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Retraction

Retracted: Enhancing Vehicular Ad Hoc Networks' Dynamic Behavior by Integrating Game Theory and Machine Learning Techniques for Reliable and Stable Routing

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This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article. Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] N. Phull, P. Singh, M. Shabaz, and F. Sammy, "Enhancing Vehicular Ad Hoc Networks' Dynamic Behavior by Integrating Game Theory and Machine Learning Techniques for Reliable and Stable Routing," *Security and Communication Networks*, vol. 2022, Article ID 4108231, 11 pages, 2022.

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Research Article

Enhancing Vehicular Ad Hoc Networks' Dynamic Behavior by Integrating Game Theory and Machine Learning Techniques for Reliable and Stable Routing

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VANETs (vehicular ad hoc networks) have evolved as a platform for enabling intelligent inter-vehicle communication while also improving traffic safety and performance. VANETs are a difficult research topic because of the road dynamics, high mobility of cars, their unlimited power supply, and the growth of roadside wireless infrastructures. In wireless networks, game theory approaches have been widely used to investigate the interactions between competitive and cooperative behavior. In this research, we propose a technique for vehicular ad hoc networks that uses a game theory approach to automate vehicle grouping and cluster head nomination. This will eliminate the need for cluster reformation on a regular basis. Furthermore, each vehicle's social behavior will be exploited to establish clusters in the vehicular environment. For the development of clusters on the social behavior of the cars, a machine learning approach (K-means algorithm) is applied. The proposed system is tested against a variety of characteristics, including CH life time, average cluster member life time, average number of reaffiliation times, throughput, and packet loss rate, and the results indicate that the VANET performed very well with high accuracy in validation and testing, and overall in the range of 0.97 to 0.99.

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1. Introduction

With advance in electric vehicles and Internet of Things (IoT) platform, a promising and emerging field of research has been opened in which VANETs are integrated with wireless network, global positioning technology, and different sensors for making the vehicular interaction infrastructure more reliable. The research for wireless network deployment specially for the vehicular network was started specially for the medical services, emergency information, and weather condition provided for the long highways. The increasing need for wireless communication, combined with the specifications of new wireless devices, has prompted interest in self-healing and self-organizing networks that operate independently of centralized or pre-established infrastructure/authority. There is no pre-existing or centralized infrastructure in ad hoc networks. It is a self-contained mobile node-based ad hoc network (MANET). The VANET is a critical area for improving the intelligent transportation system in order to provide road users with safety and comfort. Road users may also benefit from VANET comfort applications.

Internet access, mobile e-commerce, other multimedia applications, and weather information are just a few examples. "Crash Avoidance Matrices Partnership (CAMP), CARTALK2000, Fleet Net, and Advance Driver Assistance Systems (ADASE2)" are the most well-known applications, which were created in partnership with major automobile

manufacturers and governments. Figure 1 depicts the VANET's general operating architecture. It has 4 main communication networks as stated below:

(i) First Network: It is called vehicle to vehicle commination network. The role is to help in communication between different vehicles associated with the system.

(ii) Second Network: It is vehicle to infrastructure commination. The infrastructure can be any unit which provides different services like radio, navigation, etc.

(iii) Third Network: It is the infrastructure to infrastructure connection. Generally, it is used to provide emergency services. But it can be used according to the requirement of the area/system.

(iv) Fourth Network: It is the connection to Internet/cloud. For all the three networks, it is compulsory to connect the devices with the Internet or cloud.

From the figure, it is clear that every section of the VANET interacts with each other. The type of interaction is already stated in the above points. The best part is that all points are included in the VANET like vehicles, infrastructure, traffic, and many more. VANET is becoming an emerging trend in real-time applications to suit varied demands [1]. This is because, there is now a rush in interest in Internet of Vehicles (IoV) technology as a result of the rapid expansion of the smart automotive sectors. Because of IoV technology, vehicles may talk with public networks and respond to stimuli [2, 3]. VANET has piqued the interest of both academics and industry in the transportation sector, and it is an important and interesting MANET application. The VANET is a valuable solution for achieving improved performance and ensuring a safe transportation system in the future [4–6]. Precisely talking, VANET is a form of wireless multichip network that is limited by the requirement for quick topology changes due to high dynamic topology. Inter-vehicle communication becomes a viable subject for research, standardization, and expansion as the number of vehicles equipped with computing technology and wireless communication devices develops [7, 8].

Because a strong end-to-end link between the source and the target is mainly incomprehensible owing to its irregular scalability and sporadic network availability, VANET connects precisely defined steering standards [9, 10]. The VANET was used to provide wireless technology, and it was equipped with on-board units (OBUs) and used as mobile nodes. The road segments are also used with roadside units (RSUs) to offer real-time traffic and road topological information [11, 12]. The VITP-proposed push-based solution sends alert messages to motorists approaching the afflicted area. When a vehicle detects such a situation, it generates an alert message and sends it via the VANET [13, 14]. The VANET is a self-manageable and self-configurable network that allows a large number of cars to be connected over a few hundreds of meters, forming a network.

It should be noted that, given the importance of AI in IoV because it provides smart models in the majority of its applications, this study provides a brief overview of one of the AI approaches known as machine learning and the possibility of its use in many specific elements connected to the IoV network [15, 16]. Communication occurs between nodes in ad hoc mode, but communication occurs with the roadside in infrastructure mode. The following are some of the properties of VANET that distinguish it from other ad hoc networks:

(1) Network Topology: The position of nodes moves often due to high node mobility and varied vehicle speeds. As a result, the VANET architecture changes on a frequent basis.

(2) Rapid Mobility: In a VANET, nodes often move at a high rate. The speed variation is the cause of frequent disconnection and topological changes. The mesh in the network is hampered by the fast speed of the cars.

(3) Wireless Communication: The VANET was intended to be used in a wireless environment. The nodes are linked together and communicate wirelessly.

(4) Sufficient Energy: The VANET nodes do not have a problem with computed resources or energy. This enables VANET to use difficult techniques like ECDSA implementation and RSA, as well as give infinite transmission power. The VANET provides extensive storage and power, removing one of the key concerns of previous ad hoc networks [17–20].

(5) Improved Physical Security: As a result of VANET node physical security, physically compromising VANET nodes and minimizing the impact of infrastructure assaults have become more difficult.

(6) Frequent Information Exchange: The ad hoc nature of VANET encourages nodes to gather data from other vehicles and roadside infrastructure. As a result, information exchange between nodes has increased.

(7) Unbounded Network Size: The VANET can be constructed for a single city, a group of cities, or a whole country. The scale of a VANET is not limited by geography.

(8) Communication Types: In addition to multicast and unicast communication, the VANET also allows communication to specified geographical regions for packet forwarding, which is frequently required for safety applications.

(9) Delay Constraint: Some applications require timely delivery of messages in order to become meaningful. In the event of an accident, for example, information should be shared rapidly so that other nodes can make appropriate decisions or change routes in a timely manner. The maximum delay will be critical in such cases [21, 22].

(10) On-Board Units: The nodes are imitated with on-board units that aid in the transmission of information for routing purposes. The availability of the

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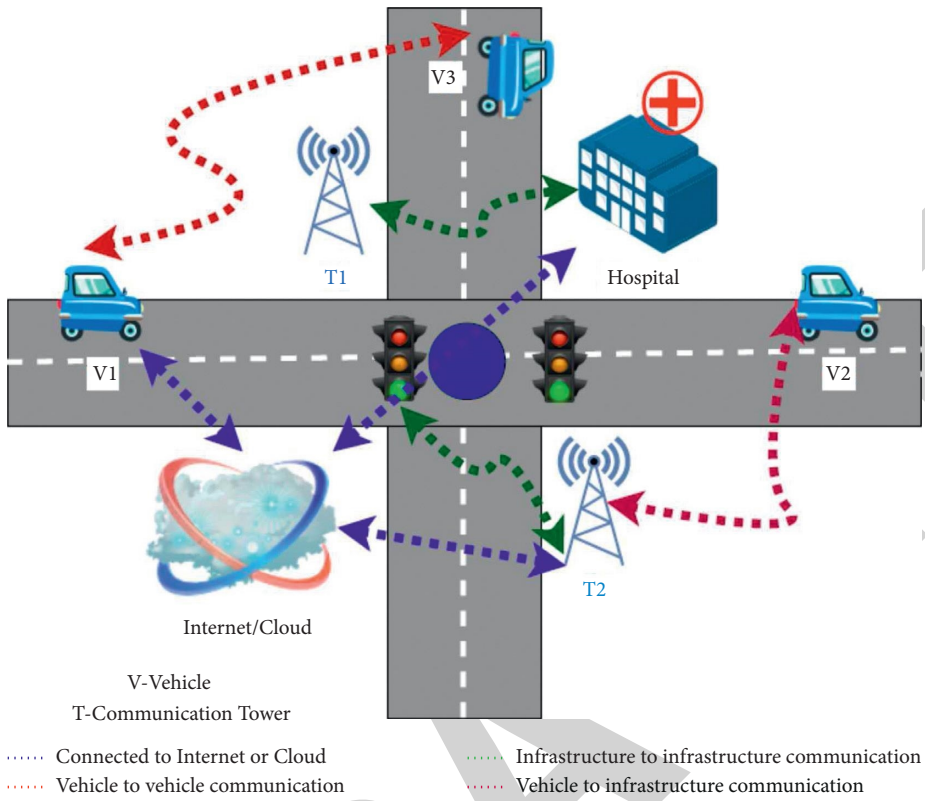

Figure 1: Vehicular ad hoc network architecture.

Global Positioning System (GPS) and the determination of speed in vehicles offer location information. Furthermore, GPS and GPS-based navigation systems provide information regarding road topology and traffic, allowing the driver to choose an absolute route [23, 24].

(11) Dynamic Topology: The increased mobility of vehicles causes topology to alter regularly. The behavior of the driver and the substance of the message make up the transit topology. Because of their dynamic and unpredictable character, connection times are brief, especially when they are traveling in opposite directions [25, 26].

All these characteristics make the VANET an extraordinary architecture which can be implemented in the complex network. Now in the next section, we are going to highlight some research and development on VANET with their statistical data.

The concept of the "Internet of Vehicles" is a game changer that is propelling the VANET forward in related industries. The Internet of Autos emerged from the classic VANET, which is a network of many things that allows for real-time communication, such as automobiles, people, roadways, parking lots, and municipal infrastructure. Infotainment systems, sensors, brakes, and GPS are among the devices used. Vehicle communication and interconnection advancements are in high demand. Automobiles, as they evolve into sentient entities, are becoming an increasingly important component of smart cities. The Institute of Vehicles develops sensor platforms for automobiles that collect data from the environment, other vehicles, and the driver. At every level, efforts are being made to improve navigation, traffic control, and pollution reduction. The Internet of Vehicles (IoV) is a network of cars that communicate with one another, as well as with pedestrians, handheld devices, roadside units (RSUs), and public networks, through vehicle-to-vehicle (V2V), vehicle-to-road (V2R), vehicle-to-human (V2H), and vehicle-to-sensor (V2S) interconnection. As a result, an intelligent device network is developed. However, before we can implement the IoV paradigm, we must first construct a more resilient and trustworthy VANET.

In WSNs and VANETs, ML provides useful tools for data generation, communication, and then data exchange in vehicular networks. It also assists the network in making data-driven and informed decisions. Machine learning approaches are classified into four types: supervised learning (SL), semi-supervised learning (SSL), unsupervised learning (UL), and reinforcement learning (RL). SL is used in applications that require a large number of pre-existing datasets as well as other data, such as channel decoding and e-mail spam classification. Machine learning is assisting advanced driver assistance systems (ADAS) in the detection of undesired events and the avoidance of collisions. It is also essential in the design of networking protocols for link scheduling, vehicle routing, and handoff management. Furthermore, using variation GMM and Gaussian mixture

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models, probabilistic trajectory prediction has been shown to be beneficial in predicting the vehicle's direction based on previously detected mobility patterns.

Paper Organization: First section gives the introduction of VANET and its general operating architecture, section to present the literature review along with research challenges. Section three presents the proposed methodology. Next section illustrates the simulation results and discussion on the result outcome. And the final section of the manuscript summarizes the findings of the present work as conclusion.

2. Literature Review

This section of the paper highlights the literature survey, the outcome of the literature review, the drawback of the previous model/techniques, and the objective of this paper.

2.1. Review of Systematic Models and Techniques. A modified cluster head (CH) selection formula was presented to limit the influence of fluctuations induced by vehicle motion. This paper introduces two metrics for improving VANET security. The simulation was carried out in order to compare the system to other systems. According to the statistics, the program has a low packet loss rate and a good level of stability. Qi et al. and Jakubiak et al. [27, 28] presented SDN-enabled social-aware clustering (SESAC) in 2018 as a successful vehicle clustering technique in the 5G-VANET system because it uses a social pattern prediction model under software-defined networking (SDN) architecture. To anticipate each vehicle's social pattern, it uses a semi-Markov model, which contains the upcoming traveling path and the matching sojourn duration on each road segment. The SESAC technique is implemented using the SDN controller's global perspective and computational capacity, and it is based on a social pattern prediction model of nodes with similar future paths being grouped into one cluster [29–32]. A CH election strategy is offered to increase cluster stability by taking into account multiple network parameters such as inter-vehicle distance, relative speed, and vehicle attributes. The performance of the proposed clustering approach on VANETs is evaluated and compared to that of traditional clustering techniques. The evaluation data demonstrate the efficacy of the proposed strategy [33, 34].

In 2018, Khan et al. [35] proposed an evolutionary game theoretic (EGT) framework for VANET clustering that is stable and optimal. The net utility determines the payout of the proposed game. The utility of head is calculated by subtracting the overall throughput of the cluster from the cost function. The cost function is implemented using cluster size. Clustering has emerged as a key study issue in VANETs in order to better organize and control the network. EGT's ability to cluster vehicles into different groups has a number of advantages, including stabilizing the dynamic topology of VANETs, maximizing network resource utilization, improving routing efficiency through hierarchical routing, providing fast convergence rates with minimal overhead, and lowering power consumption. In VANETs, clustering of nodes and nomination of cluster chiefs is automated using this method [36–38]. The suggested technique is simple and semi-distributed, allowing for quicker convergence. In addition, it decreases signaling overhead and complexity in large-scale VANETs while improving cluster stability.

Their proposed framework is capable of ensuring cluster stability as the clusters evolve to optimum sizes and the system coheres on a cluster average total throughput. After demonstrating the equilibrium point analytically, the stability of the equilibrium point is verified using a Lyapunov function. Two performance evaluation approaches are used to evaluate the efficacy of the proposed game under varying populations and speeds. This paper establishes the groundwork for VANET stability and optimal clustering, but much more work remains to be done. To verify the overall efficiency of the protocol stack, the proposed EGT can be tested across different routing protocols in VANETs using a network simulator [39–41].

A machine learning system aids RSUs in maintaining road traffic information using machine learning-assisted route selection (MARS). MARS estimates vehicle movement in order to determine the chance of passing within range of other RSUs. According to these projections, packets can be routed through more appropriate routing routes. They used real-time state monitoring of urban traffic to give reference data for a VANET routing protocol. Machine learning is utilized to estimate truck movements and route transmission capacity projections for new automobile arrivals. According to their simulation results, the proposed strategy outperforms other approaches for different vehicle densities. Furthermore, changes in V2V capacity were observed to have a modest impact on MARS performance. They also showed that their proposed protocol is more dependable and efficient for data transmissions in VANETs with high mobility vehicles. As a result, by combining VANETs with the proposed machine learning system, routing performance can be greatly enhanced. Figure 2 shows the different research platforms where research articles based on VANET are published. It can been see that still the number of research is very low and needs an urgent focus to boot the smart vehicular infrastructures.

2.2. Research Challenges. From the introduction and literature survey, it is clear that VANET is still a vast research area. Increasing in vehicular communication technology, the need of VANET is going to increase by 10–12-folds in upcoming years. Although VANETs have unique qualities that set them apart from conventional ad hoc networks, they nonetheless confront a number of obstacles. The following is a list of them:

(1) Bootstrap: At the moment, only a few automobiles are wireless-enabled, and roadside units (RSUs) may not be used everywhere. As a result, even if we try to formulate communication, only a small number of automobiles will be able to receive and communicate. To boost the number, business firms must be persuaded to invest in the technology.

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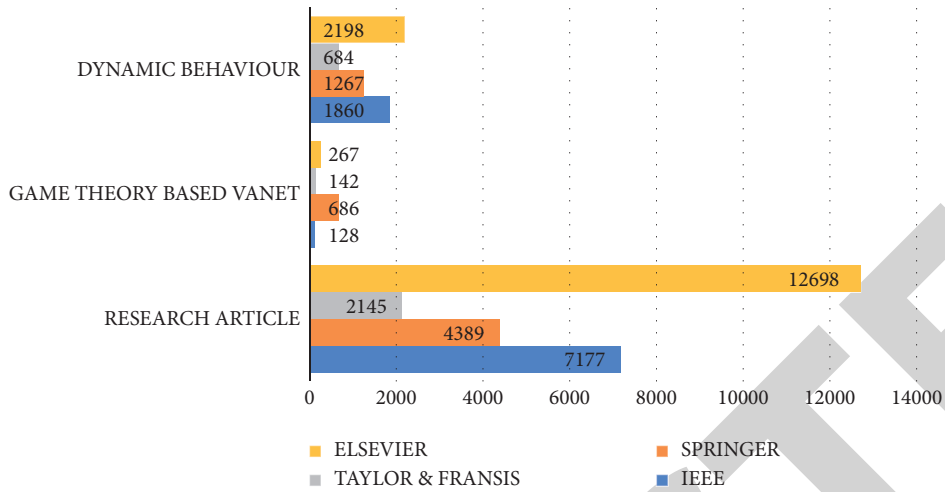

Figure 2: Research regarding VANET [till March 2022].

(2) Connectivity: VANET's distinguishing characteristic is also a difficulty. The links between participating cars get disconnected when the speed of the vehicles rises and technology changes. As a result, sufficient connectivity must be in place through the deployment of access points in order to offer constant and updated information. This leads to an increase in the number of access points deployed along the roadside, resulting in an unjustified cost increase.

(3) Fault Tolerance: Nodes may enter or depart the network at any time due to frequent topological changes. If a node leaves the network, routing protocols may need to determine new routes to keep the network running. The problem can be solved by anticipating route failure, which necessitates the transmission of a huge amount of updated data, resulting in opaque communication and high overhead [24].

(4) Hard-Delay Constraints: In some instances, such as accidents, real-time information must be transmitted to all nodes so that appropriate actions, such as alternative routes, can be taken by drivers on time. This, too, necessitates constant and dependable communication.

(5) Signal Fading: Signal strength may deteriorate owing to obstructions such as other nodes that can obstruct signal or buildings that may obstruct direct communication, such as those found alongside the road. All of these factors can cause signal fading [25].

(6) Information Security and Confidentiality: Keeping information secure is a difficult undertaking that must be accomplished. Because of the high mobility of nodes and frequent disconnections, the link between nodes can be for a shorter amount of time, and these cars may never meet again; therefore, protecting personal information about the vehicle is a key concern [25]. Furthermore, if routing protocols do not provide security, a malicious node can enter the network, abusing data and inflicting damage.

(7) Mobility: Cars with high mobility can communicate for longer periods of time or interact with vehicles they have never met before and are unlikely to meet again [26]. As a result, mobility must be imitated.

(8) Power Management: Vehicular communication must be designed so that interruptions in current transmission do not impede communication at distant nodes. As a result, in a congested network, less TX power should be used to improve energy efficiency. To improve overall throughput and reduce interferences, routing techniques should be used [27].

2.3. Objective of This Research. The objective of this research is stated in phases which are stated below:

Phase 1: Each vehicle's social parameters are initialized when the VANET is deployed.

Phase 2: Determine each node's social score in the VANET and use k-mean clustering to create vehicle groupings.

Phase 3: Initialize the cluster nodes and pick the cluster head for each cluster created in the previous step using a new technique.

Phase 4: Check the stability of cluster formation using an evolutionary game theory technique.

Phase 5: If the result converges, move to the next step; otherwise, go to step 4.

Phase 6: With the help of RSUs, route the packets in this step.

Phase 7: The packet is transmitted to the next node (destination); if it arrives, calculate the average CH lifetime, average cluster member lifetime, average

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number of reaffiliation times, throughput, and packet drop rate.

3. Proposed Methodology

This section discusses the modeling of the proposed system architecture.

3.1. System Architecture. In this paper, the system architecture is shown in Figure 3. There will be 4 types of communication system as shown in Figure 1. By using these two information, the overall system is model which has source vehicle, hop vehicles, and the infrastructure.

3.2. Game Theory for VANET. Every interactive device has its social characteristics with the surrounding environment. A different research has been done to study these social characteristics which are present in this universe in different systems. Dealing with network clustering again is a part of social networking among the similar/nonsimilar devices. A cluster group is considered social if the average clustering coefficient of the group is higher than its graph-based construction mapping. For getting the social parameters and score of the cluster first the cluster formation is required.

In this proposed method, game theory approach is used to form the cluster. To form the cluster, the system is divided into three main parts which are stated below:

(1) Source Vehicle: It is the vehicle from which the message and data are origin for the communication purpose according to the requirement of the individual.

(2) Hop Vehicle: These vehicles act as data forwarding system. Its helps to forward the data to the destination as soon as possible.

(3) Access Point: All those stationary infrastructures used in the VANET act as access point.

Figure 3 shows the systematic diagram of the cluster. Every cluster has one source vehicle and other hop vehicle to pass the information to the access point and to other nearby hop vehicles.

Using the above information, for playing the game there will be X number of source vehicle and Y number of hop vehicles. For simplicity, we are assuming that the source vehicle will choose one hop vehicle to transmit data. Table 1 shows the game theory approach for selecting the cluster head using game theory.

The complete flowchart is shown in Figure 4. This game theory approach first deploys the VANET and then classifies it between the source vehicle and the hop vehicle. Now, the social parameters of each vehicle are identified, which makes it a more novel and new approach to the VANET analysis. After computing the social scores, the K-mean clustering is used for the CH selection. After selecting a possible CH, game theory is used to identify the best CH out of the selected CH. This approach makes the proposed method different from the other classical methods.

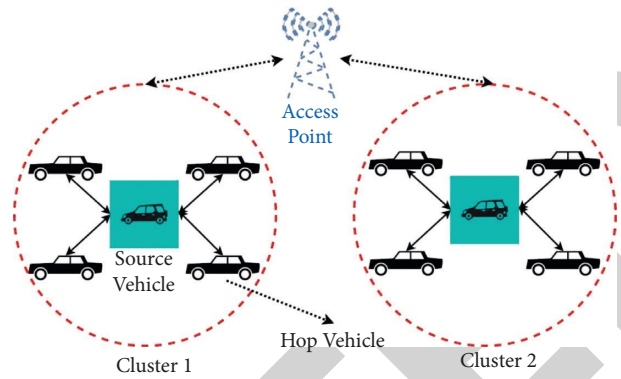

Figure 3: Systematic diagram of cluster.

Table 1: Game theory-based CH selection.

Steps	Description
1	Initialization of the system
2	Number of vehicles (nodes) in the system
3	For $i = 1 : N$
4	If $S(i)$ $E > 0$ means node is live
5	Cluster details and id is gathered
6	If node needs to forward the data
7	Else >> system is inactive
8	If >> social parameter score is high
9	Make the node as head for transmitting the data
10	Else >> act as hop vehicle
11	End

The node distribution pattern, the additional value of Global Positioning System (GPS) to the nodes, and the network's scalability capacity are all aspects of VANET. Because of considerations such as traffic control and allowable speed limitations, the VANET node distribution pattern is nonhomogeneous along the road length. This distinguishes it from other ad hoc networks on the market. Furthermore, VANET node heterogeneity arises from the fact that different types of vehicles will be on the road at any given time; as a result, conventional wisdom holds that applications in these vehicles will differ; i.e., only emergency vehicles, including law enforcement vehicles, will be able to issue emergency warnings about oncoming traffic. The nodes receive real-time position and weather data thanks to the GPS. Furthermore, because node organization or reorganization is a function of space and time, the number of nodes on the network grows and reduces as vehicle density and speed increase. This makes VANET more suitable than other ad hoc system.

4. Simulation Results and Discussion

4.1. Simulation Results. The simulation result shows the superiority of the proposed model. The clustering of the datasets is shown in Figure 5. There are three clusters represented by three different colors. The data are then trained, and validation is done. The training of data means around 20% of the data are used to train in this proposed

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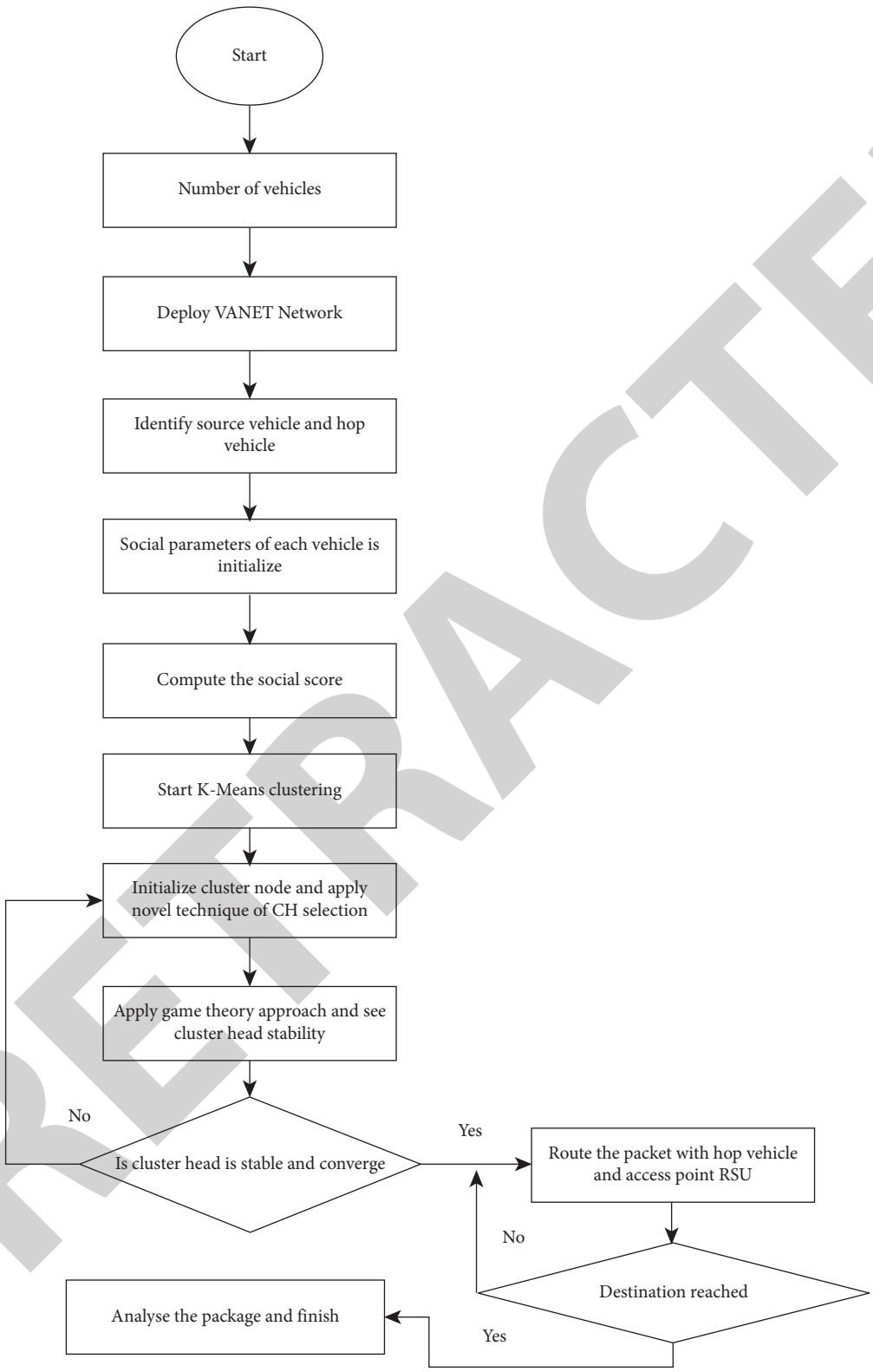

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Figure 4: Flowchart of the proposed method.

system. After the training, the validation of the data is done using the other data in the system. Finally, the data are test for different values. The average social parameter data collection validation is shown in Figure 6. The suggested algorithm achieves an excellent social score, as shown in the figure. The reason for this is that the suggested algorithm takes into account both transmission collision and backoff delay. It can also be seen that the positive social score rises

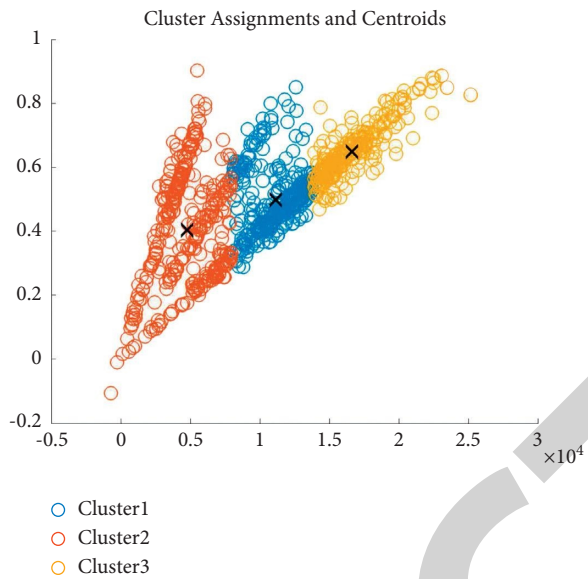

Figure 5: Cluster assignment and centroids.

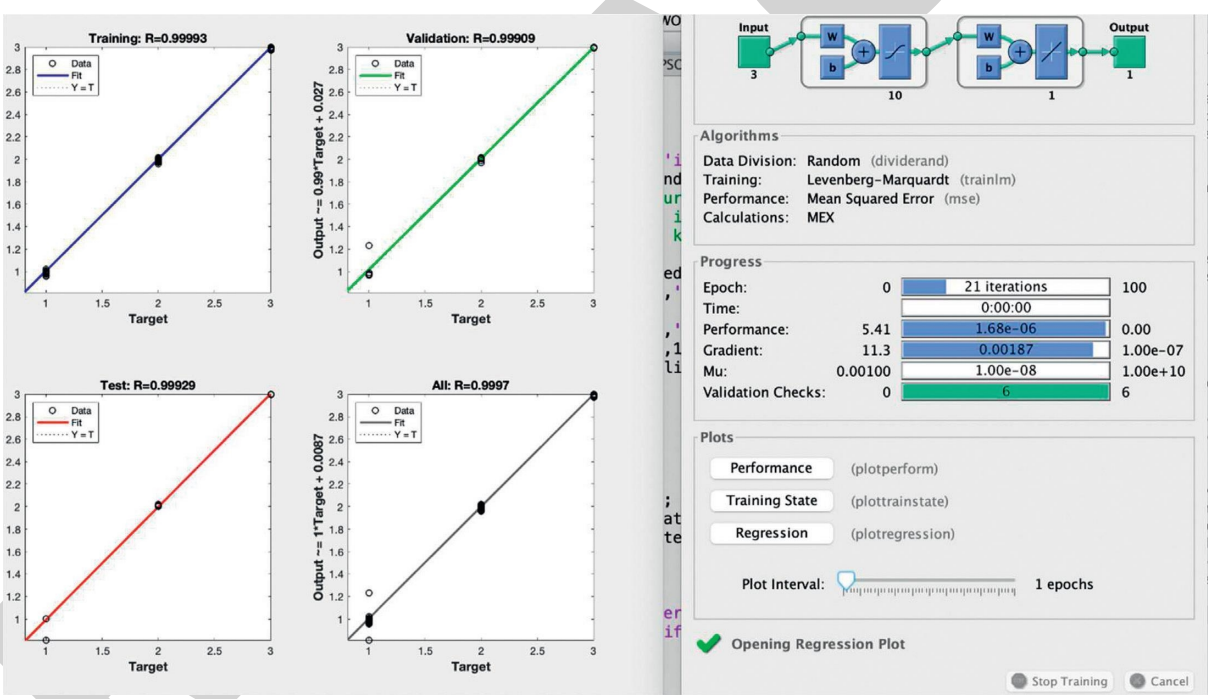

Figure 6: Training and validation of the system.

with the number of vehicles, which is due to the fact that as the number of vehicles grows, so does the likelihood of an accident and the backoff wait.

The proposed technique outperforms the other algorithm, as demonstrated in the graph. This is because the algorithm considers factors such as link reliability, bandwidth resources, and transmission time, resulting in a higher likelihood of successful transmission. The figure also shows that for a small number of vehicles, the successful rate is relatively high; however, as the number of vehicles increases, more collisions are likely to occur, resulting in longer backoff times and a higher number of re-transmissions, resulting in a low successful transmission probability. Figure 7 depicts the various parameters and their associated values for ten trials.

Comparison of the proposed work with different other techniques is shown in Table 2. The comparison is done using the social connectivity within the system and the different social parameters.

4.2. Discussion. One of the most well-known ways for improving the efficiency and safety of modern transportation systems is the use of virtual private networks (VPNs).

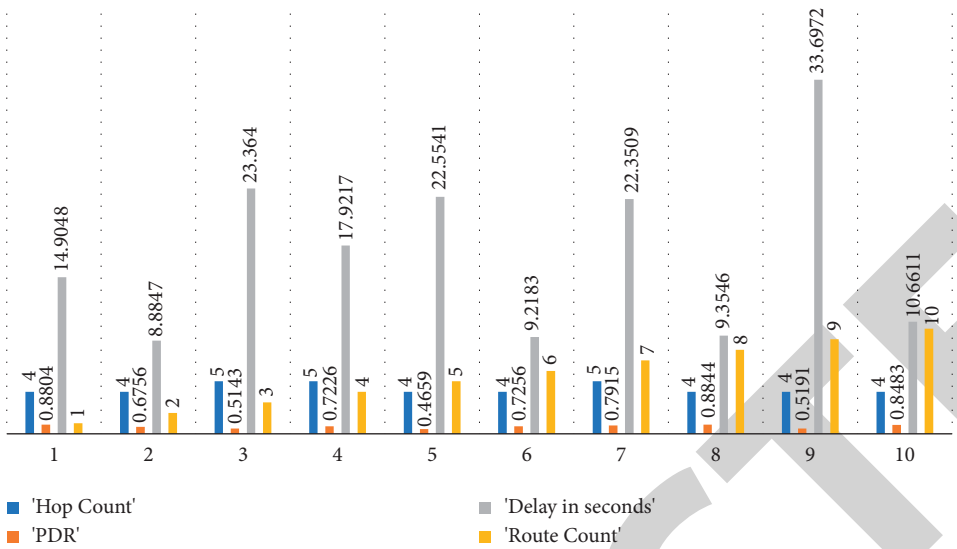

Figure 7: Simulation result.

Table 2: Comparison with existing model.

Model/Technique	Reliability	Stability	Response time	Efficiency
Graph theory	Low	Low	Low	Low
Fuzzy	Medium	Medium	High	Medium
ANN	High	Medium	High	High
Proposed method	High	High	High	High

Vehicles, for example, can communicate early with neighboring vehicles about detours, traffic accidents, and congestion in order to reduce traffic congestion near the afflicted sites. Vehicles can use VANET programs to connect to the Internet and receive real-time news, traffic, and weather updates. VANETs also enable a slew of online vehicle entertainment alternatives, like as gaming and file sharing over the Internet or local ad hoc networks. VANET data rates are entirely determined by the type of service and its own set of parameters. When the transmission rate is only a few Mb/s over a few tens of meters, the lower data rate is used for toll and payment services (e.g., motorways). Regardless of whether the required rate reaches 54 Mb/s, Internet access has the same range. The safety message service should enable proactive actions across hundreds of meters at a required rate of less than 20 Mb/s, maybe as low as 6 Mb/s. Finally, when compared to previous services, emergency vehicle services necessitate a rate of 5 Mb/s over an extremely long distance.

In this work, we have covered the fundamentals of machine learning and outlined the ML-based problems, constraints, and remaining issues for WSNs and VANETs. We also talked about how to use machine learning to track the dynamics of vehicular environments and WSN. Various machine learning approaches are applied to a variety of unresolved problems that require significant attention due to their complexity. Although game theory-based research in this area is still in its infancy, we have sought to map existing knowledge in order to explore new vistas of possibilities. Many of the concerns raised by the research gap have yet to be thoroughly studied and described.

5. Conclusion

The social features of vehicle ad hoc networks are investigated in this research. We examine the distribution of degrees and shortest pathways of VANETs by representing vehicle encounters as social interactions and vehicle interconnection as a social graph. Several social features, such as power-law distribution and the small world phenomena, are seen in our study. It shows that node popularity is unbalanced: there are a small number of nodes that interact with other nodes regularly. It also showed that the average length of the shortest path between two nodes is less than three hops. VANET nodes are more closely clustered than nodes in random networks. Our findings could aid in the facilitation of inter-vehicle communications in VANETs. The quantity of transmitted messages increases as the number of linked vehicles on a road network grows, resulting in congestion in the wireless communication channel. *e*. Each vehicle takes on the role of a player in the game, requesting a high data rate for its own benefit. *y*. According to simulation results, the suggested solution outperforms the wireless access for vehicular environment protocol's carrier-sense multiple access with collision avoidance mechanism. The graph theory approach makes it more reliable and stable for the cluster head. The simulation results suggest that the game theory-based energy-efficient clustering approach is

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successful in improving the sensor network's time response, increasing sensor node data transmission, and extending sensor node lifetime.

Data Availability

Data can be obtained from the corresponding author on request.

Conflicts of Interest

The authors have no conflicts of interest to disclose.

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