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An Efficient Cluster based Routing Protocol using Hybrid FCM-Q LEACH for Vehicular Ad Hoc Networks

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Abstract

Vehicular ad-hoc Network(VANET)comprise of vehicles with dedicated access points of communication. It transmits and receives the information from the Sensor Nodes (SNs) and environment to manage the traffic loads. So, the routing of destination, manage the speed and direction of vehicles are major issues in VANETs. The routing issue in VANETs overcome by using the hybridization of two clustering techniques Fuzzy C Means (FCM) and Quadrature- Low Energy Adaptive Cluster Hierarchy (Q-LEACH). First, the FCM based clustering cluster the network and then the network optimize by Q-LEACH. During the clustering process, the optimal Cluster Head (CH)chosen for aggregating the data from the SNs. This proposed method is named as FCM-Q LEACH-VANET. The communication from the Road Side Unit (RSU) to the Base Station (BS)was performed by using IEEE 802.11p protocol for minimizing the transmission time from the source (SN) to the BS. The performance of FCM-Q LEACH-VANET was analysed in terms of energy consumption, network latency, total packet sends and throughput. The result showed that the throughput of the FCM-Q LEACH-VANET is more compared to the existing IDVR protocol.

Keywords: Vehicular ad-hoc Network, Fuzzy C Means, Q-LEACH, IEEE 802.11p protocol, Energy consumption and Network latency.

1. INTRODUCTION

VANETs consisting of a network of vehicles moving at high speed, that communicates with RSU (V2R) or vehicle to infrastructure (V2I) and other vehicles (V2V). It helps to know real time details through wireless communications [1-2]. The RSU locates in critical locations like service stations, slippery roads, dangerous intersections and etc. [3]. The applications over the VANET are road safety, route planning, information services, user interactions, sharing traffic, cooperative driver assistance, road conditions, etc. [4]. A cluster based protocol used for effective data transmission in VANET. The cluster formed for intra cluster data transmission between SNs and inter cluster formed for RSU [5]. Dedicated Short Range Communication Standard (DSRC) introduced in VANET for enhancing the bandwidth and also it decreases the latency for V2V and V2I communications. The suitable DSRC range for both V2V and V2I is 1000 m [6-8]. The vehicles movement predicted by Predictive Variation algorithm. Additionally, the predictive clustering adopted for electing optimal clusters from the VANETs [9]. The single-layers routing protocols depends on the traditional layered Open Systems Interconnection (OSI) model and cross-layer routing allows information exchange between layers to gain superior network performance [10].

The proper selection of relay nodes gives high delivery ratio and the V2V multi hop dissemination provides the safety in the VANET. Here the useless transmissions avoided by ordering the node with respect to potential of each node [11]. The lightweight symmetric encryption and message authentication code are required to transmit the data over the vehicles [12]. The efficiency and road safety achieved by using Bayesian coalition game and learning automata (LA) in the mobile video surveillance system. Here the route is created based on the path score[13]. The reliable communication over the nodes are made by Hierarchical clustering algorithm (HCA) that is fast randomized clustering and the channel access is handled by scheduling algorithm [14]. The vehicle density and local aware routing protocol used in the network to identify the route that depends on the traffic load and distance to the receiver node. This routing protocol is aimed at finding an optimal route that reduces transmission delay and hop count with better achievement of the high packet delivery rate at the same time [15]. The cluster based VANET architecture created by a trust-based authentication scheme. The CHs are chosen based on the estimated trust degree and this trust degree is a combination of direct and indirect trust degree [16].

The major contributions of this research work are stated as follows:

- The energy consumption of the VANET architecture minimized by introducing the hybrid clustering technique that is a combination of FCM [17] with Q-LEACH [18]. This kind of clustering used for enhancing the network performance.
- The effective CH obtained from the clustering process. The CH receives the data from various sensor nodes and it aggregates this data. Then the data transmit to the RSU.

- Here the DSRC i.e., IEEE 802.11.p [19] introduced to decrease the latency on RSU to BS communication. The status of the vehicles and roads monitored by transferring the data from RSU to BS.

This research paper is organized as follows; the literature survey of the VANET is given in section 2. The section 3 explained the VANET using FCM with Q-LEACH based clustering. The section 4 evaluates the performance of the FCM-Q LEACH-VANET system and also it provides the comparative analysis. Finally, the conclusion of this research work is given in the section 5.

2. LITERATURE REVIEW

Razvan Stanica *et al.* [20] presented the Medium Access Control (MAC) layer properties in the safety vehicular ad-hoc networks. An efficient Intelligent Transportation System (ITS) was made by using Direct V2V communication. ITS and communications over vehicles pays a special attention toward VANETs MAC layer issues. The safety messages (e.g. lifetime) and the metrics related to the safety context ate broadcasted by the vehicular MAC layer. V2V communications will assist new protocols and mechanisms for the future vehicular network.

Lei Liu et al. [21] introduced a data dissemination scheme named Clustering and Probabilistic Broadcasting (CPB). The clustering was performed based on vehicles direction and its location. Here each vehicle takes own decision over the selection of CH in a distributed manner and this decision reduced the clustering management overhead. The forwarding probability of each vehicle was assigned based on the traffic condition and vehicle density. The packet delivery ratio affects with the increase of velocities of the node.

Michele Rondinone *et al.* [22] demonstrated a contention-based broadcast forwarding protocol. This broadcast forwarding protocol used for finding the transmission path which depends on the ability to route packets among the anchor points. Topology-aware contention-based forwarding algorithm provided a good packet delivery ratio and decreased the number of transmissions through the network. This method unable to explain routing discovery.

SabihurRehman*et al.* [23] presented a multi-hop cross layer decision based routing for VANETs. The routing mechanism used a queue buffer information and beaconing information in a MAC layer to minimize the routing objectives. At sometimes, this routing protocol was integrated with channel quality information and queuing information about other layers for delivering the information. The optimal values of channel quality indicator together with the queuing information for all vehicular environments under the realistic channel conditions not addressed in this paper.

G. G. Md. Nawaz Ali et al. [24] presented the Cooperative Load Balancing (CLB) between the RSUs which used their residual bandwidth to decrease the request drop rate because the RSU and vehicles have only less communication range. So, the remaining delay tolerance and knowledge about the fixed road layout is considered here in CLB, named as Enhanced CLB (ECLB) on V2I communication systems. The overloaded load was readjusted when the route of the vehicle changed while transferring the data to the destination. The energy consumption and number of successful messages sent to the destination not discussed is this paper.

The above-mentioned techniques have some disadvantages like issues in route discovery, channel conditions, etc. Here, these problems overcome by FCM-Q LEACH-VANET method and a clear explanation about this methodology described in the following sections.

3. FCM-Q LEACH-VANET

A VANETs can generally be partitioned/divided into a cluster. A Cluster is a set of SNs, wherein every pair of nodes connect through a multi-hop path. Here the clustering over the VANET perform by hybridization of FCM with Q LEACH clustering. This kind of clustering use for enhancing the network performance. The data from the cluster members (SNs) receive by CH and then it transfers to the RSU which is near to the optimal CH. The RSU transmits the data to the destination via IEEE 802.11.P. The following Figure 1 illustrates the FCM-Q LEACH-VANET.

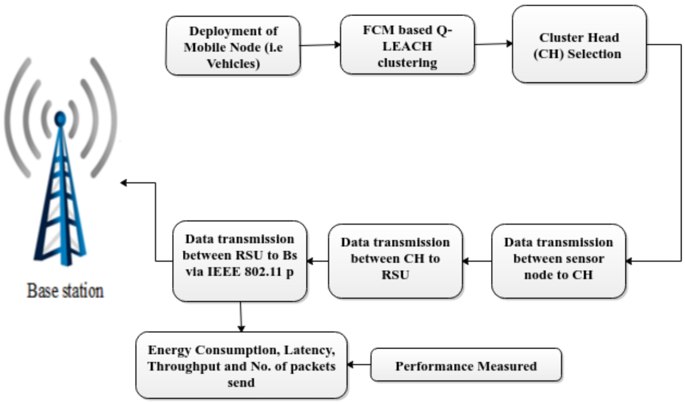

Figure.1. Block diagram of FCM-Q LEACH-VANET.

In this FCM-Q LEACH-VANET, the clustering is performed by FCM based Q-LEACH. The Q-LEACH clustering data aggregation method is used for clustering of node. Additionally, the Q-LEACH decreases the energy consumption and prolong the lifetime of ad-hoc networks.

The FCM-Q LEACH-VANET method consists of seven major steps such as

- Mobile Node Deployment
- FCM with Q-LEACH Clustering based data aggregation (In each quadrant, the clusters are generated and CH is selected from each cluster)
- CH selection of the respective clusters.
- Data transmission from nodes to the CH.
- Data received to CHs.
- Data from CHs transmit to the road side unit.

- Finally, Data from RSU transmit to BS via IEEE 802.11.p.

3.1. FCM based Q-LEACH clustering

3.1.1. FCM clustering

FCM is a centralized clustering algorithm [17]. The BS assigns the SNs into clusters based on the location about each SNs as well as the centroid is selected. The main objective of this FCM algorithm is to solve the problem of SNs distribution into clusters and this FCM minimize the objective function which is given in the following equation (1).Consider the network has M number of nodes, it is partitioned into c number of clusters like$c_1, c_2, c_3 \ldots c_m$.

$$J_m = \sum_{j=1}^{c} \sum_{k=1}^{M} \mu_{jk}^{m} \, d_{jk}^{2} \tag{1}$$

Where, the degree of belongingness of nodes$k$ to cluster j is represented as μ_{jk} and the euclidean distance between the node$k$ to the cluster center j is reprented as d_{jk}.

The centroids from the desired network is achieved by equation (2).

$$D_k = \frac{\sum_{j=1}^{M} \mu_{jk}^{m} O_j}{\sum_{j=1}^{M} \mu_{jk}^{m}} \tag{2}$$

Where, the centroid of kth cluster is denoted as $D_k$and $O_j$is the position of the j th node

The following equation (3) defines the membership function of FCM algorithm. The degree μ_{jk} of vehicle k respected to cluster is calculated and fuzzified with the real parameter $m > 1$ as below.

$$\mu_{jk} = \frac{1}{\sum_{l=1}^{c} \left(\frac{d_{jk}}{d_{kl}}\right)^{\frac{2}{m-1}}} \tag{3}$$

The above membership function updates in every iteration in terms of distance between each node. From this membership function, the group of SNs which have the least amount of distance cluster together. Energy balance between the nodes optimize by achieving the minimization of spatial distance.

The FCM algorithm is an iterative process, it is stated as follows,

1. Choose $(n > 1)$; The membership function values μ_{jk} are initialized,$j = 1,2, \ldots \ldots m; k = 1,2, \ldots \ldots c$.
2. Discover the cluster centres D_k,$k = 1,2, \ldots \ldots c$.
3. Calculate the Euclidean distance d_{jk}, $j = 1,2, \ldots \ldots m; k = 1,2, \ldots \ldots c$.
4. The membership function μ_{jk} is updated by equation (3), where $j = 1,2, \ldots \ldots m; k = 1,2, \ldots \ldots c$.
5. If it is not converged, go to step 2.

The FCM is stopped when the centroid values are small or the objective function is not reduced more.

3.1.2. Q-LEACH Cluster based data aggregation

The TDMA cycle of FCM CHs are added in Q-LEACH clustering [18] for achieving the hybrid combination of FCM based Q-LEACH clustering. Generally, the data aggregation is aggregating the data from the different sources which needs to send the information to the BS. The cluster based data aggregation creates use of the hierarchical structure in the network. In Q-LEACH, the network is divided into four clusters and from the clusters CHs are selected. The selected CHs are act as aggregation point to transfer the information to the RSU. Q-LEACH has two kinds of phase set up and steady state phase.

i) Set-up phase

In Q-LEACH, the network separates into four quadrants. The coverage of the whole network obtained by using this Q-LEACH. In VANET architecture, there are two sides of roads and each side roads divide as four quadrants by this Q-LEACH. For example, the nodes deploy on the road of 500m*500m field. In the middle of the road, the road side units placed for receiving the data from the CH which is elected by CH.For example, the left side direction road divided as four quadrants. Based on the location information of the vehicles, the network is divided as four quadrants such as $a_{l1}, a_{l2}, a_{l3}$and a_{l4}. This overall network division is given in the following equation (4).

$$A_1 = a_{l1} + a_{l2} + a_{l3} + a_{l4} \tag{4}$$

$$a_{ln} = A_1(x_m, y_m)$$

Where, n=4, because the network is divided as four quadrants. The overall distribution of a left side road is described as in equation (5).

$$A_1 = \lim_{x_m=0:250} a_{ln} + \lim_{x_m=0:250} a_{ln} + \lim_{x_m=250:500} a_{ln} + \lim_{x_m=250:500} a_{ln} \tag{5}$$

Energy consumption of this network achieve by dividing the network into quadrants. The optimum CHs over the nodes obtain via this network division and also the transmission load of other clusters reduce by using this clustering approach. This Q-LEACH better than the conventional LEACH. Because in conventional LEACH, the clusters are arbitrary in size and the CHs locate far from the cluster. Due to this nature, the network suffers from heavy energy loss as well as it degrades the network performance. But, in Q-LEACH the network is divided into quadrants and also the clusters and CHs obtained within the respective divisions. In general, set up phase have three different steps such as CH advertisement, cluster set up and generation of transmission schedule.

In the first step, the selected CH from the set up phase broadcasts the message to each node present in the network for informing the current state of the node. The random number generation of the Q-LEACH (between the 0 to 1) is used for deciding the node's state that is the node is either SN or CH. The mathematical expression for calculating the threshold value is given in equation (6).

$$T(n) = \begin{cases} \frac{P}{1-P[r_c * \text{mod}(1/P)]} \text{if} m \in g \\ 0 \text{otherwise} \end{cases} \quad (6)$$

Where, the threshold value is $T(n)$; percentage of CHs is P; the current round is r_c and the group of SNs which are CH for last $1/P$ round is g.

If the random number is less than the calculated threshold value, then the desired SN is selected as a CH and consequently the selected CH delivers the broadcast message to inform the status of the node. The information from the CH to the normal nodes are delivered in the second step. The CHs from the previous round is not selected as a CH again, until all the nodes present in the network to be a CH. Based on this consideration, each nodes of the VANET has equal chance to a CH. For current iteration, the connection between the SNs to the CH is decided by the received signal strength. Then the SNs transmits the information to the desired CH which is shown in the Figure 2. In third step, the selected CHs creates the TDMA schedule for the respective cluster members (i.e., nodes). The TDMA schedule is created mainly based on the number of nodes present in the VANET and then the nodes data transmission is mainly based on the TDMA schedule.

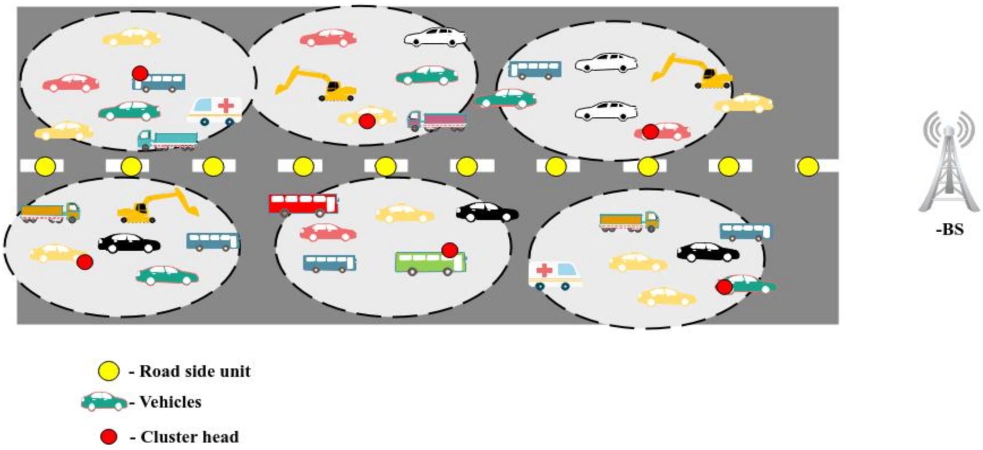

Figure.2. Setup phase for FCM-Q LEACH-VANET

ii) Steady state phase

In steady state phase, the TDMA schedule is used for the data transmission from the node to the CH and CH to the RSU. Based on the TDMA schedule, the nodes in the vehicle transmits the data to the CH. By changing the modes of the node (either active mode or sleep mode), the unwanted collision exist in the network is avoided. The CHs of the VANET is aggregated the data which is received from various SNs and then this data is transferred to the RSU. In each data transmission, the selected CH finds the channel to transmit the data from the CH to the RSU. The CH waits for data transmission until next round, when another CH transmitting the data to the same RSU. The steady state phase of FCM-Q LEACH-VANET is shown in Figure 3.

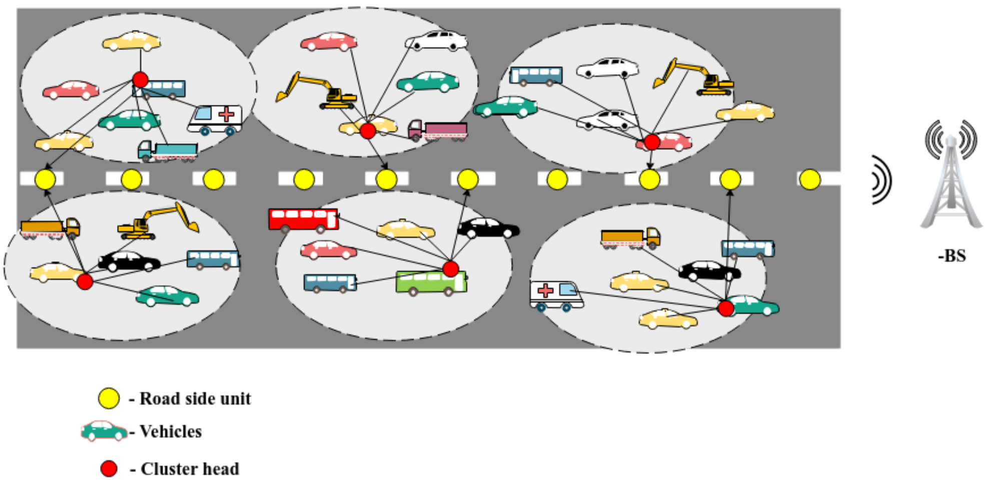

Figure.3. Steady state phase for FCM-Q LEACH-VANET

After electing the CH from the vehicles the data from the nodes are transmitted to the CH of the group of vehicles and the data from the CHs are transmitted to the RSU which is near to the CH. Then the data from the RSU is transmitted to the BS via IEEE 802.11 p protocol.

3.2. IEEE 802.11.P VANET system

In the vehicular environment, the IEEE 802.11p [19] has introduced for allowing the communications among the RSU to BS. This IEEE 802.11p has a set of physical (PHY) and MAC layer specifications. The IEEE 802.11p is functioned in the DSRC frequency band of 5.85-5.925 GHz and also the MAC layer of the IEEE 802.11p is an extended version of the 802.11a. The core mechanism present in the IEEE 802.11p MAC layer is Enhanced Distributed Channel Access (EDCA). The EDCA is indicated in 802.11e and it is mainly depending on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) scheme.

The algorithm for overall FCM-Q LEACH-VANET is given as follows:

Input: Location of the vehicles ($v1, v2, \ldots vn$), RSU locations ($Rloc$) and BS location ($Bsloc$)

Output: CH_id (The vehicle node which wants to transmit the information from some of the cluster member)

1. The CH_id of FCM is selected from the equation (2).

$$fori = 1: iter$$

$iter$ is the maximum iteration count

2. The TDMA cycle of CH_id of FCM is updated in BS.

3. S_id=random(v);

S_id the random vehicle node wants to transmit the data to their network.

4.The left side road area is divided based on the equation (5).

5. $T(n)$ is calculated by equation (6).

6. $R \leftarrow random(0,1)$

7. $if\ (S\_id\ belongs\ to\ = \text{‘}al1\text{’})$

    $v = val1;$

The nodes are in the communication range of CH_id that is selected by the FCM.

    $for\ k = 1: length\ (v)$

    $if\ (R < T(n))$

    $CH\_id\ =\ v(k);$

    end

    end

end

The RSU which have minimum distance is elected for receives the data from the CH_id.

8. $forj = 1: length(RSUloc)$

$dist\_RSU = sqrt(CH_{id(x)} - RSUlocj(x))^2 + sqrt(CH\_id(y) - RSUlocj(y))^2$;

$$[id] = \min(dist\_RSU);$$

$$end$$

9.$Rloc = RSUloc(id);$

10. CH_id sends the data to $Rloc$

#$Rloc$ is the ID of the RSU unit.

11.$Rloc$ transfers the information to destination (BS).

Communication between the RSU and BS is occurred through the IEEE 802.11.p

end

4. EXPERIMENTAL SETUP

The FCM-Q LEACH-VANET system is developed by MATLAB 2015b software (for the simulation purpose). Here, the hybridization of FCM with Q-LEACH clustered the nodes in the VANET architecture. For analysing the performance of the FCM-Q LEACH-VANET system, the node counts are varied from 100 to 400.The following Table 1 shows the simulation parameters which is used in the proposed methodology.

Table 1. Simulation parameters

Parameter	Value
Area	500*500 m^2
Sensor nodes	100, 200, 300 and 400
Road side unit	10
Number of simulation iterations	100
Clustering protocol	FCM with Q-LEACH
Base station location	650, 250
MAC protocol	IEEE 802.11p
Type of channel	Wireless channel
Packet size	4000 bits
Message size	200 bits

5. RESULTS AND DISCUSSION

The proposed method implemented with different number of SNs and 10 road side units. The performance of FCM-Q LEACH-VANET analysed with Intersection Dynamic VANET Routing (IDVR) [25] to know the VANET efficiency. The coverage area of the entire network is 500*500 m^2 and the position of the BS is 650, 250.The performance parameters which are analysed in this system described in the following sections.

5.1. Energy consumption

The total amount of energy requires for each node to deliver the message through the path that is from the CH to RSU and RSU to BS. The energy consumption of an entire network is given in equation (7).

$$E_c = E - (E_T - E_R) \quad (7)$$

Where, E_c represents energy consumption of the WSN, E is the total amount of energy, the transmitting and receiving energy is represented as E_T and E_R respectively.

5.2. Throughput

Throughput is defined as a number of successful messages delivered to the destination as well as this value should be high for an effective data transmission and the throughput is given by the following equation (8).

$$T_H = N_T \times P_L \quad (8)$$

Where, T_H is throughput of the network, N_T is total number of rounds and P_L is the packet length.

5.3. Latency

Network Latency is the communication of how much time it takes for transferring the packet of data from source to BS. The mathematical expression for the latency is given in the following equation (9)

$$L = d_{tot}/S + P_L \quad (9)$$

Where, L is network latency, total distance from the source to the BS is represented by d_{tot}, speed of the nodes is S.

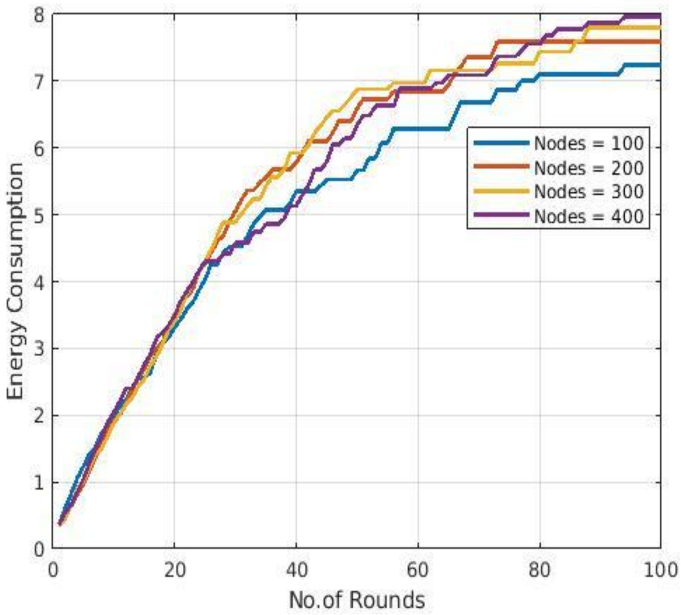

Figure 4. Comparison of energy consumption

Figure 4 shows the comparison in terms of energy consumption for FCM-Q LEACH-VANET method by varying the number of nodes. Energy consumption significantly decreased by considering the distance between each SN and number of hops present in each CH. If the hop count of a CH is high, it will lead to consumes more energy while performing the data transmission. Furthermore, the load among the CH is maintained for reducing the energy utilization of an entire network. The lifetime of the network is more, when the energy consumption of a network is too less.

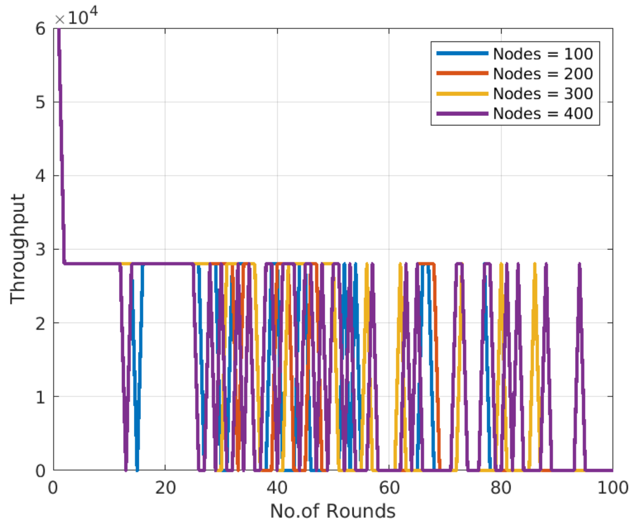

Figure 4. Comparison of throughput

Figure 5 shows the FCM-Q LEACH-VANET comparison of throughput. The throughput of the entire network maximized by making the successful transmissions without any packet loss. The throughput of the network maximized by using the optimal transmission path.

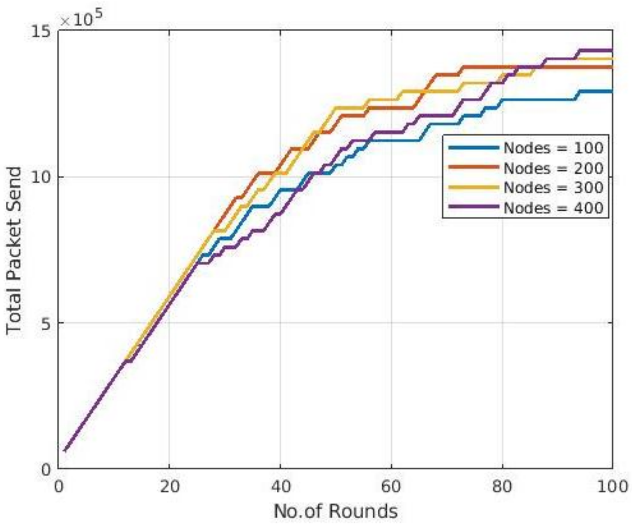

Figure 6. Comparison of total packet send

Figure 6shows the energy consumption comparison of FCM-Q LEACH-VANET by varying the number of nodes. The packet sends to the BS increased by considering the energy of each vehicle while creating the shortest path. By considering the energy, the link failure among the vehicles are avoided. Because, throughput of the entire network is maximized by making the successful transmissions without any packet loss.

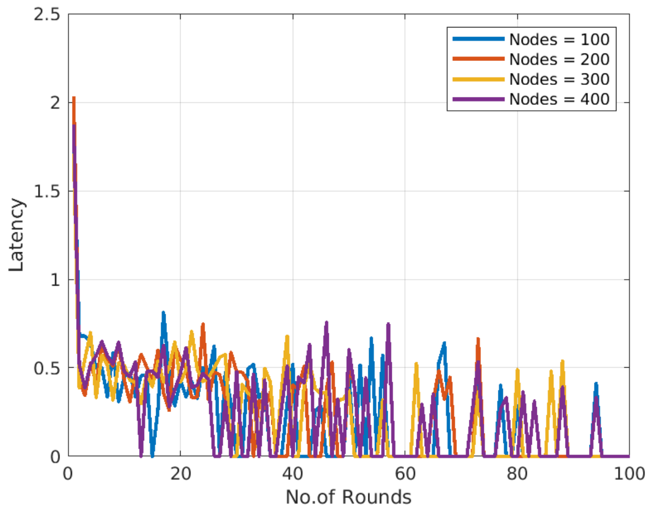

Figure 7. Comparison of latency

Figure 7 shows the network latency comparison of FCM-Q LEACH-VANET by varying the number of nodes. The latency of the network improved by generating the shortest route from the source node to the BS. Because, the latency of the network is depends on the distance from the source node to the BS.

The performance of the FCM-Q LEACH-VANET analysed using IDVR [25]. In this IDVR protocol, a route is selected based on the current location and destination location. The FCM-Q LEACH-VANET have a high amount of throughput compared to the IDVR protocol. The FCM-Q LEACH-VANET selects the CH based on the T(n) value and this method does not select the same vehicle as CH in another iteration. This consideration used for avoiding the link failure and packet drop. Based on the random probability of selecting the vehicles as a CH, the throughput of the VANET becomes increased. The following Figure 8 shows the comparison for the FCM-Q LEACH-VANET and IDVR. Then the comparison is made when both the system transmits 512 bytes of packet size in each iteration.

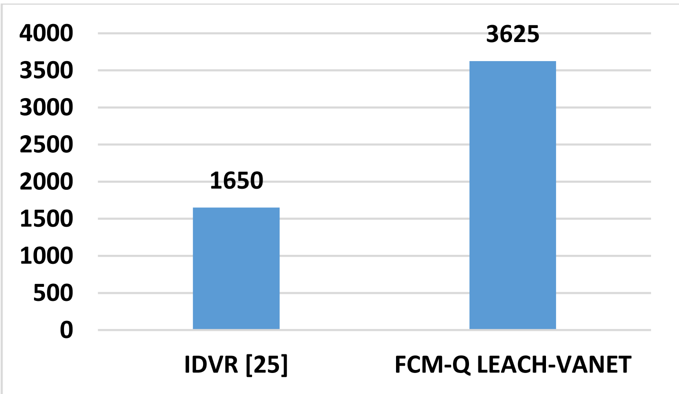

Figure 8. Comparison of IDVR [25] and FCM-Q LEACH-VANET in terms of throughput

6. CONCLUSION

This paper presented a hybridization of FCM based Q-LEACH clustering using the VANETS. The optimal CH from the group of SNs obtained through this clustering. This CHs transmit the collected information to the road side unit which is near to CH. The communication from the RSU to the BS occurred via IEEE 802.11.p protocol. Here, total 9 classes of messages transmitted through the vehicles like roundabouts, accident, etc. Based on the information from the BS, the users come to know about the road side environment. The performance of this FCM-Q LEACH-VANET analysed in terms of energy consumption, total packet send, throughput and network latency. Results showed that the FCM-Q LEACH-VANET has better performance in terms of throughput compared to the IDVR [25] protocol.

REFERENCES

[1] Yang, Z., Wu, W., Chen, Y., Lin, X. and Chen, X., 2017, October. Navigation Route Based Stable Clustering for Vehicular Ad Hoc Networks. In International Conference on Communications and Networking in China (pp. 552-562). Springer, Cham.

[2] Ramakrishnan, B., Selvi, M., Nishanth, R.B. and Joe, M.M., 2017. An Emergency Message Broadcasting Technique Using Transmission Power Based Clustering Algorithm for Vehicular Ad Hoc Network. *Wireless Personal Communications*, *94*(4), pp.3197-3216.

[3] Bitam, Salim, Abdelhamid Mellouk, and Sherali Zeadally. "HyBR: A hybrid bio-inspired bee swarm routing protocol for safety applications in vehicular ad hoc networks (VANETs)." Journal of Systems Architecture 59.10 (2013): 953-967.

[4] Kakkasageri, M. S., and S. S. Manvi. "Multiagent driven dynamic clustering of vehicles in VANETs." Journal of Network and Computer Applications 35.6 (2012): 1771-1780.

[5] Abbas, Fakhar, and Pingzhi Fan. "Clustering-based reliable low-latency routing scheme using ACO method for vehicular networks." Vehicular Communications 12 (2018): 66-74.

[6] Daeinabi, Ameneh, Akbar Ghaffar Pour Rahbar, and Ahmad Khademzadeh. "VWCA: An efficient clustering algorithm in vehicular ad hoc networks." Journal of Network and Computer Applications 34.1 (2011): 207-222.

[7] Kumari, N.D. and Shylaja, B.S., 2017. AMGRP: AHP-based multimetric geographical routing protocol for urban environment of VANETs. Journal of King Saud University-Computer and Information Sciences.

[8] Bilal, Sardar Muhammad, Carlos Jesus Bernardos, and Carmen Guerrero. "Position-based routing in vehicular networks: A survey." Journal of Network and Computer Applications 36.2 (2013): 685-697.

[9] Bali, R.S., Kumar, N. and Rodrigues, J.J., 2017. An efficient energy‐ aware predictive clustering approach for vehicular ad hoc networks. *International Journal of Communication Systems*, *30*(2).

[10] Awang, A., Husain, K., Kamel, N. and Aïssa, S., 2017. Routing in Vehicular Ad-hoc Networks: A Survey on Single-and Cross-Layer Design Techniques, and Perspectives. *IEEE Access*, *5*, pp.9497-9517.

[11] Alotaibi, M.M. and Mouftah, H.T., 2017. Relay Selection for Heterogeneous Transmission Powers in VANETs. *IEEE Access*, *5*, pp.4870-4886.

[12] Wang, M., Liu, D., Zhu, L., Xu, Y. and Wang, F., 2016. LESPP: lightweight and efficient strong privacy preserving authentication scheme for secure VANET communication. *Computing*, *98*(7), pp.685-708.

[13] Kumar, N., Lee, J.H. and Rodrigues, J.J., 2015. Intelligent mobile video surveillance system as a Bayesian coalition game in vehicular sensor networks: Learning automata approach. *IEEE Transactions on Intelligent Transportation Systems*, *16*(3), pp.1148-1161.

[14] Dror, E., Avin, C. and Lotker, Z., 2011, June. Fast randomized algorithm for hierarchical clustering in vehicular ad-hoc networks. In *Ad Hoc Networking Workshop (Med-Hoc-Net), 2011 The 10th IFIP Annual Mediterranean* (pp. 1-8). IEEE.

[15] Li, C., Zhao, C., Zhu, L., Lin, H. and Li, J., 2014. Geographic routing protocol for vehicular ad hoc networks in city scenarios: a proposal and analysis. *International Journal of Communication Systems*, *27*(12), pp.4126-4143.

[16] Sugumar, R., Rengarajan, A. and Jayakumar, C., 2018. Trust based authentication technique for cluster based vehicular ad hoc networks (VANET). *Wireless Networks*, *24*(2), pp.373-382.

[17] Izakian, Hesam, Ajith Abraham, and Václav Snášel. "Fuzzy clustering using hybrid fuzzy c-means and fuzzy particle swarm optimization." Nature & Biologically Inspired Computing, 2009. NaBIC 2009. World Congress on. IEEE, 2009.

[18] Verma, Deeksha, and Satbir Singh. "Quadrature Based Energy Efficient Hierarchical Routing Protocol for Heterogeneous Wireless Sensor Networks." International Journal of Current Engineering and Technology 5.3 (2015): 1921-1925.

[19] Campolo, C. and Molinaro, A., 2011, March. On vehicle-to-roadside communications in 802.11 p/WAVE VANETs. In Wireless Communications and Networking Conference (WCNC), 2011 IEEE (pp. 1010-1015). IEEE.

[20] Stanica, R., Chaput, E. and Beylot, A.L., 2012. Properties of the MAC layer in safety vehicular ad hoc networks. *IEEE Communications Magazine*, *50*(5).

[21] Liu, L., Chen, C., Qiu, T., Zhang, M., Li, S. and Zhou, B., 2018. A Data Dissemination Scheme based on Clustering and Probabilistic Broadcasting in VANETs. Vehicular Communications.

[22] Rondinone, M. and Gozalvez, J., 2013. Contention-based forwarding with multi-hop connectivity awareness in vehicular ad-hoc networks. Computer Networks, 57(8), pp.1821-1837.

[23] Ur Rehman, S., Khan, M.A. and Zia, T.A., 2015. A multi-hop cross layer decision based routing for VANETs. Wireless Networks, 21(5), pp.1647-1660.

[24] Ali, G.M.N., Chong, P.H.J., Samantha, S.K. and Chan, E., 2016. Efficient data dissemination in cooperative multi-RSU vehicular ad hoc networks (VANETs). Journal of Systems and Software, 117, pp.508-527.

[25] Abuashour, A. and Kadoch, M., 2017. Performance improvement of cluster-based routing protocol in VANET. IEEE Access, 5, pp.15354-15371.