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Research Article

Performance Enhancement of Cluster-Based Ad Hoc On-Demand Distance Vector Routing in Vehicular Ad Hoc Networks

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Recently, extensive research has focused on the design of clustering algorithms for grouping vehicles in a set of clusters in Vehicular Ad Hoc Networks (VANETs). However, due to the dynamic nature of VANETS, frequently connected or detached nodes threaten the stability of the network. When these nodes are clustered heads (CHs), the impact of these disruptions on network performance is even worse. Therefore, the stability of clusters is an important issue that should be maintained to enhance the performance of the network with minimum data loss. In this article, a novel clustering approach is proposed, which is based on the average weight concept of three main attributes, namely, the geostationary coordinates (x, y) and drop density. The average of the above-mentioned attributes is calculated and compared with the values of other vehicles' attributes. Those vehicles having minimum average values are dropped and not to be considered in the cluster formation. The cluster members having minimum Euclidean distance are considered as Cluster Head (CH) until a certain checkpoint is not attained. The checkpoints are created in order to generate the social score of the vehicles. Once the social score is attained, a multiobjective framework is developed, which considers minimizing the Euclidian distance and maximizing the social score. The social score is generated based on the Quality of Service (QoS) attained attributes, and the data transmission is performed using Ad Hoc On-Demand Distance Vector (ADOV) routing protocol. A comparison of the proposed work and existing work has also been undertaken to demonstrate the improvement in the proposed work. As a result, throughput, PDR, network longevity, and energy consumption have been improved by 28.27%, 20.9%, 23.12%, and 27.48 percent, respectively. Extensive simulations show that the proposed scheme, unlike other popular clustering algorithms, can significantly increase the stability of the network by extending the life of the cluster head.

1. Introduction

Vehicular Ad Hoc Networks (VANETs) are a new field of research that helps improve road safety and congestion. VANETs will increase driver safety and hence reduce accidents and death by designing improved and intelligent VANET systems [1]. Because of the rapid expansion of the smart automotive sectors, there is presently a surge in interest in Internet of Vehicles (IOV) technology. A connected automobile has built-in technology that allows it to talk with the Internet, devices, and even other vehicles or systems. The Internet of Things in vehicles will help drivers by making driving faster, safer, and more pleasurable. Drivers may now access data on traffic, road conditions, fuel economy, auto diagnostics, driving behavior, and other topics. The ability to access data that will assist in making informed management decisions an advantage of automotive IoT for businesses. The benefits of automotive IoT spread across society. Allowing automobiles and systems to communicate, as well as large-scale data collection and analysis, can help reduce carbon emissions and traffic congestion and make roads safer. Vehicles can communicate with public networks and respond to stimuli, thanks to the Internet of Vehicles technology [2, 3]. Both academia and industry in the transportation sector are interested in VANET, which is an important and interesting MANET application. The VANET is an important future solution for improving performance and maintaining a safe transportation system [4, 5]. Collision avoidance, safety, blind crossing, dynamic route routing, real-time traffic condition monitoring, and other applications are all possible using VANETs. The provision of Internet access to vehicle nodes is another key usage of VANETs. The establishment of distributed service infrastructure via VANETs is aided by an information transfer protocol for vehicular computing (VITP), which provides the syntax and semantics of communications between vehicles. VANETs allow users about the traffic as well as about the conditions of the road. This is possible by navigation means, which reduced congestion by diverting drivers to the active route that helps avoid road hazards and problem areas [6]. The extensive sensor network created by VANETs pushes countless other applications, making VANETs the most recent topic in the ad hoc network technology [7]. VANET connects precisely defined steering standards [8, 9] since a strong end-to-end link between the source and the target is largely incomprehensible due to its irregular scalability and inconsistent network availability. The VANET provided wireless technology and was equipped with onboard units (OBU) that served as mobile nodes. The road segments are also utilized in conjunction with roadside units (RSU) to provide real-time traffic and topological data. The roadside unit gathers information from a stationary sensing region along a road and sends it to traffic control devices and a centralized traffic management center. These devices also act as a source of data for intelligent cars, allowing them to gather upcoming traffic data [10, 11]. VANET is the composition of vehicles termed as mobile nodes that communicate with each other by wireless means without any fixed infrastructure. The vehicles communicate with each other either by the peer to peer (P2P) means or by following the instruction given by the Roadside Unit (RSU) [12]. In order to attain safety and security in the network, the vehicles in VANET are equipped with sensor technology. In addition, standardization of wireless communication systems is also required to offer essential features to passenger [13]. However, VANETs have considerable drawbacks, such as the potential for vast size and high mobility. Because most autos drive at high speeds and frequently change places, nodes in the vehicular environment are much more dynamic [14, 15]. Because of the high mobility, the topology of the network is reactive, with node links joining and disconnecting often. Several articles have attempted to summarize problems about vehicular networks. The researchers examined routing challenges in VANETs before summarizing and comparing routing strategy performance [16, 17]. Currently, mobile networks (VANETs) are critical for increasing traffic safety and assuring the comfort of automobile drivers. These systems require a strong foundation, communications networks, and effective routing techniques. Because of its unique characteristics, VANETs are one of the most difficult study topics; establishing the optimum routing method and assuring quality of service is also a significant task [18, 19]. Considering these facts, research on VANETs has received a growing interest in the last four to five years, both in algorithmic aspects and in standardization efforts such as the IEEE 802.11 p and IEEE 1609 standards. In the clustering process, the vehicles are categorized into multiple groups based on some set of rules known as clusters. The cluster consists of multiple nodes. Each node corresponds to different nodes in the network through the Cluster Head (CH). A cluster head is a node that collects and transmits data from cluster sensors to base stations [20]. CH is the main leader of the entire group and is responsible for inter- and intra-transmission of data. A cluster gateway is an intercluster node that can be used to access the neighboring cluster and helps forward data from one cluster to another. Cluster members are the ordinary nodes that are also part of CH and participating in communication [21]. A brief overview of the VANET structure is shown in Figure 1.

VANETs provide users with information on traffic and road conditions. This is made feasible by navigational aids, which reduced traffic congestion by redirecting cars to a more active path that avoids road dangers and trouble locations. Because a strong end-to-end link between the source and the target is mainly unintelligible owing to its uneven scalability and unpredictable network access, VANET links clearly established guiding criteria. The concept of interconnected vehicles and their networks has gained a significant impetus to carry on the interconnectivity to vehicles along with the other equipped computing as well as sensing technologies, which has become a major provider of the smart transportation system [22].

The design and development of an improved clustering approach for VANET become a hot topic for research today. The clustering approaches in VANET are mainly used to resolve two problems. The first one is to manage the VANET efficiently. Typically, a VANET is composed of a defined vehicle count. In flat VANET structure, when the number of users/vehicles is exceeded above the defined level, then this results in generating insignificant and unnecessary data. Unlike mobile ad hoc networks (MANET), VANETs are more difficult to scale [23], due to the movement and speed of vehicles. Thus, it becomes essential to manage VANET successfully. Till now, clustering is the most experienced technique examined by several researchers for managing VANET. Second, clustering serves as a basis for a number of other important issues in VANETs, such as topology control, appropriate routing, and detection of malicious users. The above problems can be solved by designing a well-established VANET structure [12].

The purpose of a clustering procedure is to identify a real set of interconnected Cluster Head-Vehicles (CH-Vs) that cover all vehicles as well as the RSUs in a VANET. At a single instance, the vehicle can be a member of the participant of the single cluster [24]. Therefore, using CH-V in VANET makes the management of VANET easy. The formation of clusters in the network should be done in such a way so that the latency period, as well as the load on the communication link, should be minimum. Also, the creation cost of the cluster should be minimum. Else, the clustering process will be more expensive than flat routing in VANET [25]. The scenario of clustering is shown in Figure 2.

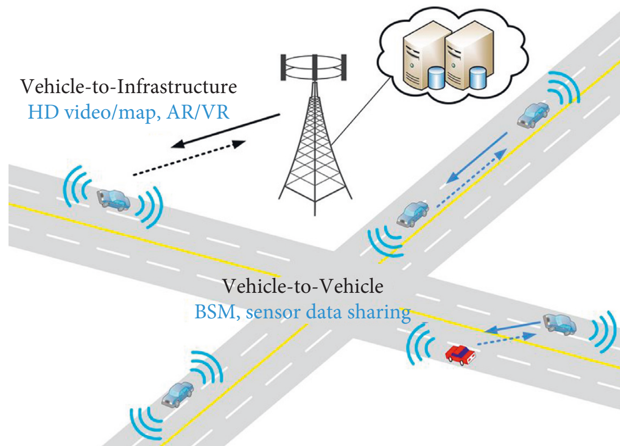

Figure 1: VANET architecture.

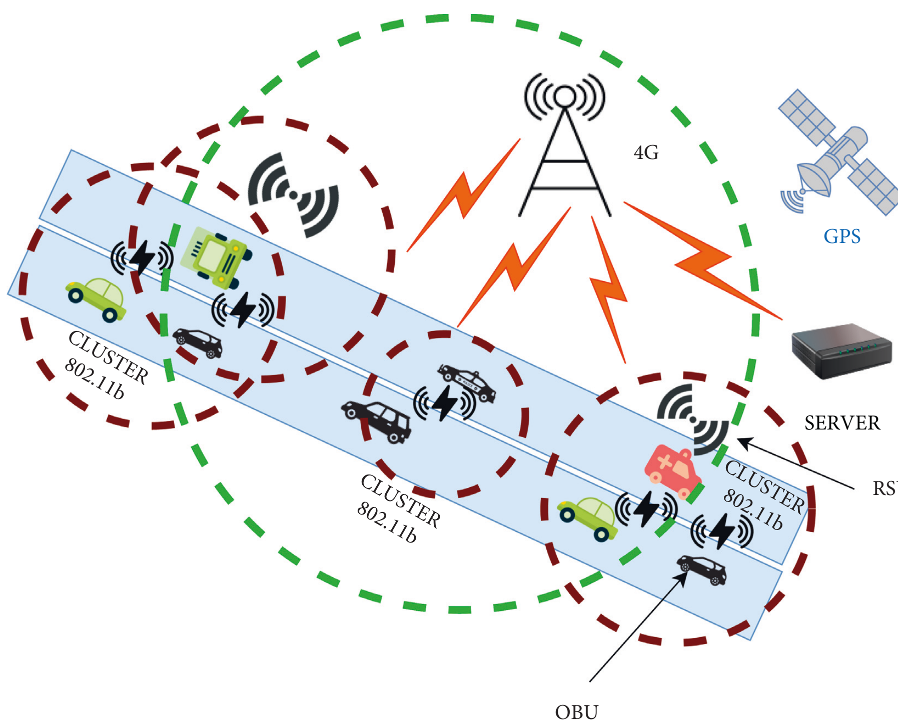

Figure 2: Clustering process in VANET architecture.

The movement of the vehicle from one cluster to another cluster is shown in Figure 2. Here, the blue car is moving out of the cluster. Before moving out from its current cluster, the vehicle checks whether it is a member/participant of the other cluster or not. If the vehicle found its memberships in the next cluster, then the vehicle moves into the next one and join that cluster [26]. The cluster is made up of many nodes. Through the Cluster Head, each node responds to other nodes in the network (CH). CH is the overall group's principal leader and is in charge of transmitting data both internally and outside. A cluster entry point is an intercluster node that may be used to contact a nearby cluster and aid in data forwarding from one cluster to another. This process of leaving one cluster and joining the next cluster is called "reaffiliation." But in the case of rapidly changing network topology, the chances of reaffiliation are high. This will increase the calculation process to identify CHs, which in turn increases network overhead. Thus, it is necessary to reduce the number of reaffiliations in VANETs. Consequently, an improved VANET clustering algorithm is required, which can reduce the number of cluster changes and improve network stability [27].

1.1. Paper Contribution. The contribution of this research article is as follows:

(i) To design a suitable vehicle communication scenario for VANET.

(ii) To present a clustering-based approach works on the weighting clustering approach, which used three different parameters, that is, the average of vehicles x coordinate, y coordinate, and average drop connection in order to enhance the performance of the VANET.

(iii) HELLO packets are used for the data transmission initialization process. This technique makes sure that an appropriate user receives the data.

1.2. Paper Organization. The rest of the paper is organized as follows: related work is covered in Section 2. Section 3 describes the overall working process, along with designed algorithms. The results and discussion are illustrated in Section 4. The brief conclusion, along with future direction, is provided in Section 5.

2. Related Work

The clustering techniques used in ad hoc networks are classified into distinct types such as zone-based, energy-efficient based, mobility-based, trust and reliable based, and many more. The hierarchy of clustering is shown in Figure 3.

2.1. Energy Efficient Clustering. Karaoglu et al. have presented a power-efficient, clustering approach for data transmission. The probability of dead node appearance is minimized with the enhanced lifetime of the network. The route is created with a minimum power level. In case the nodes required high data transmission, then high power nodes would have been used [28]. Elhoseny and Shankar have presented K-Medoid clustering-based VANET model. In addition to the K-medoid algorithm, a metaheuristic algorithm named as Enhanced Dragonfly Algorithm has been used [29]. Mehra et al. have presented a clustering-based routing in addition to OLSR for VANET with an outstanding data dissemination rate. Also, the algorithm performed better in terms of latency with minimum overhead. For cluster formation, the vehicles used information like GPS and speed [30]. Toutouh et al. have used to resolve the issues related to the power consumed by the OLSR routing protocol in VANET. Using a parallel evolutionary algorithm, an optimal route that required minimum energy is determined [31]. A number of researchers have been performed to minimize energy consumption while utilizing OLSR as a routing approach. Ghanem et al. [32] and Azzuhri et al. [33] have used MRPs as a selection criterion to select the route based on the remaining energy of the nodes. Also, in De Rango and Fotino [34], the route is determined based on the remaining energy level of the intermediate nodes.

2.2. Zone-Based Clustering. In this approach, the clustering has been done according to the geographical area, and a number of researchers have used this approach for data transmission. Lin et al. have presented a new approach to model VANET structure from the large database of moving objects through the V2V communication protocol [35]. Ali and Sankar have used a zone-based clustering approach in addition to the Ant Colony Optimization (ACO) approach, which results in improved performance of VANET [36].

2.3. Mobility-Based Clustering. Research in recent years has shown that mobility-based clustering algorithms perform better with increased stability of clusters. The direction of movement, the density of vehicles, relative speed, relative distance, etc. are considered as mobility measurements, in addition to Received Radio Strength (RSS).

Ren et al. have presented a novel mobility-based clustering approach for an urban area. The metrics, such as the direction of vehicle movement, position, and the active state of connection, have been considered. For cluster formation, the information such as unknown node (UN), CH, CM, and temporary CH is used [24]. Chen and Yang have presented a mobility-based approach to increase the VANET stability. The selection of CH has been performed by considering the direction, speed, and the position of vehicles [37]. Girinath and Selvan have used a novel cluster-based approach, in addition to the mobility model, to solve the vehicle congestion problem. Random waypoint and group mobility analogy have been performed to design a new cluster-based approach. In addition to this, the Location-based Multipath Flooding (LMF) algorithm has been used to establish long-term connectivity with improved data delivery rate [38]. Table 1 shows the relative comparisons of several clustered based routing systems.

3. System Model

In this section, the step by step description of the proposed work, along with the designed game theory algorithm, is discussed. The game theory method enables a sensor to choose between two courses of action, that is, entering the game and sending a message or remaining out of the game, hence increasing the effectiveness of VANET. Game theory is used as an optimization method, and the possibility of a node becoming a cluster leader is altered based on the remaining energy, enabling clusters to exist longer. To address the issues raised above, we formulated a series of algorithms for evaluating redundant data in VANETs by forecasting each node's cluster head updates.

The designed model is performed in three steps. First, the entire area is divided into several groups, each composed of a number of vehicles [39]. Secondly, the selection of centroid and then CH based on certain metrics is performed. Finally, the route is created using HELLO packets, and data is transmitted successfully from the source vehicle to the destination vehicle [29, 40].

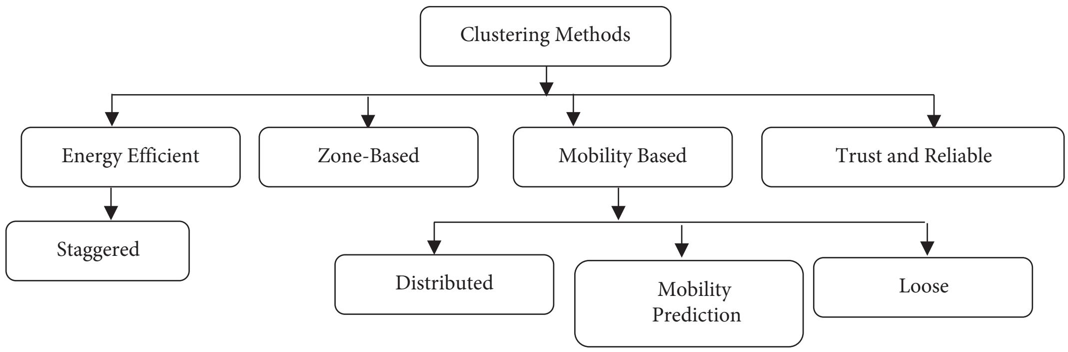

FIGURE 3: Classification of clustering.

TABLE 1: Comparison of routing protocols for VANET.

Technique	Speed	Cluster life	Bandwidth	Feasibility	Scalability	Vehicle density
Scalable reliable datagram	High	Medium	High	Medium	Medium	High
Coin	Medium	High	Low	Medium	Low	Medium
Augmented tree-based routing	High	High	High	High	High	Medium
C-VANET	High	Medium	High	Medium	High	Low
FTL	NA	High	High	High	High	Low

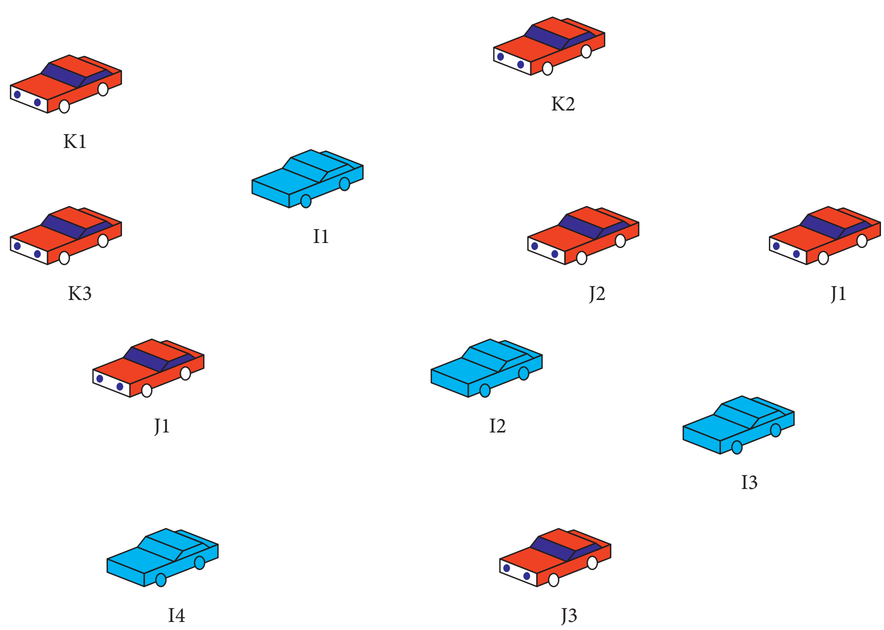

FIGURE 4: Deployed network.

3.1. Network Deployment. Initially, the network is designed using 200 vehicle nodes. The topology of the network is scanned using a city map, and the development of the vehicle is linked to the road and the traffic congestion conditions. An example of deployed vehicles is shown in Figure 4.

The nodes are deployed with their x and y coordinates along with the information like a drop packet rate.

3.2. Cluster Formation in Network. Let us consider that vehicles enter into the designed network one by one with a predefined speed. Moving vehicle broadcasts beacon messages in a certain time slot. As per our consideration, the CH should be selected with minimum weight, which is the average of the three metrics as defined above. The network's design is reactive, with node linkages joining and detaching often due to its high mobility. This shows that if the traffic will be slow, the clustering will be more efficient than the clustering with high speed. This is because of the mobility in Vehicular Network; as fast as the vehicle will move, the probability of leaving a cluster and finding a new cluster will increase. Thus, the number of clusters at high speed highway will increase. Therefore, we elect a node as CH as the vehicle closest to the central geographical position of a cluster so that the nearby vehicles devote more time to get out of the cluster. Therefore, the cluster is considered more stable.

Cluster formation is done by considering the three below parameters:

First CH_$P1 = n$.get avg (x)
First CH_$P2 = n$.get avg (y)
First CH_$P3 = n$. get avg drop

The CH selection is made about 10% of the total number of vehicles. Therefore, total CH in a network is given by

$$CH\left(J_c\right) = \frac{N \times 10}{100}, \quad (1)$$

where *Jc* is the total number of cluster heads, and *n* is the total number of vehicles.

Based on the above-defined factors, the rest of $(p - 1)$ is calculated as

$$\begin{aligned} \text{Rest}\,(p-1)J_c, r\,J_c &= J_c - 1, \\ r\,J_c! &= 0. \end{aligned} \quad (2)$$

Now, during the selection of cluster centroid, remove those vehicles having values less than $P1$, $P2$, and $P3$.

Therefore, the rest of the CH's metrics are calculated, and the values of $P1$, $p2$, $p3$ are modified as follows:

$$\begin{aligned} \text{Res}\,CH\_P1 &= n.\text{get avg}\,(x), \\ \text{Res}\,CH\_P2 &= n.\text{get avg}\,(y), \\ \text{Res}\,CH\_P3 &= n.\text{get avg drop}. \end{aligned} \quad (3)$$

In Algorithm 1, the entire work can be written as follows:

After deploying the nodes, the average of *x* coordinates, *y* coordinates, and drop data rate of each vehicle is calculated. If the vehicles having average values of the above-mentioned metrics are less, they are removed from the process of cluster head (CH) formation. In the same way, the average parameters for the remaining vehicles are calculated until our requirements are met. For example, if we want five centroids in a network, then the process is repeated, that is, the above-defined process, until the formation of five centroids in a network.

After centroid formation, the next step is to elect CH for each centroid, and the creation of CH has been performed based on the Euclidean distance from the vehicle to the centroid. The process of CH formation through pictorial representation is shown in Figure 5. The entire area in VANET is a two-way path, and each route is divided into multiple groups composed of different vehicles. Initially, it is assumed that all the vehicles have predefined knowledge of cluster metrics. The vehicle must become as CH having minimum Euclidean distance from vehicle to centroid.

In the VANET, each vehicle enters into the cluster with a unique ID, and the formation of the cluster along with the cluster edge is shown in Figure 5. In any case, if the vehicle moves from one cluster to another one, then it automatically becomes a member of that cluster. It also intimates the CH of that cluster by sending the HELLO packet.

LT represents the minimum average weight calculated using (5), and based upon that, CH (I1) and CH (K1) are elected as CHs for cluster 1 and cluster 2, respectively.

3.3. CH Selection.

Each vehicle that comes in the range of predefined clusters must calculate the minimum and maximum power of vehicles as a member of clusters in the centroid. Then, calculate p_1, current, p_2, current and p_3, current using equation (2), equation (3), and equation (4). The values have been calculated for each cluster member in the current cluster, and the node is having a minimum average value of three parameters p_1, current, p_2, current, and p_3, current considered as CH for that cluster.

3.3.1. The Social Score.

The social score is actually the feedback of the nodes based on the simulation results in contrast to other nodes in the same region. In addition to the Euclidian distance, delay and throughput are also incorporated for the calculation of the social score. The aim is to minimize the Euclidian distance along with energy consumption and maximize the throughput. Hence, social score is defined as

$$\text{Social}_{\text{Score}} = f_{\text{minmax}}\,(E, e, t), \quad (4)$$

where *f* is the fitness function for the social score, *E* is the Euclidian distance, *e* is the energy consumption, and *t* is the throughput.

As all three variables are of different units, it is necessary to neutralize them. In order to neutralize them, the proposed algorithm uses the Critic Method (CM) [38].

The method neutralizes the values by subtracting the minimum value of the lot followed by the division of the difference of max and min value of the lot. CM can be represented as

$$CM = \frac{x - X\min}{X\max - X\min}. \quad (5)$$

After neutralization, f is evaluated as follows: $f = \int_{t1}^{t2} \sum_{0<i\leq nj<n} \max\left(tnz + \left(1/\left(Enz + enz\right)\right)\right)$, where $t1$ and $t2$ are time intervals between the checkpoints, tnz is the normalized throughput, *Enz* is normalized distance, and *enz* is normalized energy consumption. The highest *f* containing node is selected as CH.

3.3.2. Dimension Reduction in for Clustering the Data.

Principal component analysis is utilized to process data in this study. Principal Component Analysis is one of the most widely used linear dimension reduction techniques (PCA). It

Start
Deploy nodes, initialize attributes
Total CH $(J_c) = N \times 10/100$
First CH_$P_1 = n$.get avg (x)
First CH_$P_2 = n$.get avg (y)
First CH_$P_3 = n$. get avg drop
Calculate rest
$(p-1)Jc, rJc = Jc - 1$
While $rJc! = 0${Remove nodes having values less than $P1, P2, P3$}
Res CH_$P_1 = n$.get avg (x)
Res CH_$P_2 = n$.get avg (y)
Res CH_$P_3 = n$. get avg drop
$rJc_= rJc - 1$
End
Foreach
Veh in vehlist
$V_p = [x, y, \text{drop}]$
Calculate Euclidean distance from the vehicle to the centroid
For each I in vehicles
E_d. Append $(E_{cl}\ [V_p, \text{CH}_2])$
End
Calculate min $E_d \longrightarrow$
Append I to cluster
For each member in the cluster
$m_a V = \max . P1$
Min $v = \min \int_0^t p_1$
Where t is the total no. of centroids in clusters
$P_1\text{current} = P_1\text{current} - \min V/\max V + \min V$,
$P_2\text{current} = P_2\text{current} - \min V/\max V + \min V$,
$P_3\text{current} = P_3\text{current} - \min V/\max V + \min V$,
Therefore $W = P_1 + P_2 + P_3/3$.
Select min $(W) \longrightarrow$ Assign as CH
Stop

ALGORITHM 1: Centroid selection.

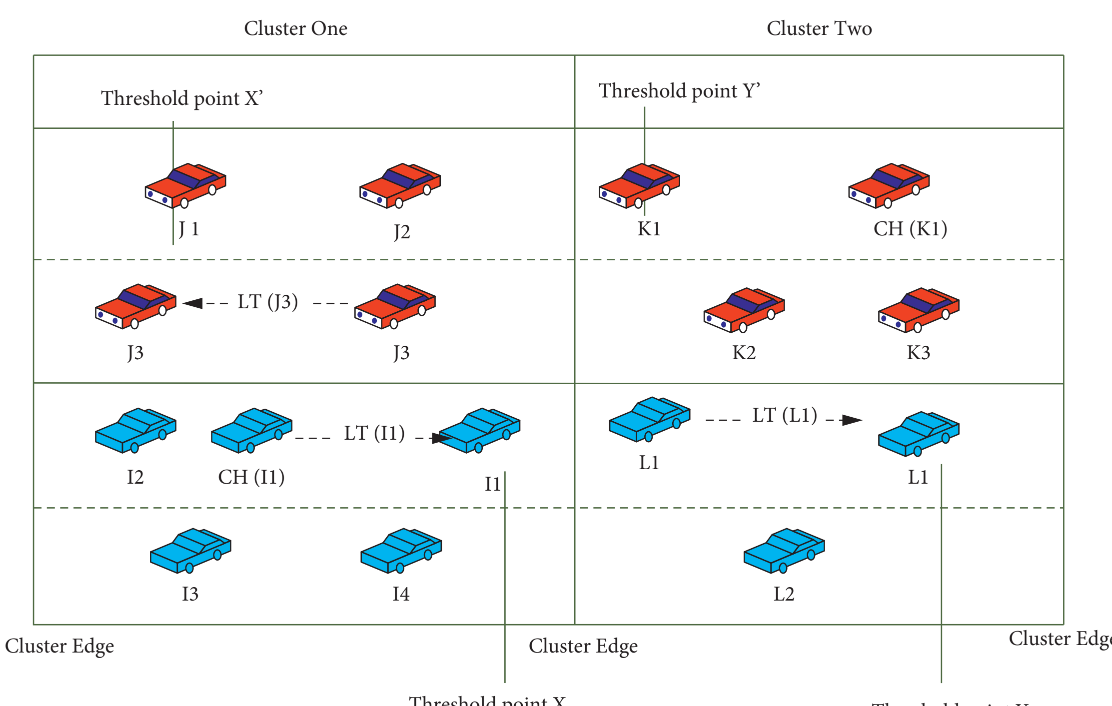

FIGURE 5: Cluster formation.

can be utilized as a stand-alone solution or as a jumping-off point for additional dimension reduction methods. Data is transformed using the PCA method by projecting it onto a set of orthogonal axes. The following methods are taken to minimize the dimensionality of smart meter data:

(i) Step 1: smart meters are used to capture all data
(ii) Step 2: create the covariance matrix
(iii) Step 3: convert the original data to mean cantered data in step three
(iv) Step 4: if the reconstruction loss is less than the dimension reduction, go to the next step

We will specify basic PCA parameters that will be utilized for simulation to make things simple. The correlation coefficient ranges from 0.75 to 0.98.

3.3.3. Game Theory Approach. As an optimization process, game theory is employed, and the likelihood of a node becoming a cluster leader was changed based on residual energy, allowing clusters to live longer. To solve the aforementioned difficulties, we developed a set of methods for analyzing data redundancy in VANETs by predicting each node's cluster head updates, as illustrated in Figure 6. When the topology of a VANET changes radically, and the network structure is significantly deteriorated, the aggregation performance of the cluster suffers. When a cluster enters the cluster reconstruction stage, the original cluster head sends a "Next round" message to all of its cluster members, informing them that the cluster head selection process has been restarted.

3.4. Route Creation. The route between the source node and the destination node is created, that is, the well-known Ad Hoc On-Demand Distance Vector (AODV) protocol. It is a well-known on-demand routing approach used to create routes only when required by the vehicles.

Figure 7 shows the routing process using the AODV routing protocol. AODV mainly follows three steps:

(i) Cluster Formation
(ii) Cluster Maintenance
(iii) Clustered Routing.

In VANET, the ad hoc on-demand distance vector (AODV) is the most utilized topology-based routing protocol. AODV is the reactive type of routing protocol in which the route from source to destination is established when it requires so. The process of route discovery is based on the query as well as a reply for this query that is utilized to decide about routing. The routing table is stored by all intermediate nodes that composed the information about the route. Some control packets are used by AODV while performing the process of routing. To determine the route to another node, a node broadcasts a routing request message (RREQ). The intermediate node that contains information about routing replies with a routing reply message (RREP). The route error message (RERR) is used to notify different nodes regarding the loss of the link. To detect and monitor the links to its neighbors, the HELLO message is utilized by each and every node. The entire network is flooded by AODV during the process of route discovery, including a large number of control packets by which it can find a number of unused routes among source and destination. Because of the reason for routing overhead, consumed bandwidth, including the node power, is the major drawback of AODV.

As shown in Figure 8, the vehicle with ID ($I3$) behaves as the source node, as indicated by the yellow color. The source node broadcasts a beacon message to its nearby vehicles, such as $I4$, $I2$, and CH ($I1$). The network is quiet in AODV until a link is established. At that time, the central node that requires a connection sends a request message. Other AODV nodes relay this signal and record the node from which it was received, resulting in a torrent of transitory routes back to the needed node. As the source vehicle is in the range of CH, therefore, it directly sends data to Ch instead of $I4$ and $I2$. Now, CH passes the message to its nearby vehicles as $J3$, $I3$, and $I1$. Since $J3$ is in the direction of the destination node, therefore, Ch sends data to $J3$ instead of the other two vehicles. In this way, the route is created between the source and the destination.

4. Results and Discussions

This section covers the overall computed results after the execution of the proposed work. The simulation environment for the proposed work is listed in Table 2.

The performance of the designed model has been investigated in terms of energy consumption, packet delivery ratio, throughput, and network lifetime. The performance has been examined in MATLAB simulator, and the computed results are discussed in this section.

4.1. Computed Parameters. Throughput: it is defined as the total packets delivered successfully over the communication channel. Packet Delivery Ratio (PDR): it is defined as the rate of the total number of packets delivered to the destination vehicles to the number of packets transmitted by the source vehicle. Energy Consumption: it is the total energy consumed by the vehicles either in an ideal state or in a communication state.

The computed parameters for throughput are shown in Table 3.

The throughput analyzed for the proposed and the existing work is shown in Figure 9, indicated by the orange and blue bars. From the graph, it is clearly seen that, with the increase in the number of vehicles in the communication network, the throughput rate, that is, the rate of successful transmission of packets, increases.

The maximum and minimum throughput using the proposed work have been examined as 14253 kbps and 8248 kbps, which are observed when the number of vehicles is deployed as 50 and 350, respectively.

The average throughput examined for the proposed and the existing works is 10704.10 kbps and 8345.14 kbps, respectively. Therefore, the enhancement in

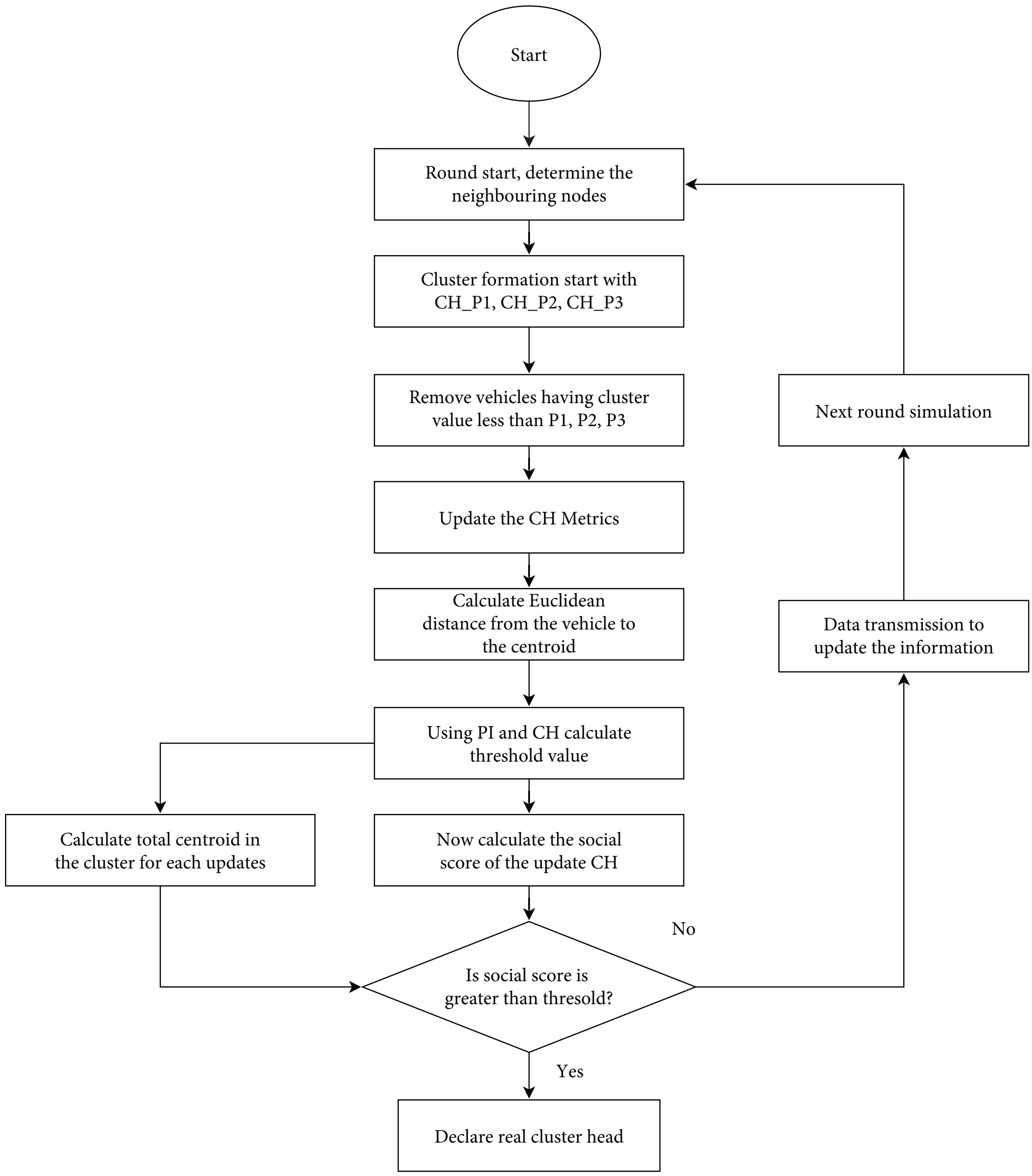

Figure 6: Game theory-based VANET cluster.

throughput can be calculated as ((10704.10 − 8345.14/8345.14) × 100) = 28.27% against the existing work performed by Elhoseny and Shankar [29].

Table 4 shows the PDR value at different numbers of vehicles using the game theory approach techniques stated above.

The PDR examined with various vehicles deployed in the designed network are 50, 100, 150, 250, 300, and 350 as shown in Figure 10. From Figure 10, it is clearly seen that, with the increase in the number of vehicles, the PDR decreases. The average value of PDR examined for the proposed work and the existing work is 89.27% and 73.84%, respectively. Therefore, the percentage increase is calculated by ((89.27 − 73.84/73.84) × 100) = 20.9% against the existing work performed by Elhoseny and Shankar [29]. This is due to the appropriate selection of centroid and the CH using a novel cluster formation process, as discussed in Section 3. Also, using AODV as a routing approach, the data is transmitted with a higher rate.

The network life of the system increases significantly by 1-2% using the proposed game theory-based approach. Table 5 shows the and compares the network lifetime for different scenarios.

The network lifetime analyzed for the proposed and the existing work is shown in Figure 11. Network lifetime is used to measure the timespan of sensor nodes deployed on the vehicles that are responsible for data communication. Each sensor node is powered with the battery, and it is essential that these nodes

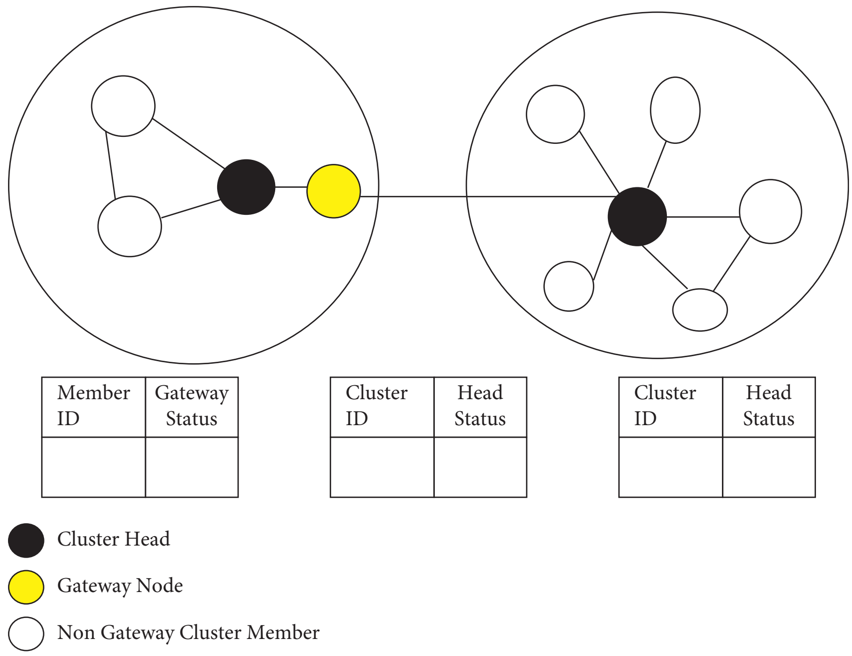

Figure 7: Routing process using AODV.

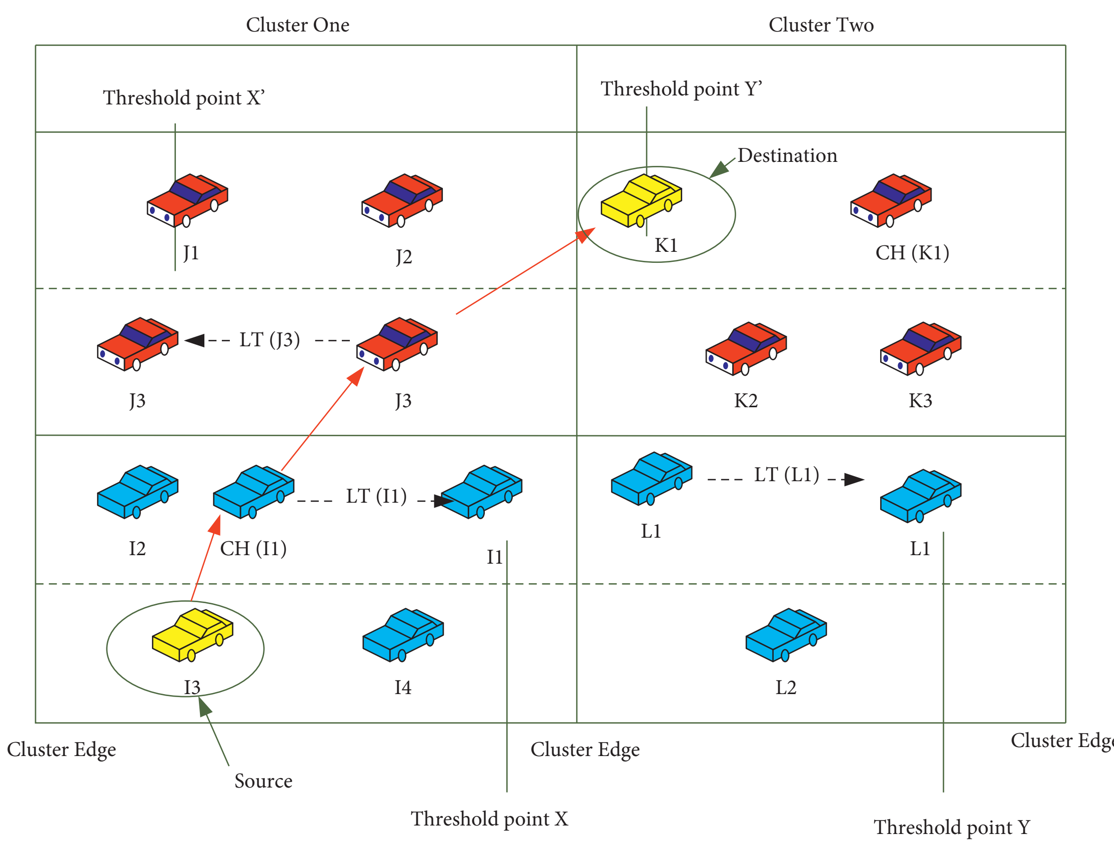

Figure 8: Route creation using AODV.

consume less power and hence increase the lifetime of the network. Here, the network lifetime is measured in days. The network lifetime measured for different vehicles is 50, 100, 150, 200, 250, 300, and 350. Figure 11 shows that the minimum lifetime of the network is observed at 50 vehicles, and the maximum lifetime is at 350 vehicles. Also, the comparison between the proposed and the existing network lifetime is represented by the orange and the blue bars, respectively. The

Table 2: Simulation environment.

Parameter	Values
Environment	Highway
Dimension	1000 ∗ 1000
Simulation time	300 s
Vehicle's speed	60 km/h and 120 km/h
Packet size	300 bytes
A time slot of sending hello message	3 s

Table 3: Throughput.

Number of vehicles	Existing [37]	Proposed
50	10547	14253
100	8247	12453
150	8045	11362
200	8115	10487
250	8012	9785
300	7825	8341
350	7625	8248

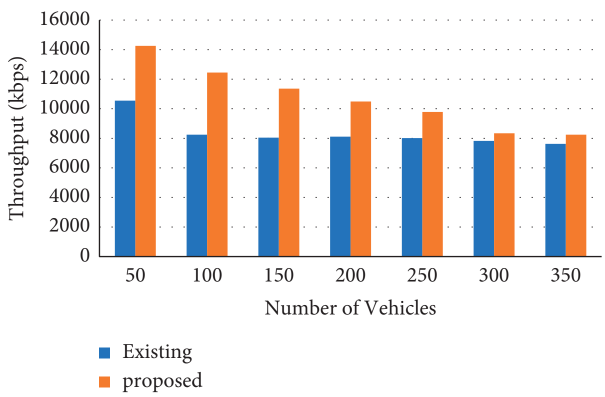

Figure 9: Throughput.

Table 4: PDR (%).

Number of vehicles	Existing [37]	Proposed
50	92.75	97.57
100	89.64	95.26
150	78.44	93.17
200	69.78	91.36
250	65.24	84.71
300	61.79	82.67
350	59.24	80.15

average network lifetime examined with proposed and existing work is 13.42 days and 10.9 days, respectively. Thus, the percentage improvement using a novel clustering approach compared to the existing k-medoid approach has been obtained as $((13.42 - 10.9/10.9) \times 100) = 23.12\%$. The most significant achievement of the proposed game theory-based approach for VANET cluster formation is the energy consumption. As shown in Table 6, almost more than 40% of the energy is saved.

The energy consumed by the communicating vehicle is shown in Figure 12. The energy-saving plays an important role in the ad hoc network. From the graph, it is seen that

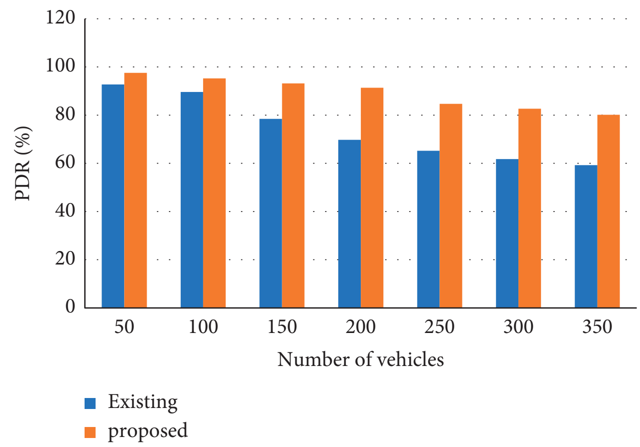

Figure 10: PDR.

Table 5: Network lifetime (day).

Number of vehicles	Existing [37]	Proposed
50	10	11
100	9.2	10
150	9.5	12
200	10.5	13
250	11.2	15
300	12.4	16
350	13.5	17

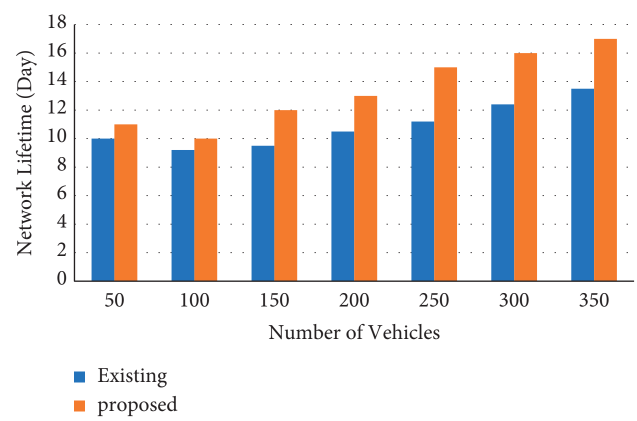

Figure 11: Network lifetime.

Table 6: Energy consumption (J).

Number of vehicles	Existing [37]	Proposed
50	189	44
100	156	51
150	227	57
200	220	62
250	235	68
300	248	73
350	297	85

using a novel clustering approach with AODV routing, the energy consumed by the vehicles is less compared to the existing approach. This is due to the appropriate selection of CH, and hence, the vehicles pass the data to an appropriate

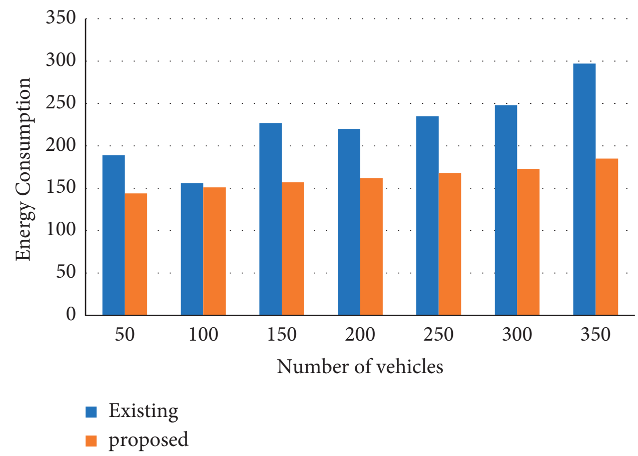

FIGURE 12: Energy consumption.

TABLE 7: Comparative analysis.

"Nodes"	"Throughput proposed"	"Throughput Fahad and Ali [41]	"PDR proposed"'	"PDR Fahad and Ali [41]	"PDR Zhang et al. [42]	"Delay in seconds proposed	"Delay in seconds Fahad and Ali [41]	"Delay in seconds Zhang et al. [42]
50	11075.8687	10319.772	0.83086361	0.7519525	0.79280903	10.5456838	10.8825214	11.539072
70	10209.7077	10248.8188	0.83862655	0.7715402	0.83805761	10.7828892	11.1100601	11.6675194
90	11728.2835	11605.4077	0.85213864	0.81200701	0.81651534	10.9335062	11.2511064	12.0192904
110	10224.5577	9646.89438	0.85693297	0.85604239	0.78876913	11.1374073	12.3436572	12.3613088
130	11374.1389	10025.2036	0.8660448	0.8611037	0.83976989	11.3886717	12.6642022	12.6708958
150	12072.1588	10638.6879	0.88301788	0.87454231	0.84673397	11.5815243	12.3520838	12.3308957
170	10989.1103	10710.2612	0.88710949	0.88101555	0.87647971	11.7475442	13.0796477	11.9521481
190	10246.2409	11371.2247	0.89839866	0.80923518	0.88947951	11.9236814	12.8590178	12.1738079
210	10329.2591	10554.3785	0.91341884	0.87319205	0.82954678	12.1060308	12.7148412	12.482815
230	10728.1846	10032.2312	0.91782701	0.87589758	0.85656116	12.3540249	13.4453951	13.161371
250	11786.9808	10890.6607	0.92944254	0.88182792	0.91591083	12.5468718	13.7327582	13.230415
270	11146.0327	10787.8463	0.94107322	0.92868252	0.88947902	12.7975811	13.6671549	13.700376
290	11105.7217	11273.5427	0.95024957	0.89110205	0.92091153	12.9048078	14.3206725	14.0997648

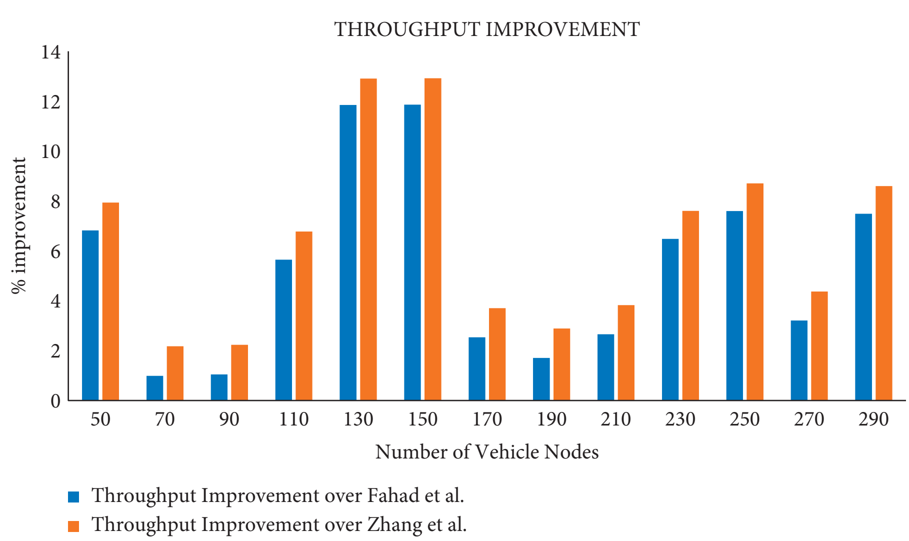

FIGURE 13: Throughput improvement analysis.

vehicle. As the number of vehicles is less, energy consumption is also minimum. With the increase in the number of vehicles, the rate of using power is also increasing, as shown in Figure 11. The average value of energy consumption analyzed using a novel clustering approach with the existing approach is 224.57 J and 162.85 J, respectively.

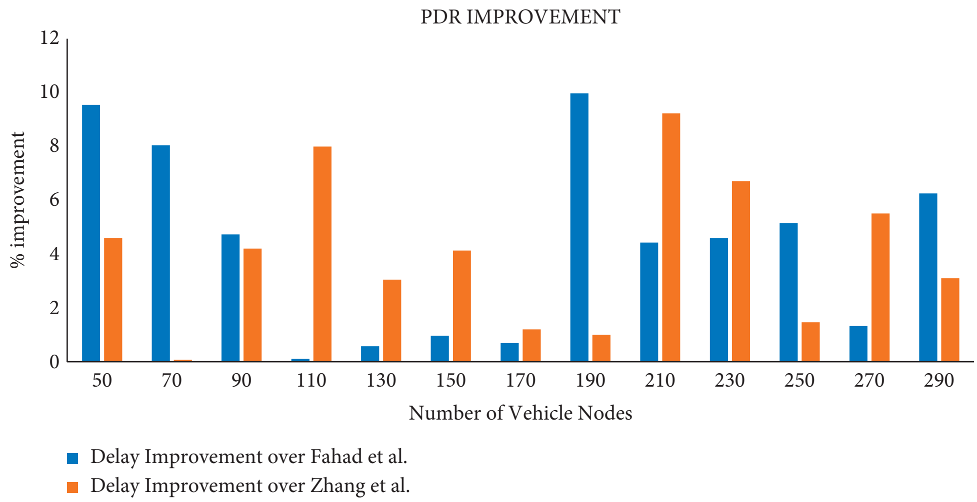

Figure 14: PDR improvement analysis.

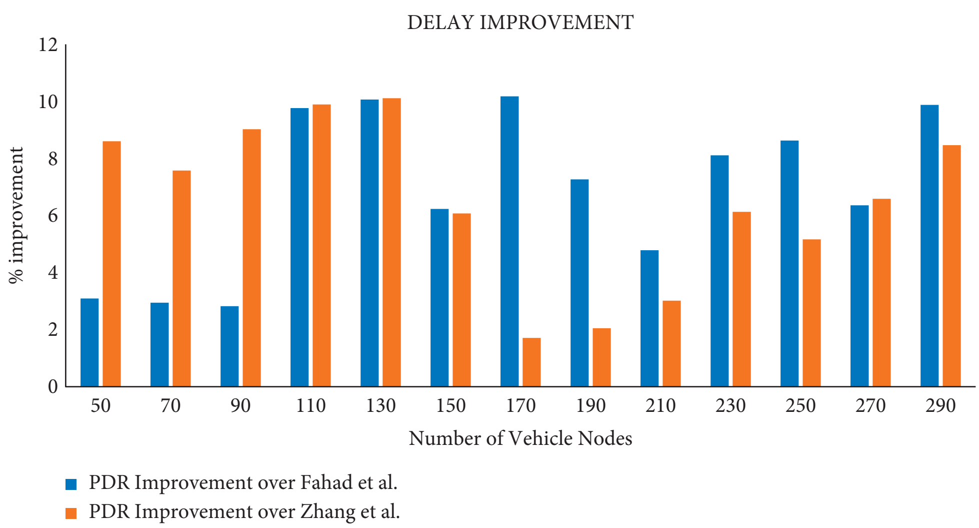

Figure 15: Delay improvement analysis.

Therefore, the energy-saving of about $((224.57 - 162.85/224.57) \times 100) = 27.48\%$ has been achieved.

With safety and entertainment applications, the potential utility of VANETs in the future intelligent society is unpredictable. New car applications have lately arisen in a variety of fields, including navigation safety, location-aware content delivery, commerce, and games. As a result, we feel that VANETs are worthy of further investigation and development and that there will be more applications and research findings in the future. Architecture: the design of an integrated system architecture that can leverage many distinct technologies (e.g., 3G/4G/5G) and heterogeneous vehicular networks will be a major research challenge in vehicular ad hoc networks in the future. As a result, we feel that VANETs are worthy of further investigation and development and that there will be more applications and research findings in the future. Although current algorithms have provided some solutions to specific data dissemination difficulties in VANETs, due to the unique characteristics of VANETs, it is still difficult to assess their performance and security. The end-to-end communication path, for example, may not exist due to nonpersistent network connections.

4.2. Discussion Related to Performance. To check and validate the results, some more parameters are used for testing and validation. These parameters are as follows:

(i) Throughput: it is defined as the total packets delivered successfully over the communication channel.

(ii) Packet Delivery Ratio (PDR): it is defined as the rate of the total number of packets delivered to the destination vehicles to the number of packets transmitted by the source vehicle.

(iii) Delay: it is the observed delay in seconds in the receiving of the data packets at the destination end.

To evaluate the performance of the proposed algorithm, throughput, PDR, and network delay have been utilized with increasing node and deployment zone scenario.

The results have been formed by keeping the node in a varying architecture where, after every interval, 10–50 nodes have been increased to check the effect of the performance. The ordinal measures are illustrated as follows.

The testing of the proposed work is performed against two existing works, and the outcomes in terms of throughput, PDR, and delay are summarized in Table 7. The proposed work is further evaluated in terms of % improvement observed over the two existing works for each of the parameters under study. The improvement analysis for throughput is illustrated in Figure 13, which shows that the average % improvement of 5.38% is observed over Fahad and Ali [41] and 6.51% over Zhang et al. [42].

The improvement analysis shown in Figure 14 shows the % improvement exhibited by the proposed work over the existing works when the number of vehicles increases in the network. The % improvement for the PDR observed over Fahad and Ali [41] is 4.31% and that over Zhang et al. [42] is 3.99%.

The proposed work is also validated for the overall network delay. The improvement analysis shown in Figure 15 shows that the proposed work exhibited relatively lower delay when the number of vehicles is increased in the network. The improvement analysis shows that the average improvement of 6.93% and 6.49% is observed for the proposed work over Fahad and Ali [41] and Zhang et al. [42], respectively.

5. Conclusion

Based on much-needed research on routing schemes for classical base MACs and VANETs, in this research, a novel and stable clustering algorithm based on mobility was proposed. The game theory technique allows a sensor to choose between two actions, that is, entering the game and transmitting a message or staying out of the game, making VANET more effective. The scheme works on the concept of automatic selection of centroid using an average of three attributes (x coordinates, y coordinates, and packet drop), and the election of CH has been performed using Euclidean distance. The algorithm discovered best clusters that minimize the distance from the beginning of each CH to the cluster members using an average weight mechanism. The clusters created are stable, and there is a long average cluster member, along average cluster head time, and a low average rate of cluster head change. The results are simulated by deploying nodes in various numbers such as 50, 100, 150, 200, 250, 300, and 350. The performance has been evaluated in terms of throughput, PDR, network lifetime, and energy consumption. Also, to show the improvement in the proposed work, a comparison between the proposed work and existing work has been performed. Therefore, the performance of throughput, PDR, network lifetime, and energy consumption has been increased by 28.27%, 20.9%, 23.12%, and 27.48%, respectively.

Data Availability

Data is available upon request.

Conflicts of Interest

The authorsdeclare that they have no conflicts of interest.

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