IBCAV: Intelligent Based Clustering Algorithm in VANET

Mehrnaz Mottahedi[1], Sam Jabbehdari[1] and Sepideh Adabi[1]

[1]Computer Engineering Department, North Tehran Branch, Islamic Azad University, Tehran, Iran

Abstract

Study of Vehicular Ad-hoc Networks (VANETs) is among challenges facing researchers today. Nodes in such networks have a relatively high speed, while there is a great shortage of the time needed for data transmission between them as a result of node speed difference as well as persistent changing of the network. Consequently, routing algorithms and modes of access to the conductor is considered as a serious challenge in such networks. In this context, researchers have introduced various protocols, including cluster-oriented methods to overcome such challenges. In cluster-oriented methods, it is of vital importance to select a sustainable cluster with due regards to the high speed and density of nodes. The proposed method is called Intelligent Based Clustering Algorithm in VANET (IBCAV), The present project seeks to improve routing algorithms in VANETs by employing inter-layered methods, awareness of the existing traffic flow as well as combination of various factors on the basis of a smart method based on artificial neural network. Here cluster size, speed and density of nodes are the factors which have taken into account. Finally, our simulated results show that the IBCAV outperforms better than AODV, DSR and epidemic routing in terms of packet delivery ratio, end-to-end delays and throughput.

Keywords*: *VANET, Routing, Clustering, artificial neural network

1. Introduction

VANET is a special form of MANET which is a vehicle to vehicle and vehicle to roadside wireless communication network. It is an autonomous and self-organizing wireless communication network. The purpose of VANET is transferring data with high speed and minimizing the delay in a communication range. Due to the nature of mobile nodes in the VANET, the location is constantly changing. Given the distinct features of VANET, different problems are tackled by the researchers. The main part of research works has focused on routing algorithms. Since the wireless nodes in VANET, i.e., vehicles are faster than nodes in a usual MANET and the mobility patterns of vehicles are confined to road maps and thus more predictable, selecting a suitable routing algorithm is significant. Two main types of common routing protocols in VANET are Proactive and Reactive.

Proactive algorithms rely on the tables containing nodes data. Since vehicles are in a constant change of their positions accompanied by rapid change of network topology, therefore the routing data in those tables rapidly lose their validity. To keep validity of the huge amount of data should be communicated between the nodes, which cause such algorithms to use a high bandwidth. Proactive algorithms are also known as table-based algorithms. DSDV, OLSR and STAR are referred as the algorithms used for routing purposes, which as expected, use a high bandwidth [1,2]. Reactive algorithms, on the other hand, operate to detect a route only when there is a need to a route. AODV, DSR and TORA are algorithms that use this method for routing.

Disadvantage of the proactive method relates to its poor scaling system, while the problem with reactive method is that before transmission of the first packet it needs to detect the route, thus leading to longer transmission time and when the route detected from its original point of departure to its destination may disappears even before transmission of the first packet due to the high movement of the nodes. Meanwhile, active duration of a route declines with the number of hops. A route may fade away at the same speed it appeared [3,4].

The moving nature of nodes in VANETs and the fact that they are constantly changing positions, has made researchers use the location of the nodes in order to be able to communicate with the specific node for transmission of messages, an initiative which resulted in routing based on position. In routing based on node position, a device, for example, Global Positioning System can help pinpoint the position of every node as well as that of the destination node. GSR, GPSR are algorithms that use this method for routing [5,6].

Also due to the high mobility of nodes in VANET the topology is changing constantly, so in this situation to keep the communication between nodes all nodes must constantly sending packages to update their tables that have led to widespread storms in the network. The research on the issue of scalability in VANET where there are a high number of nodes, it has been shown that the clustering approach is an efficient solution to the scalability issue.

In clustering methods, the moving nodes are categorized into different groups and stand together in one single cluster. Nodes in each cluster can have different roles, including cluster head, member node, or gateway node. Cluster head acts as a coordinating agent of that cluster and is responsible for transmission of data and making arrangement for such data transmission between clusters. Gateway nodes establish communication between two clusters. The advantages of clustering method that encourage using such method: have less overhead as compared with non-clustering methods, making it easier to redeploy resources. Therefore, this method increases the system capacity. Since it does not need the data of all nodes in the network, this network is smaller than any other moving terminal. Also, clustering methods can be suitable for creating scale acceptability in the network. COIN, CBLR and CBR are algorithms that use this method for routing [7,8].

The rest of the paper is organized as follows: Section 2 introduces IBCAV. Section 3 relates the header selection and training an Artificial Neural Network with Genetic Algorithm. Section 4 presents simulation and experimental results. Finally, section 5 concludes the paper.

2. IBCAV

In the IBCAV some important factors are considered such as cluster size, velocity and density. In clustering methods, moving nodes are divided into different groups and stand together in one single cluster based on certain rules. The size of each cluster represents the number of vehicles in a street or highway within a communication range and form a cluster. Within each cluster a vehicle should be designated as cluster head. What makes a vehicle qualified to become a cluster head depends on a series of computations, time and consumption of network resources, that is why the size of cluster is of prime importance. In the case of a small cluster, the vehicle chosen as cluster head can rapidly leave the confines of the cluster, causing a recurrent algorithm of choosing new cluster head. In the case of a large cluster the vehicle chosen as cluster head stay there longer even though there might be another vehicle which could be more efficient as a cluster head. Therefore, it is of great importance that the cluster size should neither be too large nor too small.

Clustering techniques are usually employed in VANETs to reduce resources consumption and improve the efficiency of the network. Vehicles have specific role in clustering and only a few of them chosen as cluster heads carry or transmit packets of data. Thus, once vehicles are placed inside a cluster it is very important to select a cluster head. In the IBCAV, RSU is chosen as a cluster head if it is within the confines of the cluster. That is because RSUs have stronger processing capabilities than other nodes and since they are motionless, there is no need to change the cluster head. In general, they could provide better services as compared to other nodes. However, in the event RSU is not present within the confines of the cluster, a vehicle with slower speed is designated as a cluster head. It is assumed that this vehicle would stay longer within the confines of the cluster as compared with a vehicle with higher speed.

In addition to the vehicle with lower speed, other factors are also considered in the IBCAV, selecting a vehicle with lower speed that stands in an appropriate position as the cluster head. Appropriate position here means: density of vehicles around it is greater and to be in a spot that with due consideration of the moving direction of the cluster stay longer within the confines.

Following header selection, a Store-Carry-Forward concept is used to send a message. In fact, if cluster heads fail to stand within the communication range of one another, they store the message inside their buffer and as soon as a cluster head is in range, they transmit a Hello message to them. [9,10,11].

3. Header Selection

So far, key factors of clustering and header selection introduced and explained how each one helps to improve clustering process. Now in order to place all factors next to each other, need a smart function or algorithm to combine them. In the IBCAV, take up an artificial neural network for header selection [12]. By training it through an algorithm, can combine the effective factors in such a way that the network turns into an optimized one with due regards to the defined optimization criteria. The advantage of this method is that such optimization criteria allow VANETs to be specifically defined based on their physical environment. In addition, it would permit to train the artificial neural network to meet optimization criteria as closely as possible.

3.1. Training an Artificial Neural Network with Genetic Algorithm for choosing Header

For the purpose of training such a network by using genetic algorithm, can employ an artificial neural network with five inlets and one outlet channels. Such a network conforms to the figure.1.

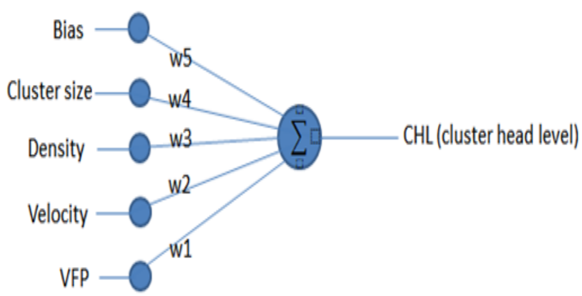

Figure.1: Scheme of the proposed artificial neural network

In the relation.1, (CHL) represents cluster head level. It determines the score that each vehicle inside the cluster has in order to become a cluster head. A vehicle with higher score could be selected as cluster head.

CHL= w5* Bias + w4*Cluster size + w3* Density + w2* Velocity +w1*VFP (1)

where VFP (Vehicle in cluster Flow Position) indicates the place of vehicle in relation to the cluster movement, velocity stands for the node speed and density stands for the related nodes connected in every direction. Bias represents the threshold for different assessments. Here bias is attached to fixed amount of 1. Therefore w5 weight determines the amount of bias. Cluster size stands for the size of cluster and the inlet connected to the neuron with fixed amount of 1.Therefore w4 weight determines the appropriate cluster size.
The issue is to find w1 to w5 in a manner that the network has the best output. But it is enough to determine the weights w1 to w4 for the network. It is necessary to note that w5 is considered as a bias network, is used as the threshold for evaluation and its value does not depend on the output of optimality criteria.

4. Simulation and Experimental Results

4.1 Simulation setting

After training the artificial neural network and employing it for the purpose of simulation, here present the result of our findings together with preliminary conditions and the parameters used.
The simulation was carried out using NS3 software [13]. Common and general parameters, default settings for all stimulations and the final results can be found in Table.1.

Table.1: Simulation Parameters

Simulation Parameters	Value
Number of simulation run time	1100
Highway Length	1040 m
Velocity	Varied between 0 to 29 m/s
Power Transmission	41.5 W
Number of nodes	Varied between 90 to 100

The working method is that the algorithm starts to work with a casual population composed of a population between 20 to 100. Then simulating units carry out simulation process and the clustering units choose suitable cluster head based on the weights specified in each repetition of the algorithm. Once simulation process ends, the algorithm calls the cross over or mutation operations and error function to change the population and direct searching to the optimal outlet. To adjust weights by using algorithm a genetic composition as explained before, a working current similar to figure.2 has been considered. In the process of adjustment of artificial neural network weights, the number of repetition for the used genetic algorithm, which is very important, can be obtained experimentally.

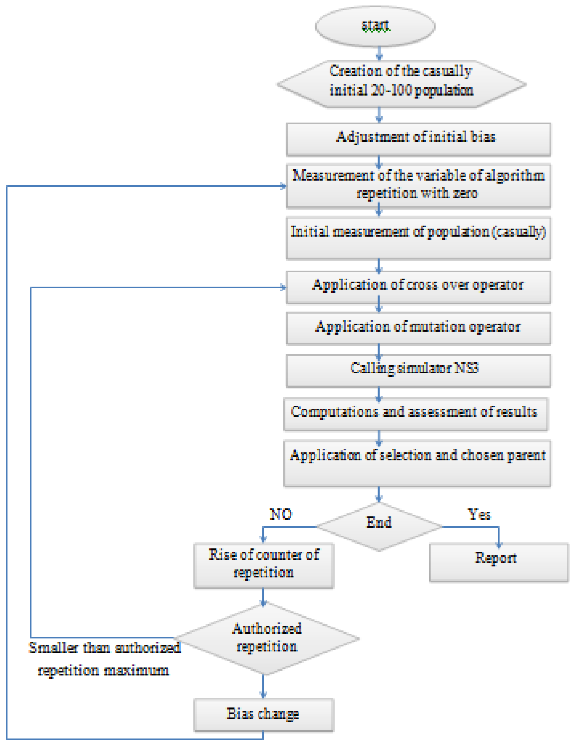

Figure.2: Training of artificial neural network based on the IBCAV

4.2. Simulation Results and Discussions

Cluster head election affects control packets and usage of networks resources. The better operation of the clustering method and cluster head election, the lesser will be the number of operations for cluster head election or change of cluster head. Therefore, overhead and used resources of the network will decline. It is shown in the figures.3-4 that the IBCAV has effectively decreased the number of this operation taking into account these factors.

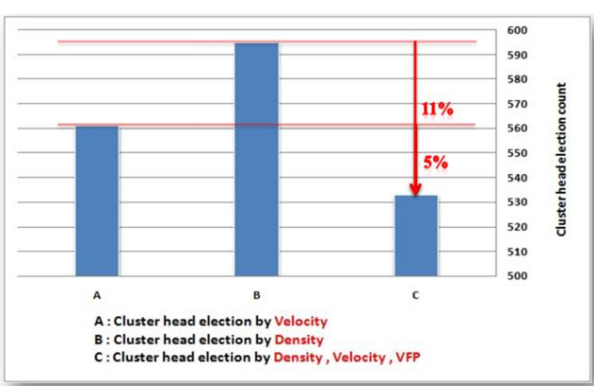

Figure.3: The number of cluster head election in the IBCAV

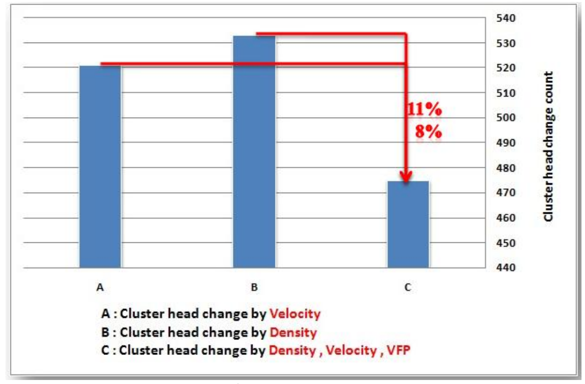

Figure.4 : The number of cluster head switching in the IBCAV

In the IBCAV, after the cluster head is chosen, a Store-Carry-Forward concept is used to send a message. In fact, when cluster heads are outside the communication range of the cluster head that intends to send message, it stores the message inside its buffer and as soon as a cluster head enters into its communication range it transmits a Hello message for that cluster head.

By taking this rule into account, based on figure.5 packet delivery ratio stand in a range of 82.66 % while, failure to use this rule, the ratio stands in a range of 22.66%.

The packet delivery ratio is defined as the percentage of packets that successfully reach the receiver nodes.

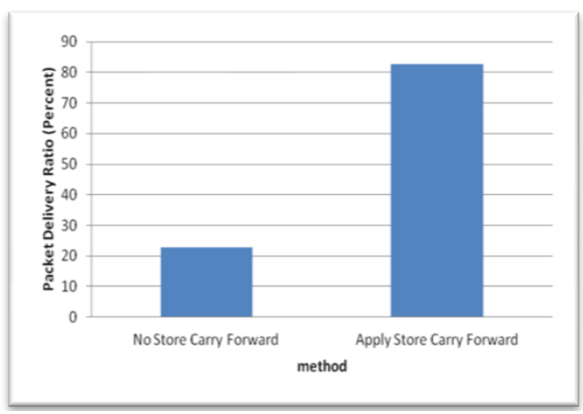

Figure.5: Packet Delivery Ratio in the IBCAV with presence and absence of Store-Carry-Forward

In the simulation process mentioned so far, vehicles speed varies between 0 to 29 m/s. Figure.6 shows the effects of higher speeds.

As it can be seen, the higher the speed of vehicles the lower becomes the packet delivery ratio. The decline in the simulation carried out is estimated at 50%. Figure.6 implies the appropriate speed of vehicles to be something between 0 to 29 meter per second. Because, according to the figure, with changes in speed between 0 to 29, packet delivery ratio will slightly changes and is nearly fixed and equal to 90%.

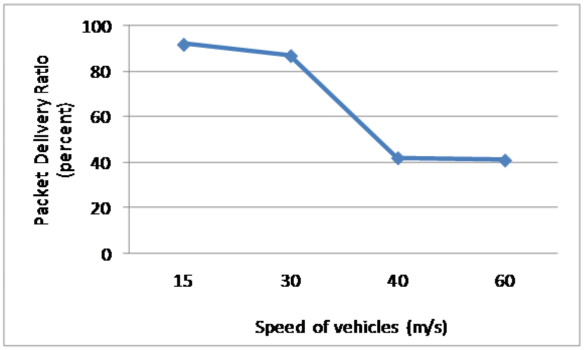

Figure.6: Packet Delivery Ratio in the IBCAV with different speeds

Figure.7 refers to the impact of the number of vehicles on the packet delivery ratio. As it can be seen the higher number of vehicles causes packet delivery ratio to increase. Simulation puts such rise at about 17%.

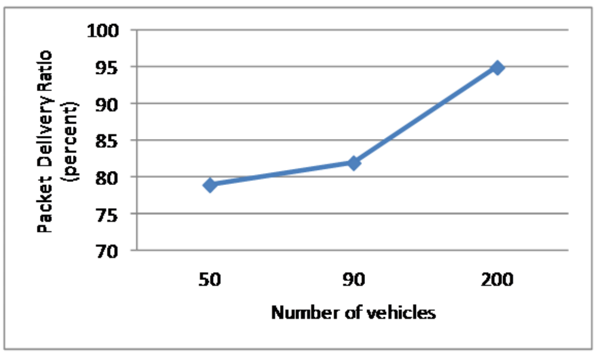

Figure.7: Packet Delivery Ratio in the IBCAV with considering the number of vehicles

This section presents some simulation results of the performance evaluation of the IBCAV in VANET and compares it with AODV, DSR and epidemic routing.

The performance of these algorithms is evaluated in terms of packet delivery ratio, end-to-end delay and throughput. The packet delivery ratio is defined as the percentage of packets that successfully reach the receiver nodes. The end-to-end delay is defined as the time between a packet being sent and being received. Throughput is the average rate of successful packet delivery over a communication channel.

Packet Delivery Ratio- Figure.8 illustrates the packet delivery ratio. IBCAV performs well. AODV performs worst due to its dropping data packets for which there is no valid route. In the IBCAV theses rates are about 18%, 17%, 2% higher than AODV, DSR and epidemic routing respectively.

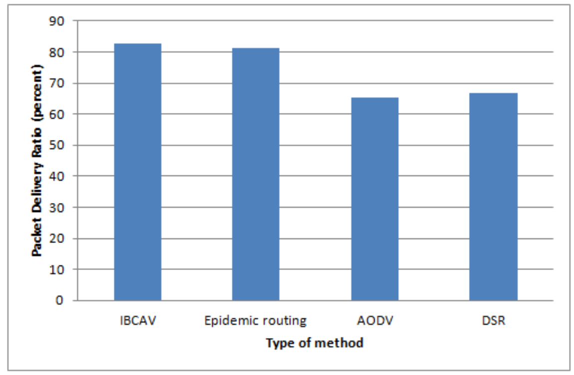

Figure.8: Packet Delivery Ratio in comparison with common algorithms

End-to-End Delay- The comparison of the end-to-end delay is shown in figure.9, DSR shows largest delay due to inefficient manner of handling route failure. On the other hand, IBCAV shows the lowest delay. The measurements in the IBCAV are about 17%, 24%, 11% lower than AODV, DSR and epidemic routing respectively.

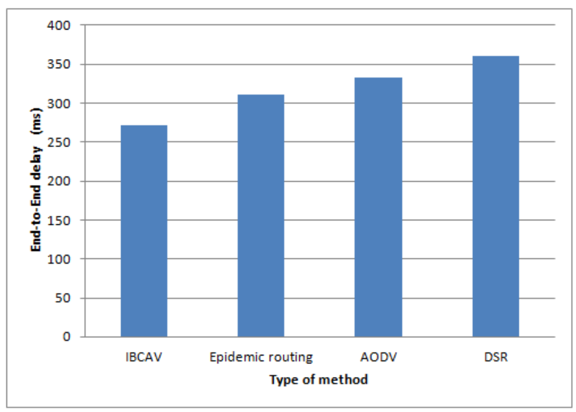

Figure.9: End-to-End Delay in comparison with common algorithms

Throughput- In figure.10 throughput in the IBCAV is compared with AODV, DSR and epidemic routing. Throughput in the IBCAV in comparison with other method is about 37%, 41% and 16% higher respectively.

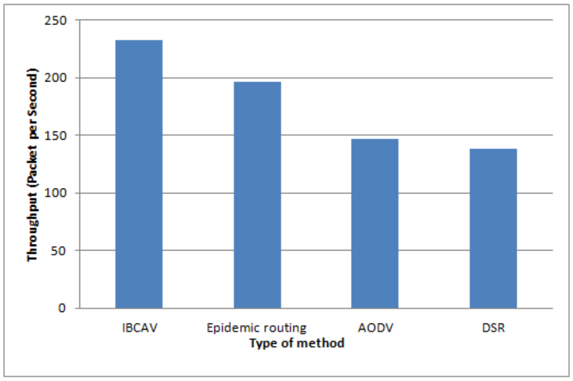

Figure.10: Throughput in comparison with common algorithms

5. Conclusions

In brief, simulation results indicate that in the IBCAV a combination of cluster size, velocity and density altogether, as compared to a manner in which each of the said elements is considered separately for header selection can, on one hand, reduce cluster head selection operation followed by a reduced usage of network resources and on the other hand with the decline of end-to-end delay, throughput is increased. Moreover such results reflect that the IBCAV outperforms in comparison to AODV, DSR and epidemic routing. In the IBCAV control packets of network decreases and packet delivery ratio increases.

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Mehrnaz Mottahedi received the M.Sc. degree in computer engineering from the department of computer engineering, North Tehran Branch, Islamic Azad University in 2012. Her research interests include Information Security, MANETs, VANETs and Wireless Sensor Networks.

Sam Jabbehdari currently working as an assistant professor at the department of Computer Engineering in IAU (Islamic Azad University), North Tehran Branch, in Tehran, since 1993. He received his both B.Sc. and M.S. degrees in Electrical Engineering Telecommunication from K.N.T (Khajeh Nasir Toosi) University of Technology, and IAU, South Tehran branch in Tehran, Iran, in 1988, through 1991 respectively. He was honored Ph.D. degree in Computer Engineering from IAU, Science and Research Branch, Tehran, Iran in 2005. He was Head of Postgraduate Computer Engineering Department IAU-North Tehran Branch during 2008-2010. He also has written “Advanced Topics in Computer Networks” book in Persian Language (Tehran, Classic, 2009). His current research interests are Scheduling, QoS, MANETs, Wireless Sensor Networks and Grid Computing Systems.

Sepideh Adabi received the B.Sc., M.Sc. and Ph.D. degrees in computer and software engineering from the Islamic Azad University, Tehran, in 2006, 2008 and 2012, respectively. She is currently an assistant professor in the Department of Computer Engineering at Islamic Azad University-North Tehran Branch in Tehran, Iran. Her research interests include distributed systems, grid and cloud computing, and resource management. She is a member of the IEEE.