A clustering approach to improve VANETs performance

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ABSTRACT

Vehicular ad-hoc network (VANET) is a technique that uses cars moved in cities or highways as nodes in wireless networks. Each car in these networks works as a router and allows cars in the range to communicate with each other. As a result of this movement, some cars will become out of range, but these networks can connect to the internet and the cars in these networks can connect to each other. This research proposes a unique clustering strategy to improve the performance of these networks by making their clusters more stable. One of the biggest problems these networks face is traffic data, which consumes network resources. Agent based modeling (ABM) evaluates better networks. The evaluation showed that the proposed strategy surpasses earlier techniques in reachability and throughput, but ad hoc on-demand distance vector (AODV) (on-demand/reactive) outperforms it in total traffic received since our hybrid approach needs more traffic than AODV.

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1. INTRODUCTION

Although vehicular ad-hoc network (VANET) is not a new subject, it gives a new research challenges and problems. The main goal of VANET is to help a group of vehicles to communicate to each other without controller or any other infrastructure [1]. Autonomous vehicle (AV) technology offers the possibility of fundamentally changing transportation. Equipping cars and light vehicles with this technology will likely reduce crashes, energy consumption, and pollution and reduce the costs of congestion [2]. The VANET is a challenging field in wireless networks and can be considered as a branch from mobile ad-hoc networks (MANETs), but it differs in path prediction and higher node speed [3]. The main benefit from using clustering approach in VANET is to reduce network traffic in addition to congestion [4]. Many studies wish to reduce collision and congestion. The clustering approach restrict network communications in specified area which is inter cluster and this will reduce total messages [5]–[7]. As well as, the clustering approach allow the cluster head to accumulate and collect the packets and this will reduce total message received [8], [9]. We use two most popular protocols for comparison with our clustering approach ad hoc on-demand distance vector (AODV) which is reactive routing protocol and destination-sequenced distance vector (DSDV) which is proactive routing protocol. The disadvantage of DSDV is discover the routes even they are not needed and this take heavy control update because of overhead [10]. The ad hoc on demand routing protocol has many benefits, such as fast convergence and modest overhead and it's considered to raise hopes for the future protocol [11].

The deployed sensors/vehicles must have an ability to communicate with each other's in order to transmit their data. They can be used in any environment system with terrain, where physical placement is difficult and wired connections are not possible [12]. VANET networks are identified by high topology change, high mobility, and inconsecutive links and there is no much energy constraints by vehicle attached with. Classically the routing mechanism isnt able to meet these requirements. So, we propose a clustering approach to enhance VANET performance. The main goal of this approach is to enhance VANET performance according routing constraints such as high changing in topology, high mobility, and inconsecutive links. Our contributions under routing problems in VANETS are, we investigate routing problems and fairy solve it. The contributions of our article may be outlined as follows: i) initially, we define routing challenges in VANETs by investigating these network requirements, ii) a clustering approach to enhance VANETs performance is proposed to fairy overcome the VANETs challenges, iii) our clustering approach is compared with most popular two VANETs routing protocols, AODV and DSDV which are re-active and pro-active respectively in terms of reachability, total traffic received and throughput, and iv) simulation results showed that our proposed approach is able to give higher reachability, total traffic received and throughput than AODV but DSDV overcome it in one term is total traffic received. The remaining of article is structured as steps, related works are discussed in section two, in section three we introduce the steps of proposed approach, in section four we introduce the simulation results and discussion, and finally in section five we introduce the conclusion of proposed approach.

- Related works

Pandey *et al.* [13] modifying sensor protocol for information via negotiation (SPIN) protocol to cluster based SPIN protocol is done by this paper. By implementing cluster based CB-SPIN in the network, each node in the network can be accessed by one hope. So that, the information is separated in the network very fast with conserving energy. If the required is only transferring data from source to sink then this protocol can be modified easily to low-energy adaptive clustering hierarchy (LEACH) by adding sink node. According to Ardakani [14], a new addressing method in this paper is used to develop clustering routing protocol for VANET, in this approach, each node take it address depending on how its move. The hamming distance is used to divide the network depending on the address. The result of simulation fined this protocol is reduced reachability and end 2 end delay time and total traffic received comparing with AODV and DSDV. According to Salih and Khudhair [15], software defined network (SDN) based routing framework for FANET flight ad-hoc network (ASR-FANET) is proposed in this paper to solve many problems in routing protocols. This approach includes three important parts. First, topology finding, where network information is periodically collected about the nodes and links. Second, gathering the statistics where wireless network status and statistics of flights is collected. Third, routes computation is occurred where the optimal path is computed. The ASR-FANET performance is evaluated using simulation and comparing. The simulation result showed that the proposed approach was better than traditional protocols in terms of end-to-end delay time, throughput, normalizing routing load, packet delivery ratio and packet loss. According to Salih *et al.* [16], a novel method for data gathering is proposed depending on Internet of Things using FANET. The main goal of this method is to solve deadline problem for FANET in IoT depending on multi objective optimization model. After that a normalizing occurs, then two weight coefficients are added to solve mixed integer linear program (MILP) problem. The simulation result showed active data accruing can be done by proposed method and grantee time of deadline. According to Gajare *et al.* [17], cluster formation algorithm run on the vehicular environment so as to have a stable form of communication amongst the vehicles. According to Hussain and Bingcai [18], a new method to select the cluster head is proposed, the k-mean algorithm is used. In this method, initially vehicles groups are divided when Floyed-Warshall algorithm calculate the shortest distance for each pair of vehicles of cluster. The minimum average distance of vehicle between clusters is selected as cluster head. Where Floyed-Warshall algorithm select the central vehicle as cluster head. So, the stability time will improve significantly. According to Debnath *et al.* [19], a VANETs protocol is adopted considering, number, position, and transmission region of vehicles to improve quality of service (QoS), overhead of packet control and end to end delay time.

2. METHOD

Initially the cars are divided into groups according transmission range. Each node measures the distance to the neighbour nodes, if the neighbour node distance from the centric node less than or equal to transmission range then the neighbour node will include in the same group of the centric node, the cluster selected in the centre of each cluster where it can connect to all nodes in the cluster. After that the cluster head is updated periodically according the cluster members updating through location change. The cluster head updating is increased when there is increasing in changing the locations of each neighbour car.

Selecting the gateway node depending on its location where the distance between two cluster heads is measured and the gateway node will be in mid of these two cluster heads and on bound of clusters where it’s selecting depending on closest node to the half distance point.

a. Joining node: when new node is come, monitoring is occurred to check neighbour node’s location where the distance between new node and neighbour nodes is measured and the node will become cluster member to the closest cluster head.
b. Disconnecting node: there are two cases:
- Leaving cluster head: when a cluster head leaves a cluster to another location, the location information is computed and the distance is measured to each neighbour cluster head, the new member will belong to closest cluster head. The fate of cluster that lost his cluster head will re-elect new cluster head by using location information where the closest node to the centre point of cluster will select as cluster head. If there is no cluster head in range the disconnected node will form new cluster and monitor neighbour nodes if it’s in range to grow his cluster.
- Leaving node: when a node leaves its cluster during changing its location it will search to closest cluster head to belong to its cluster, if there is no cluster head in rang, it will make itself as cluster head and re-arrange the neighbour nodes if it’s in range as members in new cluster.

c. Updating cluster head: when the square deviation became steady for specific times the updating cluster head procedure will stop and so that clustering process will stop until changing in topology occur, the square deviation is calculated by the summation of square distance from cluster head to the member nodes of same cluster according to Figure 1 shows a flowchart of suggested framework. Figure 2 shows square deviation algorithm. Table 1 shows min and max for x and y for 11 cluster lines. Table 2 shows x and y of two clusters lines of square deviation with colours of 95 and 85. Figure 3 shows changing in square deviation for 11 cluster shows how square deviation changes its value and then become steady.

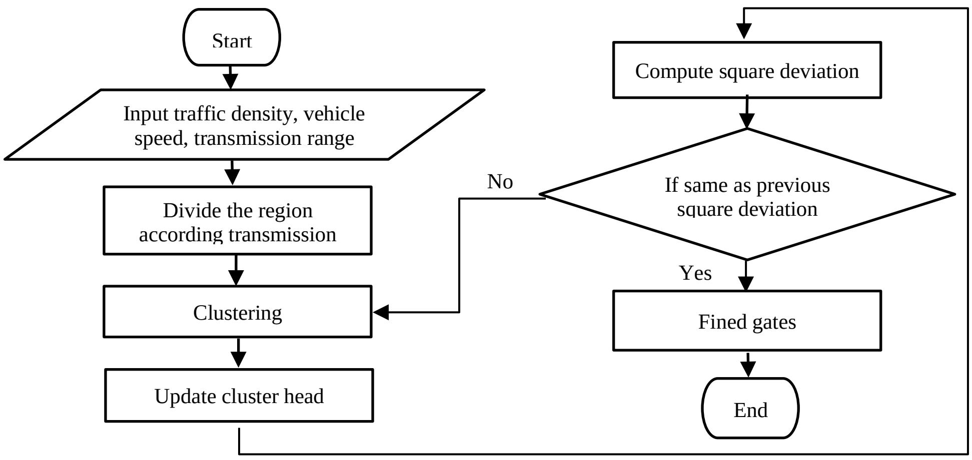

Figure 1. Flowchart of suggested framework

Inputs: the coordinates for all vehicles.
Outputs: Square deviation for all clusters.
Process:
Begin
For (all cluster heads vehicles) do
M ⟵ Closest one of cluster heads (CHs)
C ⟵ Color of m.
TR ⟵ transmission range.
For (all vehicles of C color) and (distance to C<= TR) do
SquareDeviation ⟵ (distance to m)^2.
SquareDeviation ⟵ SquareDeviation + SquareDistance.

Figure 2. Square deviation algorithm

Table 1. Min and max for x and y for 11 cluster lines

x min	x max	y min	y max	autoplot?	current pen	number of pens
0	17.5	0	351,000	TRUE	"105"	11

Table 2. x and y of two clusters lines of square deviation with colors of 95 and 85

X	*y*	*color*	*pen down?*	*X*	*y*	*color*	*pen down?*
0	6315.488	95	TRUE	0	19053.86	85	TRUE
1	20898.5	95	TRUE	1	76446.12	85	TRUE
2	20898.5	95	TRUE	2	76446.12	85	TRUE
3	21164.77	95	TRUE	3	114137.5	85	TRUE
4	21164.77	95	TRUE	4	114137.5	85	TRUE
5	17669.89	95	TRUE	5	98159.6	85	TRUE
6	17669.89	95	TRUE	6	98159.6	85	TRUE

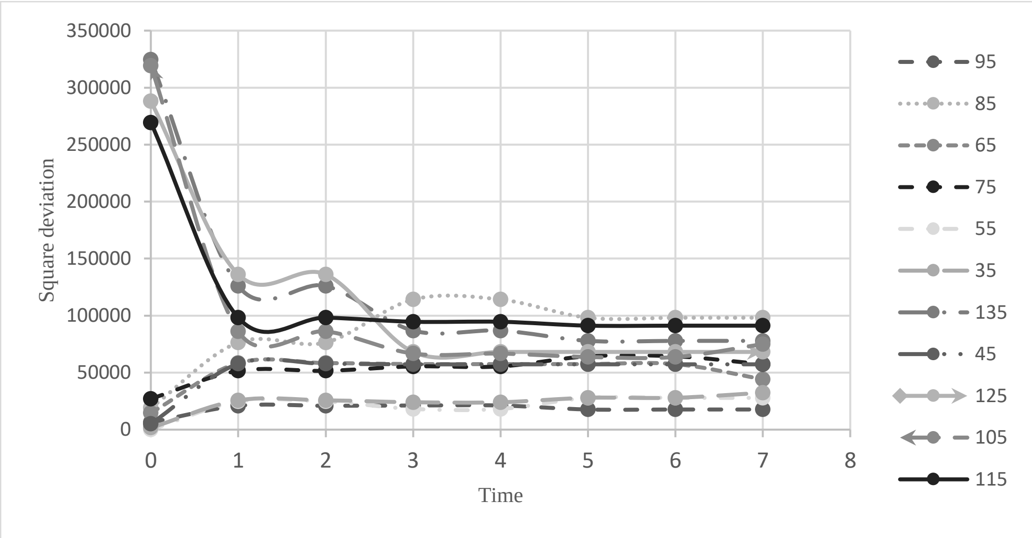

Figure 3. Changing in square deviation for 11 cluster

3. RESULTS AND DISCUSSION

Investigations are well done to know how well our approach achieve the goal. We did comparative analysis between vehicular cluster based routing protocol (VCBRP), DSDV, and AODV. We utilized these protocols because it's most popular in the previous works. We compare our approach with these two protocols in terms of reachability, total traffic received and throughput, Figure 4 shows how VCBRP clustering approach work. Where each cluster represented by specific colour, in the centre of each cluster there a cluster head with grey colour and CH label of same cluster colour, the gate way node is represented by fire engine, the colour lines are represent the links between cluster heads and gate ways nodes.

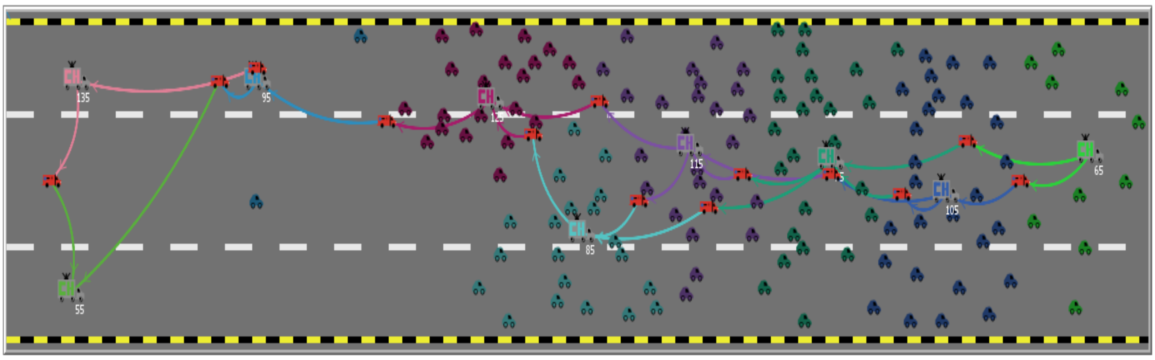

Figure 4. How VCBRP clustering approach work

3.1. Reachability

The reachability is calculated by finding the ratio of number of successful routes finding to the total number of routes finding [20], [21]. Figure 5 shows reachability for VCBRP, AODV, and DSDV. Illustrates the change of reachability through increasing the velocity of nodes. We find the reachability is reduced when we increased the nodes velocity because the increasing in velocity will increase network topology changing and this will reduce the reachability and this reduction will increase by using proactive routing. The performance of VCBRP outperform the performance of AODV in term of reachability due the clustering technique. VCBRP divides the network into clusters, each cluster considered as one unit which is moves through network and this mechanism will reduce routing table updates because the moving of any node inside the cluster will not change the network topology unless leave the cluster. The proactive routing mechanism reduces the reachability because the routing information used is expired and this give the chance be minimized to access destination node like in DSDV whereas the reachability will increase through using reactive rotting protocols because collecting dynamically updated routing information according nodes movement this mean the changing of finding root is reduces through reactive because of using updated on-demand routing information.

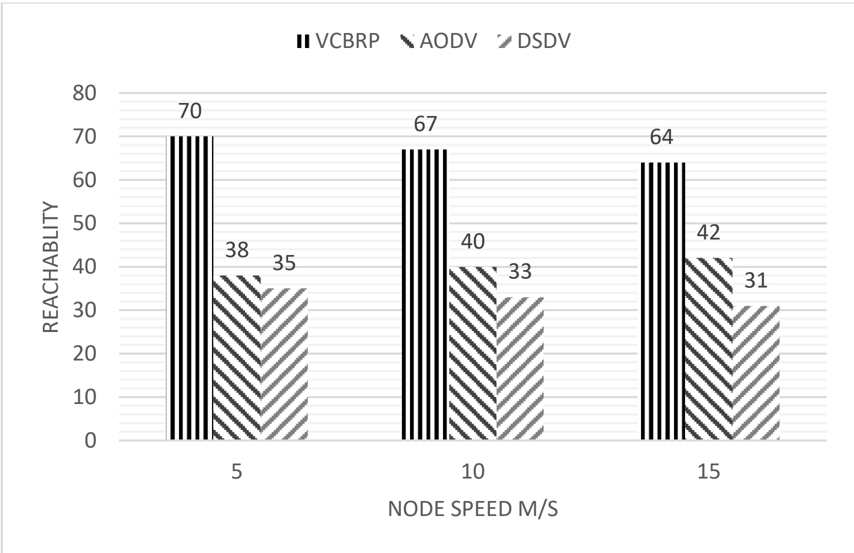

Figure 5. Reachability for VCBRP, AODV, and DSDV

3.2. Total traffic received

The increment in network traffic has its effect to reduce network throughput and this will increase network congestion and probability of message failure to access connection media will increase, therefore the increment in network traffic will grow network resources consumption such as bandwidth and connection media to transmit wireless network data packets, so the network resources utilization will increase if network traffic increased [22]. In addition, the increment in network traffic will increase the end-to-end delay time and this will increase the waiting time to access network wireless channel [23], [24]. So, the network data packet will place in queue if the channel not available to transmit data and this will increase the waiting time because the idle listening time. Therefore, the network traffic increment will grow data packets failures and as a result for this grow the packet delivery time will increased, so the packet will resend until it arrives to receiver Figure 6 shows total traffic received for VCBRP, AODV, and DSDV.

From the Figure 6, we found AODV outperform VCBRP and DSDV. The cause of this results is The AODV is on demand routing protocol that is mean its work according updated rout information created immediately when needing whereas DSDV is work according pro-active table created in previous time, so it's have old information may be changed. The VCBRP is stand between the two others because its hybrid routing protocol, work according re-active and pro-active routing mechanisms where its search in the routing table and achieve recent routing information. These two mechanisms required more traffic information than AODV but less than DSDV.

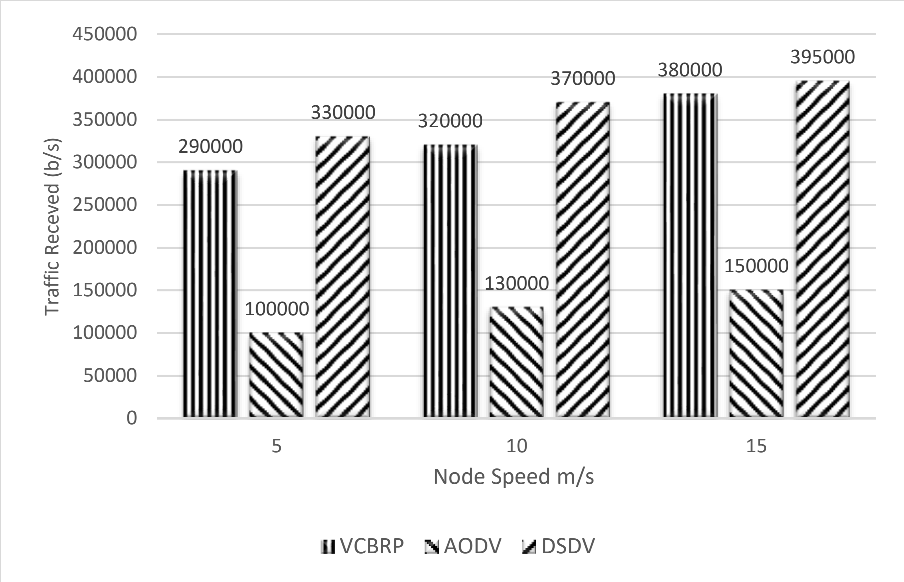

Figure 6. Total traffic received for VCBRP, AODV, and DSDV

3.3. Troughput

The ratio of successfully received packets to the total packet sent, the throughput usually measured by bits per second and sometimes by packets per seconds or by data per time slot, this data may be sent by physical link, logical link or by node. The number of dropped packets is reduced due of throughput increasing [25], [26]. Figure 7 shows packet dropped for VCBRP, AODV and DSDV. $Throughput = {\sum packets\ successfully\ received}\Big/{\sum packed\ sent}$ [22].

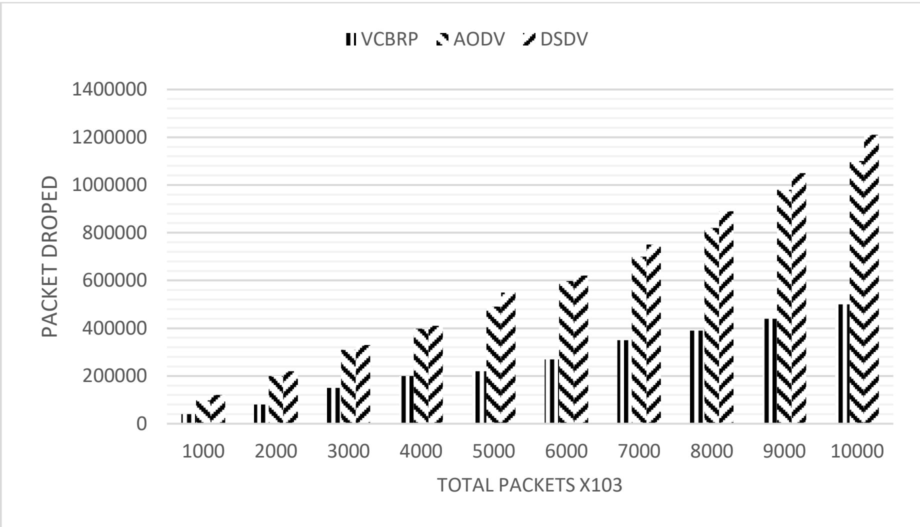

Figure 7. Packet dropped for VCBRP, AODV, and DSDV

The Figure 7 explain how our approach work in comparing with AODV and DSDV, where we found that we have minimum packet dropped than AODV and DSDV and this give guaranty to access the packet to the destination. In the face of the total traffic received of our approach was higher than AODV and we explained the cause previously, the reachability of VCBRP was the best, therefore the packet will access to its destination without fail. As a result, will decrease dropped packets and increase throughput.

4. CONCLUSION

The VANET is divided into clusters according vehicle's location and transmission range, the goal behind this mechanism is to reduce traffic received and as a result of this will improve performance of network, in this mechanism each vehicle is located in specific cluster according its location using lightweight technique for the clusters and this will reduce network traffic comparing with DSDV. This mechanism uses intra-cluster proactive and reactive routing to reduce dropped packets comparing with AODV which is just on-demand routing protocol. In addition, there is noteworthy effect of node mobility pattern upon network topology because the clusters are moved independently so the node mobility didn't lead to topology change and grow of reachability comparing with AODV and DSDV.

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