio.

Fig. 8 shows the overhead values of each routing algorithm based on the different densities of vehicles. The proposed protocol RoGV relies on the minimization of communication area and the selection of reliable limited nodes, but the overhead count starts increasing as the number of nodes increases. Because in comparison with CACA, UM-OLSR, NFA, NCA-MPR, COOP, OLSR and QOLSR protocols, nodes in RoGV will handle the request packet whether it is intended or not, owing to which additional control messages are necessary to maintain the routes.

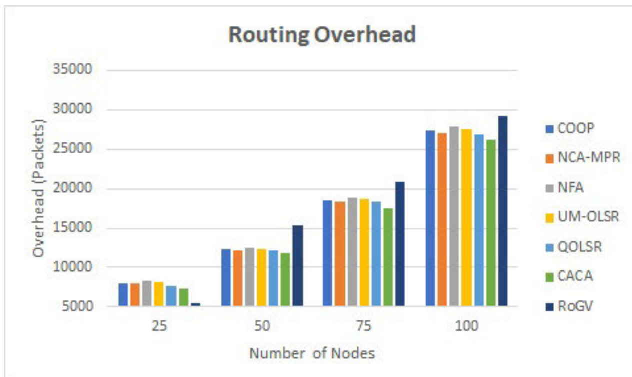

FIGURE 8. Routing overhead.

Fig. 9 presents the average end-to-end delay values for paths in the network. When vehicle density grows, each algorithm's average delay time rises proportionally however the result shows improvement as the delay time of the proposed protocol is getting reduced (especially at 100 nodes), because hop count is controlled in the proposed routing mechanism using clustering approach to get the reliable group of nodes.

In contrast to other mentioned protocols like CACA [18] algorithm where the control overhead of the network is handled using the clustering of vehicles based on proximity i.e., time and distance. The proposed protocol minimizes the

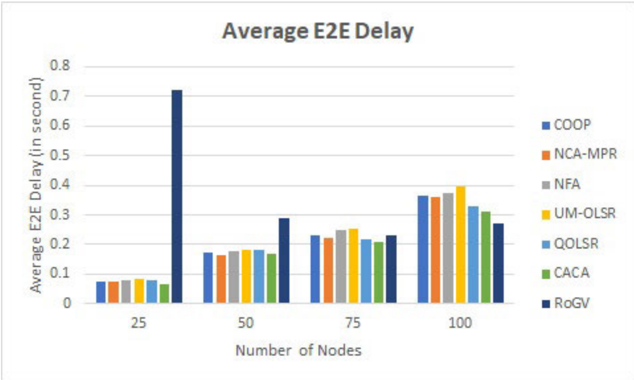

FIGURE 9. **Average end-to-end delay.**

communication zone based on the GPS coordinates of the sender and destination vehicle and then the selected group of vehicles are further minimized using the K-means algorithm to control overhead issues and improve network performance.

VII. CONCLUSION

An efficient routing protocol named RGoV is proposed to provide a reliable routing system for VANETs. This protocol is designed to increase network efficiency by eliminating the needless flow of broadcast packets. The main aim of the proposed routing protocol was to get effective information about the next forwarding neighbour for the reliable transmission. The clustering technique contributes only to the formation of a number of dependable nodes that leads to a decrease in unneeded broadcast storm transmission. The results of the simulation show that the proposed method, especially with regard to packet delivery and delays, is successful since it chooses the most reliable nodes to reach the target. The future work will be focused on improvement by supporting more parameters in order to adapt our process to include it in other routing protocols.

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