JOURNAL OF CONTENT VALIDATION 2026, VOL 2, ISSUE 2, PAGES 101-111
ISSN: 3093-8317, https://doi.org/10.67211, www.cvsgm.org

JOURNAL OF CONTENT VALIDATION ISSN: 3093-8317

Enhanced Reliable Delivery for VANET Safety Messages through Location-Aware Distributed Cluster Analysis and Fuzzy Weight-Based Clustering Scheme

Dr. R. Rajesh Kanna

Department of Computer Science, Christ University, Bengaluru - 560 029, Karnataka, India
**Corresponding author; Email: rajeshkanna.r@christuniversity.in, drrajeshkannacbe@gmail.com*

Received: 09 June 2025 • Accepted: 29 May 2026 • Published: 16 June 2026

Abstract

Vehicular ad hoc network (VANET) is an emerging and promising technology that aimed to improve the safety and provide the comfort for the passengers. However, the high mobility of the vehicles and frequent topology changes are a considerable challenge to the reliable delivery of safety applications. The numerous nodes could result in issues that lower the quality of service, like network congestion. In this paper we proposed a fuzzy weight based clustering algorithm (FWCA) to address these challenges in VANET environment. To select the cluster head CH we are identified some metrics on the basis of the vehicle mobility information. Each node value defined based on the nodes speed, link connectivity duration time and direction. Based on this parameter a vehicle node with the smallest weight value is selected as the primary cluster head (PCH). Whenever the PCH is not suitable for continuing with the leadership, the SeCH will take over the leadership. The simulation result of the proposed approach showed a better performance with an increasing the performance metrics compares to existing approaches. The new proposed scheme improves the cluster stability; throughput and reducing the re-clustering process, packet dropping rate and delay.

Keywords: *Clustering, Fuzzy Logic, VANET, Routing techniques*

INTRODUCTION

A vehicular ad hoc network (VANET) is one of the promising technologies being used to maintain resource sharing between neighboring vehicles on the road in order to improve road traffic safety and provide infotainment services. A VANET exchange the data via vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I) communication. Furthermore, to facilitate this communication, vehicles are outfitted with on-board units (OBU) [1]. All OBUs are expected to broadcast their status in packets as beacons on the control channel on a regular basis, so that each OBU has real-time information about all of its neighbors. For vehicular communication, dedicated short range communication (DSRC) was defined, which works similarly to Wi-Fi and has a transmission range of 300–1000m. Similarly, the Federal Communication Commission (FCC) of the United States has designated 75 MHz of the spectrum band for vehicular communication. This spectrum band is divided into seven 10-MHz channels, with the control channel (CCH) broadcasting safety-related messages and control and the other six service channels (SCHs) transmitting data [2].

However, the possibility of the envisioned VANET applications is dependent on the medium access control (MAC) protocol's reliability. The most important applications envisaged by VANET, which require reliable and timely delivery, are safety applications. These applications have strict quality of service (QoS) requirements in terms of delivery delay and packet loss rate, which the conventional MAC protocol cannot guarantee, especially under heavy traffic conditions [3]. The high mobility of vehicles and frequent network topology changes also has an impact on the delivery of time-bound safety-critical applications, particularly in a high density network. To address this issue, a clustering technique is employed to ensure good coordination among neighboring nodes.

Clustering is the process of organizing a set of nodes on the road to form a sub-network based on predefined parameters such as vehicle density, velocity, and position. This strategy improves the network's stability and scalability. Figure 1 depicts the cluster-based communication architecture. In this method, each group elects a cluster head (CH) based on some predetermined criteria, and the remaining group members become cluster members (CMs). The elected CH is in order to coordinate the CMs and communicating inside the cluster. As a result, the hidden terminal problem is generally reduced, and safety messages are delivered more quickly. [17].FWCA shows stable connection among clusters, elevated packet delivery ratio and reduced network overhead. A good clustering algorithm choose a CH that more stable within the cluster before exiting [4]. Dynamic vehicles have a significant impact on cluster stability. This is due to the fact that vehicles can either join or leave a cluster, causing the topology of the cluster to modify. On the other hand, the existing cluster-based MAC approaches explain that maintaining the stability of a cluster is a serious challenge because of the high mobility of vehicles and the dynamic topology changes [5]. This is because a CH can also leave or merge with another CH. Most existing clustering algorithms, it has been discovered, lack an effective mechanism to deal with a circumstance where the elected CH leaves a cluster. Furthermore, this CH is in charge of coordinating all of the CMs within the cluster, and if it leaves for any reason, the clustering structure will be disrupted, requiring reconfiguration. As a result of this effect, the CCH will have a significant communication overhead. Furthermore, this action may result in the loss of the channel access schedule, as well as a transmission collision or safety message delivery delay.

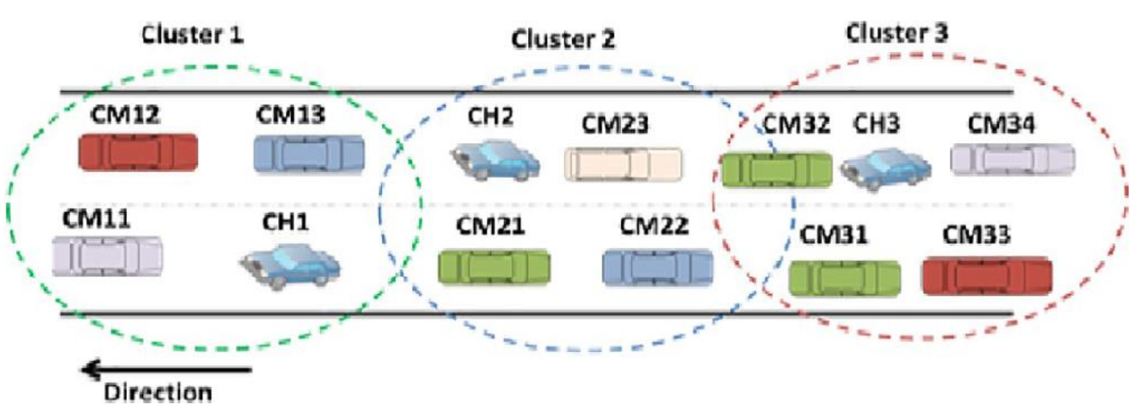

Fig 1. Cluster based communication architecture.

In this paper focuses on information propagation management for V2V and V2I communications and presents FWCA, a fuzzy weighting model for data prioritization in VANETs. FWCA uses RSUs to outperform the challenge of frequent topology changes that help neighboring

vehicles to share messages. The suggested approach employs a scheduling technique for groups of nodes to lengthen the communication link.. Moreover, our model prioritizes the vehicles in a congested scenario and tries to increase the packet delivery and decrease access delay (Mohd Pauzi & Shahadat Hossen, 2025).

The primary contributions of this paper are as follows:

- First, a hierarchical V2V and V2I communication is applied by FWCA using a Fuzzy clustering model that establishes cooperation and coordination of clustered vehicles to improve network stability.
- Next, a fuzzy logic system (FlS) is used by FWCA for weighting the clustered vehicles to provides a scalable V2V and V2I communication model for managing data propagation.
- The proposed model enables distributed data management using RSUs and cluster heads (CHs) and improves the information dissemination process in a scalable VANET. Here CHs are responsible for cluster stability and monitors cluster members (CMs) requests and mobility information.
- The proposed model more dynamic and way to improve the network stability, especially to overcome the hidden terminal problem. To improve the cluster stability FWCA elected the PCH and SeCH based on the weight factor value.

The rest of this paper is organized as follows. A review of the related work is presented in Section 2. The proposed system model is presented in Section 3. In Section 4, we present the simulation and scenario setup. The performance evaluation based on the existing approaches is also discussed. Finally, conclusion presented in Section.

REVIEW OF RELATED WORK

A. F. M. Shahen Shah, (2020) [1] proposed CB-MAC protocol is optimized by optimizing the transmission probability with cluster size for both safety message and non-safety message process. Here the optimum number cluster defined based on number of nodes in VANET. Based on analytical study they provided the Markov chain model. They used microscopic mobility model to create the SMO. Moreover they provided optimum transmission probability and increased throughput (16.5 Mbps) for safety message and non safety message (14.1Mbps) achieved for different number of vehicles. So that proposed CB-MAC protocol works better and improved throughput and reduced delay and packet dropping rate (Alam et al., 2025).

Gang Liu, Nan Qi*, Jiaxin Chen, Chao Dong& Zanqi Huang (2020) [2], proposed Spectral Clustering algorithm increased the stability of whole cluster head, such that the service is improved. Proposed scheme improved the different cluster size with different time. Mohammed S. T, Aslinda H, Thamer A, Ali Jalil Ibrahim,(2020) [3] proposed clustering in VANET environment using a center-based evolving clustering based on grid partitioning (CEC-GP) is proved the perspective of efficiency , stability and consistency. This approach based on mobility information based effective phase of data summary grid partitioning. This approach was working high level entity for assisting the cluster to creating outliers or cluster. The proposed scheme covered all the process of clustering including assigning, cluster head selection, merging and removing. The improved percentage efficiency in over the entire network Center based stable clustering and evolving data clustering algorithm was 65% and 394% respectively (Hossen et al., 2026).

Grace Khayat, Constandinos X, George Mastorakis, Jordi Mongay Batalla, Hoda Maalouf, Shahid Mumtaz & Evangelos Pallis (2020) [4] proposed new clustering protocol based on weighted formula for double cluster head selection. The primary cluster head selected based on some parameter such as trust, distance, and velocity. The primary cluster head selection and secondary cluster head selection were ensuring the end to end communication for any packet for without infrastructure. Muhammad A. S., Shijie Z., Abida S., Tanzila S., Muhammad A. Z., Ashar J., Sudipta R., &Mamta M., (2019) [5] proposed a fuzzy cluster head selection scheme in Cognitive Radio(CR) VANET. The results section that the stability, trustworthiness and security achieved effective cluster head selection. Fuzzy input and other stable cluster head selection considering speed, distance, lane weight and probability of correction detection as an input parameter. The proposed solution improved the probability of true detection of PU has higher detection probability of false detection than spectrum sensing based signal energy. This improvement of CR VANET performance improves vehicle node stability 90% of the overall network (Alam et al., 2025).

Proposed System Model

The prominent characteristics of VANET, including the high mobility and the uneven spatial distribution of vehicles, lead to frequent changes in the typologies and disconnections of the network. We suggest a clustered VANET structure to address these issues and offer dependable connectivity for a collection of nodes. Vehicles are grouped into multiple moving clusters. Each cluster contains a capital vehicle (cluster head) which is responsible for managing information about the cluster members as well as data transmission.[7] In this paper, we propose a Fuzzy weight-based clustering algorithm for data transmission approach with pure vehicle-to-vehicle (V2V) and vehicle to infrastructure (V2I)communication type being considered. To outperform loss of communications link of infrastructure, RSU collect and store the vehicles real time information. Here we assume that each vehicle has a unique identity and is equipped with an onboard unit (OBU). The position, speed, and direction of the vehicle's current motion can all be found via the GPS service. Additionally, we believed that each node could recognize its unique road ID using a computerized map. Through beacon messages, vehicles communicate with one another and exchange information. The beacon message is broadcast and collected at every beacon interval, which includes vehicle’s identifier, current position, current velocity, moving direction, vehicle’s current state. Only vehicles moving in the same direction and same road ID will be considered for cluster formation group within a transmission range of road segment on the highway (Hossen et al., 2023). A message from neighbor vehicle moving at different direction will not considered and should be ignored. Vehicles are being added to the network via Poisson distribution. (25).

Cluster formation is based on the fuzzy interference systems(FIS) weight values that are calculated based on position, speed, distance, which provides stability and Qos. The CH is chosen by the node with the lowest weight value.. The proposed network structure divided into clusters. Each node in the cluster can be in the following states:
Free Node (FN): Initial state of the vehicles which do not belong to any cluster.
Cluster Member (CM): The state in which the vehicle is attached to an existing CH.
Cluster Head (CH) : The state in which the vehicle acts as the leader of a cluster.

Algorithm 1 (Initial phase)

State (v_i)←ND
Wait for a Hello message
Receive (Hello)
Get position (Pv)
Get speed (Sv)
While (TI not expired) do
Calculate _Connectivity _ value (v_i)
Calculate _ Speed _ value (v_i)

Calculate _ Position_ value(v_i)
Calculate _Delay _ value(v_i)
Calculate Weight value W(v_i)
Update neighborhood table
End

Metrics for CH election

This section identifies the various metrics that were taken into account during the CH election process. These metrics involve the mobility information of each node including the direction of movement, road ID, speed, position, distance and node connectivity level of a vehicle to its neighbors. Sharing the mobility information through periodic messages a vehicle can identifies it neighbors. Prior to accepting and processing the broadcast message from its neighbors, any adjacent node must first identify the direction of movement of a vehicle and the road ID. In contrast, metrics including the speed, node connectivity level, distance and position of the vehicle nodes are to be calculated to determine the suitability of a vehicle to become a CH. Each of these metrics is associated with a fuzzy value weight representing its importance. The explanation of these metrics is given below.

Node connectivity level

The neighbor relationship is built using the position information embedded in the beacon message broadcast by the vehicles. If two vehicles i and j considered as a neighbors based on the difference between the two nodes within the transmission rang (r). r is the communication range defined by the DSRC standard. The node connectivity means the total number of nodes directly connected by the node i.

$$N_i = \sum_{j=1}^{n} dis\,\{i, j, t\} \leq r \text{ ------------------ } (1)$$

Here j represent the possible neighbor of node i dist(i , j,t) if the connection between i and j exist within the time t means its true otherwise the connection is false for the transmission range of node i.

Average Nodes speed

Speed is the one of the most important characteristics involving vehicle moving on the road. The speed of the vehicle is assumed to be a normal distribution [23], the probability density function (pdf) is given in Eq (2):

$$Pf_v\,(v) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{(v-\mu)^2}{2\sigma^2}} \text{ ------------------------ } (2)$$

Here σ is the standard deviation of the vehicle speed and μ is the mean speed. Each vehicle can calculate how close its neighbors mean speed is to its current speed. Therefore, the vehicle whose speed is the closest to the mean speed of its neighbor nodes will have a highest priority of the cluster head CH election process. The mean speed μ_{vehi} of the all the neighboring vehicle is expressed in Eq(3) as follows:

$$\mu_{vehi} = \sum_{j=1}^{n} \frac{\Delta d}{\Delta t} \text{ -- } (3)$$

Here Δd represent the total distance; Δt represent the total time covered by the vehicle node within transmission and j=1….n represent the neighboring vehicles nodes within the transmission range. Here both speed and distance could be modeled using a normal distribution with mean and variance of all the related neighboring nodes. The normal mean speed is represented as a v_{normal},

$$v_{normal} = \frac{v_i - \mu_{vehi}}{\sigma^2} \text{ -------------------------------- } (4)$$

Average Nodes Distance

Here every node will check the its own mobility information and get its location at the every time interval Δt. To measure the distance and in the objective to simplify our calculation we apply the Euclidean distance. To calculate the mean distance of each vehicle that is directly linked to vehicle i. The shortest the distance the fastest message will be transmitted or received by the neighboring nodes. Each node position should be represented by x and y coordinate.

$$dis_{i,j}=|x_i - y_j| \text{------------------------------------ (5)}$$

And each node position n_p can be derived from the position coordinates of the vehicle nodes. This as follows,

$$n_p = (x_1, y_1) \text{ -------------------------- (6)}$$

Where the position coordination of the all vehicle nodes are represented by the x and y, hence the mean distance μ_d all the vehicle could be expressed by

$$\mu_d = \frac{\sum_{j=1}^{n}\sqrt{(xi-xj)^2+(yi-yj)^2}}{N_i(t)} \text{ ------------------------ (7)}$$

The variable j is any neighboring vehicle that is connected to vehicle i. $N_i(t)$ is the total number of vehicles that are directly connected to the vehicle i at the timet. the normal mean distance $Normal_d$ is defined in Eq (7):

$$N_d = \frac{n_p - \mu_d}{\sigma_d} \text{ ----------------------------- (8)}$$

n_p - Node position

μ_d - Mean distance

σ_d - Standard deviation

Each node computes its weigh value w_i in Eq (9) to determine its suitability of CH.

Weight Factor

$$W_I = (\omega 1 * N_I(t)) + (\omega 2 * v_{normal}) + (\omega 3 ** Normal_d) \text{ ------------------ (9)}$$

$W_1 = \omega 1 + \omega 2 + \omega 3$

W1 = 1

Here, $\omega 1$, $\omega 2$, $\omega 3$ are the weighing factors for the corresponding system parameters, such that W1 = 1. This combined weight should be calculated for each vehicle node. The node with the least weight is selected as a CH.

Cluster formation and CH election process

When vehicle nodes joins in the network consider as a free node and share the mobility information to its neighbor node within the transmission range with the following format (node id, average speed, location, direction). Similarly receive the same information from the nearby nodes. After receiving the hello message from the neighbor nodes, every node calculate the weight factor. Then each node employs fuzzy logic to calculate a weight factor value W_i (combined weight factors) Any vehicle within the communication range that has the best acceptable weight value can start the cluster formation procedure. Each node will compete to become a CH on the basis of its computed weight value W_i. The processed weight factor value of each node is exchanged between the neighbors through periodic beacon message. Then the node with the smallest weight value is chosen as a CH.

Which vehicle nodes wins the selection process, that status changes into primary cluster head (PCH) and assigned a cluster head id (CHid). That will be responsible for broadcast safety message to entire neighborhoods. Whenever vehicle nodes joins in the network will be assigned an identifier known as node id. The node id assigned on the basis of the vehicles arrival to the network beginning with zero (0). This will minimize the variation of the selecting PCH and the SeCH. After that the selected primary cluster head (PCH) will select the SeCH from the CM which is having smallest weight factor value (Rashed et al., 2025).

Algorithm 2

Step 1: get the current speed of SeCH for the periodic update.

Step 2: check whether the current speed of PCH is greater than the SeCH speed

$(speed_{ch} > speed_{SeCH})$
Step 3: broadcast the hello message to update the SeCH status information
Step 4: update and share the status information to cluster members CMs
Step 5: CH status changes to CM
Step 6: change to leadership PCH to SeCH
Step 7: assign the CH id to the SeCH
Step 8: than assign the new cluster head and share the information to CMs

EXPERIMENTAL SETUP

The experimentation have been achieved on one dimensions of road section 1km to 3km. the transmission range of the vehicle is adjusted from 100m to 500m and nodes are modified from 10 to 50. The movement of vehicle is in same direction like highway scenario.

SIMULATION RESULTS

In this study, the simulation is using Network Simulator 2 (NS2) version 2.35.

Simulation parameter

Parameter	**value**
Simulation time	200s
Propagtion model	Two- ray ground
Highway length	4000m
Velocity	30m/s
MAC/PHY	WAVE/IEEE802.11P
DSRC channel bandwidth	10 MHz
DSRC channel frequency	5.9 GHz
Transmission range	100 to 300m
Transmission rate	6Mbps
Message size	512 bits
Weight factor value	0.3, 0.2, 0.2
Node	50, 100, 150,200

The simulation is conducted to evaluate the effectiveness of the proposed technique by comparing its performance with the two existing technique, namely the optimized CB-MAC protocol and CB-MAC protocol [1] and [24]. We compare this technique in the same environment by using the following different performance metrics such as Throughput, packet dropping rate and end to end delay report of emergency message.

THROUGHPUT

It is defined as the total packets delivered successfully over the communication channel. Throughput= N/1000
Where N is the number of bits received successfully by all destinations.

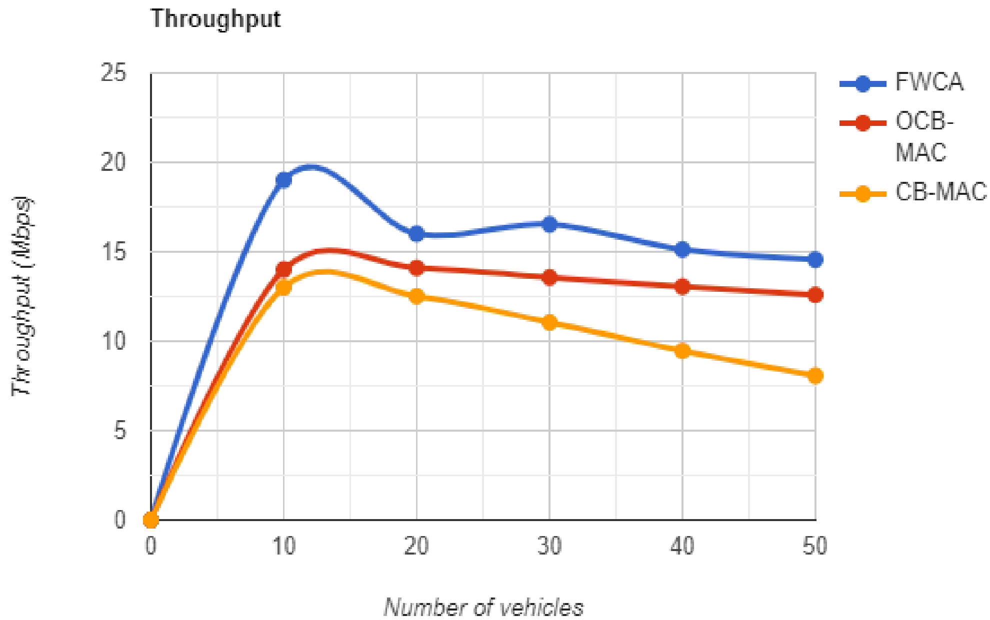

Figure 1 shows throughput versus number of vehicles. Throughput is increase when the number of vehicle nodes increase, more packets contend which result in more collision and degrades the network performance. The throughput of FWCA is better than both CB-MAC protocol and optimized CB- MAC protocol. The clustering limit controls the channel contention and the network topology efficiently. Optimized CB-MAC protocol has higher throughput than CB-MAC protocol.

PACKET DROP RATIO

It is the total number of packets dropped out of the total number of packets generated by the sources.

Packet Drop Ratio =Σ Number of packets sent / Σ Number of packets received

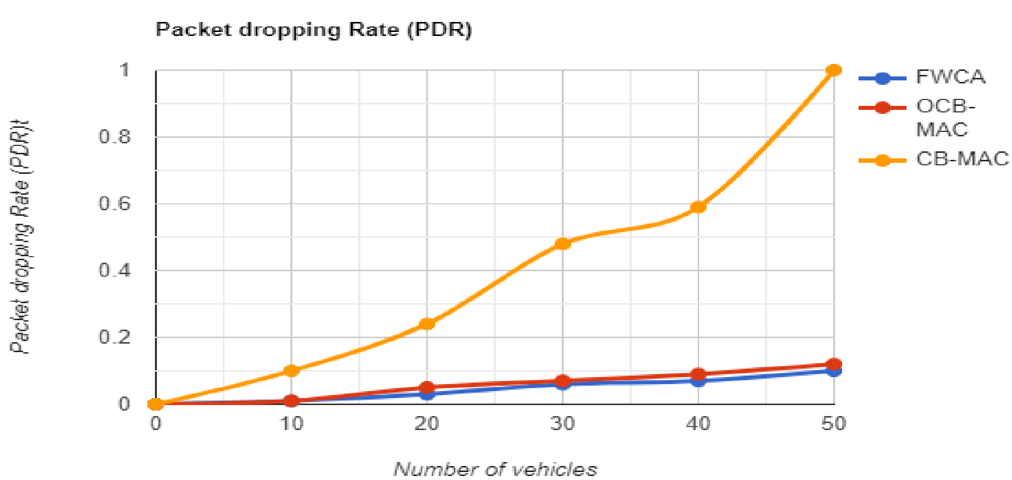

Figure 2 presents PDR against number of vehicles. PDR rises with the number of vehicles which reduces the reliability of transmission. When the number of vehicles is increased, the number of packet contending for the transmission is increased which increase collision as well as PDR. The packet dropping Ratio of proposed mechanism is lower than the Optimized CB-MAC and CB-MAC protocol. Clustering makes communication stable, optimized CB-MAC protocol has lower PDR than CB-MAC protocol.

AVERAGE DELAY

End-to-End Delay refers to the time taken for a packet to be transmitted across a network from source to destination.

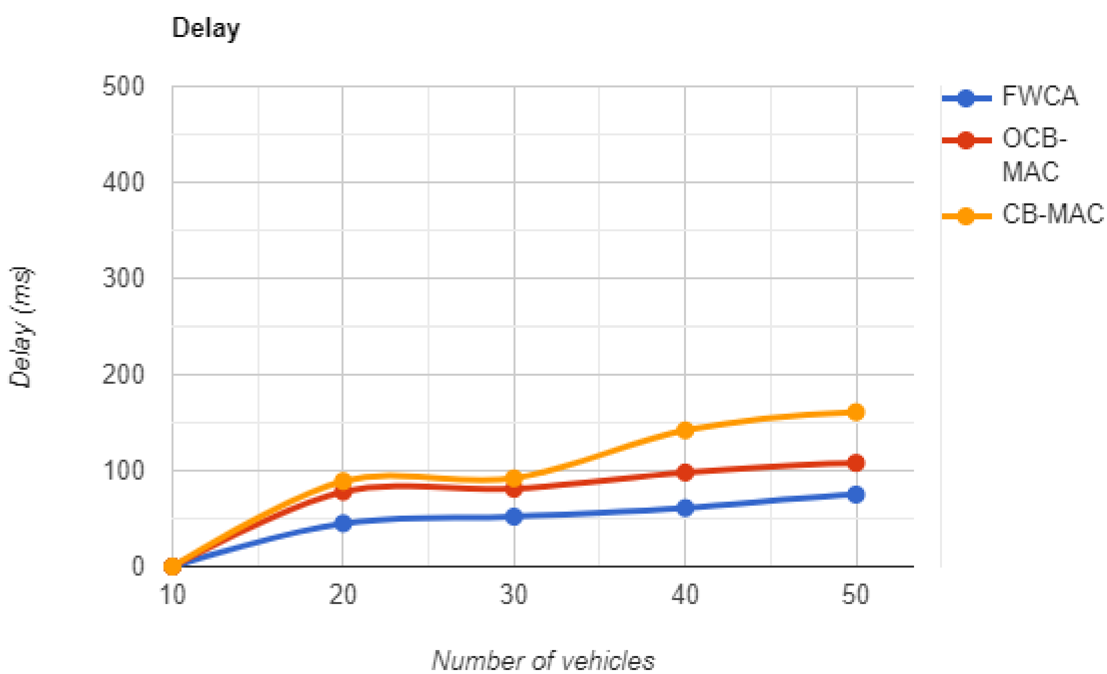

Fig 3 the average packet delays against number of vehicle. The increasing the number of vehicles increase the delay that will increase the probability of channel busy and collision increase. The delay for FWCA is less than optimized CB-MAC and CB-MAC protocol. Clustering limits the channel contention which reduces the probability of channel busy and collision that decrease delay. In our proposed approach the average delay is 100ms for the strict delay requirement of VANET safety a message. This is recognized to the fact that the SeCH is introduced in our approach minimized the time of re clustering whenever the CH moves out of the cluster, therefore minimizing the delay of broadcasting these safety messages to the CMs. Similarly we reduced that increasing the transmission range could also reduce the message delivery delay (Rahman et al., 2025).

CONCLUSION

To improve the road safety in VANET environment requires an efficient and reliable MAC protocol. This could be achieved using a cluster based scheme to satisfy the stringent requirement of safety application. In this paper we proposed new clustering technique based on highway scenario. Using the mobility information of each vehicle, the clustering algorithm selects the CH on the basis of the computed weight factor value. To ensure the cluster stability, we introduced a SeCH to take the leadership whenever the primary CH is about to leave the vicinity. The speed different of CH and SeCH was periodically checked and updated in order to ensure the smooth transition. The performance of the proposed scheme FWCA (fuzzy weight based clustering algorithm) was evaluated through a simulation study. We compared the result of the proposed approach with those of the two existing approaches and demonstrate a high superiority with respect to forming stable cluster and obtaining relatively few clusters. We observed that when increasing the vehicle density and transmission range, the vehicles would still stay connected with existing cluster for a long period of time even if the CH moved out of the cluster without the need for cluster reconfiguration process. Our proposed approach FWCA improved cluster stability compared to existing approaches is optimized CB-MAC and CB-MAC protocols. Furthermore, we significantly minimized the delay compared to existing approaches. The delay was minimized because of the introduction of SeCH , which minimized the re-clustering problem. The important thing that the cluster head CH is responsible for allocating a slice of time to its CMs in a cluster based TDMA MAC protocol. The proposed scheme improved the performance metrics throughput and reduced the packet dropping rate and delay compared to existing approaches

Funding: The research did not receive financial assistance from any funding entity.

Conflicts of Interest: The author has no conflicts of interest to disclose concerning this study.

Declarations: This manuscript has not been published to any other journal or online sources.

Data Availability: The author has all the data employed in this research and is open to sharing it upon reasonable request.

REFERENCES

Shahen Shah, A. F. M., Karabulut, M. A., Ilhan, H., & U. T. (2020). Performance Optimization of Cluster-Based MAC Protocol for VANETs. IEEE Access, 8, 168792-168805.

Liu, G., Qi, N., Chen, J., Dong, C., & Huang, Z. (2020). Enhancing Clustering Stability in VANET: A Spectral Clustering Based Approach. Emerging Technologies & Applications, January 13, 2020.

Mohammed, S. T., Aslinda, H., Thamer, A., Ali Jalil, I., & Nihad, I. A. (2020). A Center-Based Stable Evolving Clustering Algorithm With Grid Partitioning and Extended Mobility Features for VANETs. IEEE Access, 8, 170706-170722.

Khayat, G., X, C., Mastorakis, G., Batalla, J. M., Maalouf, H., Mumtaz, S., & Pallis, E. (2020). Successful Delivery in VANETs with Damaged Infrastructures Based on Double Cluster Head Selection.

Muhammad, A. S., Z, S., S, A., S, T., Z, M. A., J, A., R, S., & M, M. (2019). Expansion of Cluster Head Stability Using Fuzzy in Cognitive Radio CR-VANET. IEEE Access, 7, 71365-71379.

Muhammad, A. S., S, Z., Muhammad, U. S., A, T., M, A., S, C. S., & T, M. (2021). Deep Learning-Based Dynamic Stable Cluster Head Selection in VANET. Complexity, 2021, 9936299.

Ji, X., Yu, H., Fan, G., Sun, H., & Chen, L. (2018). Efficient and Reliable Cluster-Based Data Transmission for Vehicular Ad Hoc Networks. Hindawi, 2018, 1-17.

Çalhan, A. (2015). A Fuzzy Logic-Based Clustering Strategy for Improving Vehicular Ad-Hoc Network Performance.

Tal, I., & Muntean, G. M. (2015). User-Oriented Fuzzy Logic-Based Clustering Scheme for Vehicular Ad-Hoc Networks.

Tarak, N., Yamani, M. I. B. I., Rafidah, M. N., Ahmedy, I., & Bhattacharyya, S. (2020). A Multiple-Criteria Decision Analysis Clustering and Cluster Head Selection Algorithm in Vehicular Network. IEEE.

Shah, Y. A., Aadil, F., Khalil, A., Assam, M., Abunadi, I., Alluhaidan, A. S., & Al-Wesabi, F. N. (2022). An Evolutionary Algorithm-Based Vehicular Clustering Technique for VANETs. IEEE Access, 10, 13746-13757.

Koshimizu, T., Gengtian, S., Wang, H., Pan, Z., Liu, J., & Shimamoto, S. (2020). Multi-Dimensional Affinity Propagation Clustering Applying a Machine Learning in 5G-Cellular V2X. IEEE Access, 8, 68775-68786.

Abbas, F., Liu, G., Fan, P., & Khan, Z. (2020). An Efficient Cluster Based Resource Management Scheme and Its

Performance Analysis for V2X Networks. IEEE Access, 8, 60690-60700.

An, J., Yu, Y., Tang, J., & Zhan, J. (2019). Fuzzy-Based Hybrid Location Algorithm for Vehicle Position in VANETs via Fuzzy Kalman Filtering Approach. Hindawi, 2019, 1-13. doi:10.1155/2019/5142937.

Hanan, H., Al Malki, A. I., Moustafa, A. M. H. S. (2020). An Improving Position Method Using Extended Kalman Filter.

Mohammed, S. T., Aslinda, H., Thamer, A., Zuraida, A. A., Ali Abdul-Jabbar, M., Ali Jalil, I., & Nihad, I. (2020). A Center-Based Stable Evolving Clustering Algorithm With Grid Partitioning and Extended Mobility Features for VANETs. IEEE Access, 8, 170706-170722.

Kumar, S., Choi, S., & Kim, H. (2019). Analysis of Hidden Terminal's Effect on the Performance of Vehicular Ad-Hoc Networks. Springer, 18(1), 1-12.

Yan, G., & Rawat, D. B. (2016). Vehicle-to-Vehicle Connectivity Analysis for Vehicular Ad-Hoc Networks. Ad Hoc Networks, 50, 74-85.

Rajeshkanna, R., & Saradha, A. (2014). Adaptive Multicast Multimedia Transmission Routing Protocol System (ACMMR) for Congestion Control and Load Balancing Techniques in Mobile Adhoc Networks. International Journal of Applied Engineering Research, 9(23), 21531-21540.

Dhivya, R., & Rajesh Kanna, R. (2021). Detection of Malicious Node in Network Layer Using ESMTS Technique to Improve the Energy Efficiency in VANET. Studies in Indian Place Names, 40(3), 164-171.

Alam et al., 2025. (2025a). *Online Corrective Feedback and Self-Regulated Writing: Exploring Student Perceptions and Challenges in Higher Education*. *15*(06), 139–150. https://doi.org/https://doi.org/10.5430/wjel.v15n6p139

Alam, J., Hossen, M. S., Nawaz, I., Rahman, S., & Mahmood, A. (2025b). *Black Magic and Dark Tourism Impact Mental Well-being of Gender: A Standpoint of Embodiment Theory With Emotional Experience*.

Hossen, M. S., Pauzi, H. B. M., & Salleh, S. F. B. (2023). Enhancing Elderly Well-being Through Age-Friendly Community, Social Engagement and Social Support. *American J Sci Edu Re: AJSER-135*.

Hossen, M. S., Pauzi, H. M., Islam, M. S., & Salleh, S. F. (2026). ELDERLY LIFE SATISFACTION THROUGH SOCIAL INTERACTION AND FORMAL CARE CENTER MANAGEMENT. *Asian People Journal (APJ)*, *9*(1), 1–15.

Mohd Pauzi, H., & Shahadat Hossen, M. (2025). Comprehensive bibliometric integration of formal social support literature for elderly individuals. *Housing, Care and Support*, 1–17.

Rahman, M. K., Hossain, M. A., Ismail, N. A., Hossen, M. S., & Sultana, M. (2025). Determinants of students' adoption of AI chatbots in higher education: the moderating role of tech readiness. *Interactive Technology and Smart Education*.

Rashed, M., Jamadar, Y., Hossen, M. S., Islam, M. F., Thakur, O. A., & Uddin, M. K. (2025). Sustainability catalysts and green growth: Triangulating evidence from EU countries using panel data, MMQR, and CCEMG. *Green Technologies and Sustainability*, 100305.