Clustering Methods Survey in VANET on Roads and Mountain Trails with High Reliability

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ABSTRACT:
VANETs are one of the important technologies in recent decade. This importance is evident which can be used in road and mountains trails and also provides other information to vehicle from roads. There are many challenges and problems in this networks which can cited as routing, clustering, quality of services criteria, energy consumption, RSU placement and etc. This article tries to study and survey about VANET's clustering methods in roads and mountain trails with high reliability.

KEYWORDS: VANETs, Clustering, Roads Trails, Mountain Trails, Reliability.

1. INTRODUCTION

We are facing a large volume of traffic and highways full of vehicles due to the increasing growth of vehicles in recent years. Therefore, we need a new technology to reduce the number of fatalities caused by accidents and to increase road safety. The Intelligent Transportation System (ITS) has been established in recent years with the aim of increasing road safety and improving road efficiency. The intelligent transportation system includes various applications consisting of facilitating safe overtaking, detecting the presence of animals on the roads, implementing road arrangements and preventing road collisions. Various networks have been designed and implemented for this purpose. The main networks in Ad Hocs are MANET and VANET. The messages in this group of networks are all scattering among the nodes. The main problems we encounter in VANET are the issue of communication instability due to frequent topological changes due to high vehicle speeds, sudden changes in speed, unpredictability of these changes and high overhead due to these changes. Clustering can be used to reduce these effects and negative points. Two common methods in VANET networks could be considered which consist of communication between Vehicle to vehicle and Vehicle to roadside. VANET networks have a specific pattern of movement by vehicles according to road restrictions and traffic laws, and also have strong performance in terms of data storage memory and powerful processing units. There is also no concern in terms of battery life in these networks due to the use of sensors from car batteries. However, due to the nature of VANET networks that are used in high-speed and low-density structures in suburban areas, in some cases, the communication between cars and roadside stations is interrupted.

In this paper, various algorithms proposed for VANET clustering to date are reviewed. The most important advantages and disadvantages of these algorithms are also examined.

2. CLUSTERING ALGORITHMS CLASSIFICATION

VANET is an inter-road network that can communicate information between vehicles in different directions by placing an RSU. One of the most important parts of a VANET network is clustering. These algorithms are based on one or more specific indicators. Many algorithms have been proposed for both MANET and VANET networks so far. Each of

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these algorithms has specific criteria for creating a stable cluster. These algorithms are based on one or more specific indicators. Clustering algorithms are divided into different categories according to how groups are created, as well as the criteria for selecting headers, the most important of which are summarized below:

A. Node Specification-based Clustering Algorithm

1) ID Number-based Clustering Algorithm

In the Lowest ID algorithm, each node is determined by separate ID which distributed randomly between nodes. The cluster header in this algorithm will be selected based on the same number of IDs assigned to the nodes. In this way, node with the lowest ID number is selected as the cluster head [1]. This method has a higher output efficiency compared to the Highest Degree algorithm method, although the Highest Degree algorithm method is better from the point of view of less cluster multiplicity than the LID cluster method. There are some disadvantages in this method which are listed below:

- The theory of the lowest ID number as a parameter for distinguishing between cluster head and normal nodes is a weak decision and judgment due to the random assignment of ID numbers to nodes and the lack of consideration of the obvious features and characteristics of the nodes.
- The selected node loses more energy than the other nodes due to the role it plays in sending and receiving messages to other members of the cluster, along with collecting and concentrating the received data.

2) Highest Degree Algorithm

In this algorithm, the degree and rank of each node is measured according to its distance from other nodes of the network. The node that has the most neighbors will be selected as the cluster head. This algorithm is very good for the point of view of not changing frequently; however, it has a lower output efficiency compared to the LID algorithm. The reason for this is the lack of a certain number of members in a cluster. In other words, there is no limit to the size of the cluster in this algorithm, which reduces the output efficiency in large cluster sizes. Later in 2002, another algorithm called Connectivity based K-hop clustering (K-CONID) connections was introduced. This algorithm combined 2 popular LID algorithms and the highest degree [2]. In this algorithm, the degree of connections is considered as the main criterion and LID as the second criterion in selecting the cluster head. The cluster includes all nodes that are as far apart as the K-hop. The node that has the most connections with the rest of the nodes is selected as the cluster head. But the difference with the previously mentioned algorithms is that if in this method 2 nodes have common characteristics in terms of the number of neighbors and communications, the node that has the lowest ID number will be selected as the cluster head. By comparing this algorithm with The LID algorithm, the new algorithm with the assumption K = 1 will have a better result than the LID.

3) Force-directed Algorithm

Another related algorithm that can be mentioned in this section is Force-directed methods. In this algorithm, each node imposes a certain force on the other nodes based on the distance, velocity, and velocity of the other nodes. If the total size of the force applied to a vehicle is negative, it means that the vehicle is moving away from each other, or in other words, if the total size of the force applied by the vehicle is positive, it means that the vehicles are moving in one direction and closing together [3]. This force imposition is considered as criteria for selecting the cluster head. The node that has the most positive neighbors will be selected as the cluster head. In this algorithm, the size of the clusters is maximum 2 steps. In comparison, this algorithm has a lower average of the number of cluster changes than the LID algorithms and the highest degree. In addition, the number of clusters formed is lower than that of LID. Also, the average life time of clusters will be longer than LID.

4) Hierarchical Clustering Algorithm

The method of controlling access channels and sending schedules is used in this algorithm in order to prevent interference and having valid communication. In this algorithm, transmitting is possible only with the permission of the cluster head and by assigning a special slot to each member. In this algorithm, the collection of communication information between the nodes is used by the transmitted and received messages and there is no dependence on GPS in order to know the geographical location of the nodes. The hierarchies considered in this algorithm are: cluster head, cluster relay, and ordinary (slave) nodes. Slave nodes are ordinary nodes in the network. The relay node is the node that is responsible for transmitting cluster head's messages to ordinary nodes. And the cluster head node is the node that is responsible for managing and coordinating access to shared channels in the cluster. This algorithm consists of 4 phases. The first 3 phases are related to cluster formation and the fourth phase is related to cluster maintenance which depicted in Fig. 1 [4].

There are some challenges and disadvantages in this algorithm which is listed below:

- The process of selecting a cluster head one is not done completely correctly. For example, if a normal node receives two SYNC messages from relay nodes, it will be mistakenly chosen as the cluster head node, regardless of key factors such as speed, acceleration, and vehicle geographic location.

- The first 3 phases of the mentioned algorithm are established in the case that the nodes are not moving, which will not be possible due to the nature of the cars. So it's obviously this algorithm doesn't really work for VANET networks in real-world situations.

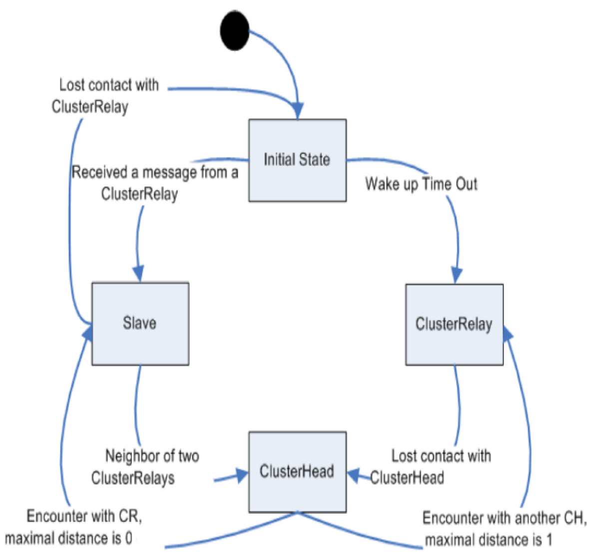

Fig. 1: HCA Clustering Algorithm [4]

B. Mobility-based *Clustering Algorithm*

1) Weighted Clustering Algorithm

WCA is one of the first algorithms that examined the parameters of speed and acceleration in vehicles and established the algorithm parameters based on the mobility of nodes [5]. In this algorithm, many parameters such as transmitter power, node movement and variability, ideal node degree as well as node battery power are considered to provide more effective parameters with the aim of achieving a stable cluster. In this algorithm, each node is responsible for measuring its combined weight, and the node with the lowest weight will be selected as the cluster head. In this algorithm, the cluster size is limited to achieve equilibrium by considering the values of the specified threshold for the head cluster. The process of selecting head cluster in this algorithm to reduce telecommunication costs as well as storage of computing resources is performed on demand and is not performed periodically. In this method, in order to create a stable cluster and also to select the appropriate source, all network nodes must be aware of the weight and information of other network nodes, which requires spending a lot of network resources and in addition to performing this process. It is very time consuming method.

2) MOBIC Algorithm

Another algorithm studied in this area that will be subject to mobility-based clustering algorithms is the MOBIC algorithm (Mobility Based Metric for Clustering in Mobile Ad Hoc Networks) [6]. This algorithm is very similar to the LID algorithm in terms of how it works, except that here the parameters of the motion pattern are used instead of the ID number to select the cluster head and forming the cluster. In this algorithm, each node is notified of the existence of its neighboring nodes by transmitting and receiving the Hello package. Then, each node measures the level of power of other nodes by examining the information received from its neighboring nodes and extracts the motion pattern of the nodes accordingly. Then, each node completes the table of motion patterns of all its neighbors according to the information received. Finally, the node that has the least movement pattern compared to the rest of the network nodes will be selected as the cluster head in the cluster. In addition, if two nodes have the same motion pattern, the node with the lowest ID number will be selected as the cluster head. The simulation program used in this algorithm to demonstrate productivity is NS-2 software. The results show a slight improvement in performance over the LID algorithm. However, in this algorithm we face various implementation limitations. For example, only at high speeds will the average result be better than the LID algorithm, which will not works in all cases. Due to its design and efficiency, the MOBIC algorithm is an algorithm that is mostly used in the field of MANET and has little application in the field of VANET and is usually used in comparison with other methods of VANET clustering.

3) Motion Pattern-based D-Hop Clustering Method

The next algorithm in this section is the D-hop clustering algorithm based on the motion pattern [7]. In this algorithm, nodes that are similar in motion pattern will be placed in the same cluster. In this algorithm, the size (diameter) of the cluster is not limited to 2 steps and will be determined flexibly according to the stability of the cluster. The distance between nodes can be calculated by measuring the power of the received signals. Initially, the nodes are grouped in 2-step diameter clusters based on their motion algorithm, and then the main cluster is developed if clusters with the same motion characteristics are observed, by merging two or more of these clusters. Each node in the network periodically transmits Hello packages to the network at regular intervals. In this algorithm, Hello packets contain information about the motion pattern of nodes, which can be calculated based on the deviation and movement of nodes in a cluster based on the signal strength received from each node. With these interpretations, after transmitting Hello packages to the network, each node has complete information and locate of the position of the node in the network. As long as Hello packets are being transmit and received on the network, it's time to unravel the node. Then, each node, according to the information received from the adjacent nodes, creates a table of neighbors and their information and examines and compares the stability parameters and movement pattern of each node. In the next step, the node is selected as the cluster head with the least amount of motion pattern. The effectiveness of this algorithm has also been proven using NS-2 simulation software. This algorithm performs better than the LID and MOBIC algorithms in terms of the number of cluster formations in the network.

4) Weight Based Adaptive Clustering Algorithm (WBACA)

Another algorithm proposed in the field of motion-based algorithms is the WBACA-based weighted clustering algorithm, which has been proposed to improve the shortcomings of the weighted clustering algorithm [8]. In the weighted clustering algorithm, we look for the least weighted node among all nodes across the network, except that in the weighted and differential clustering algorithm, it examines the weight of nodes on a smaller local scale. In this algorithm, the transmitter power transmission parameters, data transmission rate, motion pattern as well as battery level are effective in cluster formation. Each node has a specific weight that indicates the suitability and possibility of becoming a head cluster or a common element of the network. Node with minimum weight will be select as cluster head. Experimental results show that this algorithm performs better than the LID and WCA algorithms in terms of the number of clusters formation. On the other hand, due to the benefit of the WBACA algorithm from local parameters and concepts (on a smaller scale), it shows better performance in terms of delay in starting time.
Also in recent research, author combines WBACA with RSS method to provide sustainable communication on mountainous roads.[9] The mentioned method is shown in Fig. 2.

5) A Combination of WBACA with sequential and Hierarchically Methods for Clustering

Another algorithm studied in this area is a combination of weighted distribution clustering algorithm with sequential and hierarchical structure with the aim of establishing and forming more stable networks [10]. This algorithm consists of 3 different parts, which include the formation and initial stage, cluster formation and cluster maintenance. The initial part will be executed in the system startup stage, and then the cluster configuration operation will be performed according to the battery level of the nodes. This algorithm starts by specifying the ID number and the geographical coordinates of the nodes. In this way, the degree of the nodes in the cluster in same telecommunications range will be revealed. In the next step, the total distance of each node with its neighbors is calculated, and from these calculations, the average speed of each node can be calculated. Finally, the combined weight of each node is determined and the node with the lowest weight will be selected as the cluster head. Topological changes will also be investigated and controlled in the cluster maintenance phase.

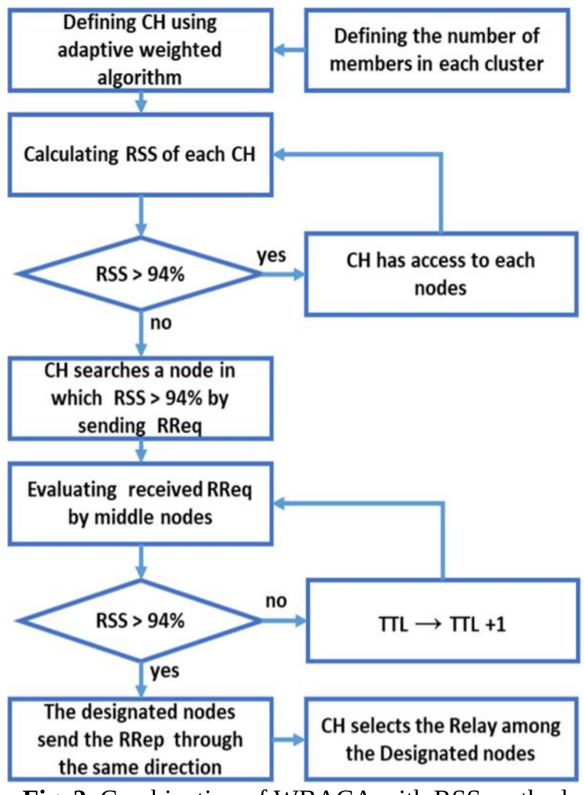

Fig. 2. Combination of WBACA with RSS method Methods for Clustering in mountainous roads [9].

After selecting the cluster head, in order to increase the reliability of the system's performance in case of unavailability of the cluster head, the cluster head selects the lowest weight node from the list of its neighbors as a predetermined alternative cluster head. When a cluster member leaves the cluster for any reason, there will be no change in the cluster topology if it is possible for the gateways to communicate with the cluster. However, if it is not possible for the gateways to communicate with the head cluster, the node must perform the clustering operation again. This affects the configuration of other clusters and reduces the stability of the clusters.

1) Distributed Mobility-Adaptive Clustering

Another proposed algorithm studied in this area is the Distributed Mobility-Adaptive Clustering (DMAC) algorithm [11]. According to this algorithm, in the first phase, each node determines its role by comparing its weight with its adjacent neighbors, and if it finds a node with more weight, will be join as a new member to the cluster in which the node with higher weight is exist. The algorithm also includes two other phases, which consist of times when the communication link is disrupted or a new communication link is added to the system. In both cases, the nodes are constantly reviewing their neighbors and changing their roles according to potential new neighbors. In the structure formation of this algorithm, important points have been ignored. For example, in this algorithm, nodes do not update their weight information frequently, which will increase the consumption of head cluster energy to check the status of the nodes.

2) Modified Distributed Adaptive-Dynamic Clustering Algorithm

In order to improve the disadvantages of adaptive-dynamic algorithm, a new algorithm called the Modified Distributed Adaptive-Dynamic Clustering Algorithm has been proposed [12]. This algorithm tries to avoid clustering operations as often as possible when the nodes are moving in different directions by periodically transmitting Hello packages that are able to detect and predict the duration of communication and connection between the nodes. In this case, a new clustering operation will not occur if the nodes are moving in opposite directions in the same telecommunications and communication range. Transmitting Hello packages periodically will also help update neighbors' information. Although this algorithm seems to be an efficient and high-interest algorithm in appearance, but due to the use of LID criterion or the highest degree as criterion for selecting the cluster head and not using motion parameters, it doesn’t achieve good results in the simulations performed.

3) Detection-based Vehicle in the Applied Line Frameworks Routes Algorithm

Another algorithm that can be mentioned in this area is the algorithm that is based on detecting the movement of vehicles within the framework of the lines applied on the routes [13]. To implement this algorithm, vehicles must be equipped with digital street maps and line identification systems marked by lines. The algorithm is designed and optimized for urban scenarios that consist of multiple passages and intersections. In this algorithm, the head cluster is selected from the machines located in the densest line in terms of traffic. In the next step, in addition to checking the information about the density of machines in each line, information about the level of connection and access to the network, the average distance and the average level of vehicle speed are also considered in order to select the cluster head from among the vehicles located in that line and the calculation will be placed. The vehicle with the highest level will be selected as the cluster head. One of the biggest disadvantages of this algorithm is considering the direction of traffic flow as the main factor in selecting the cluster head and forming the cluster in the direction of movement of the majority of vehicles. Also, cluster formation operations are repeated periodically, which increases overhead and wastes network resources.

4) Type-based Cluster-Forming Algorithm

Another algorithm proposed to reduce changes in the choice of cluster head is Type-based Cluster-Forming Algorithm (TCA) in critical situations [14]. In this algorithm, cluster formation is based on the type of nodes in the network. This means that all nodes that are similar from this point of view will be put in the same group. In this case, 3 different modes can be imagined for these groups. Rescue teams, fire engines and paramedical teams. Each node periodically notifies its neighbors by sending Hello packages that contain information including ID number, information about their vehicle type (according to the announced groupings), location and stability factor. The stability parameter includes information such as the relative velocity of the nodes relative to each other, the average sum of the distances between vehicles, the type and degree of communication of the nodes with each other, and the remaining battery power of each node. The nodes that have the least amount of stability factor will actually be considered as normal network nodes, and the node with the most stability factor will be selected as the cluster head. Each of the cluster head assigns new IDs to the members according to the built-in clusters in which they are placed. In this way, the node with the highest factor and stability rate will have the most IDs and the same number of new ID numbers will be assigned to each member. The proposed TCA algorithm performs better than the LID and WCA algorithms in terms of the average number of selected cluster head. The proposed algorithm will create more stable cluster head in the event of frequent changes in vehicle speed on the network. The proposed algorithm also performs better in terms of cluster update than LID and WCA algorithms.

5) Dynamic Clustering Algorithm

Another algorithm that is introduced in the field of algorithms related to motion parameters in VANET is Dynamic Clustering Algorithm [15]. This algorithm is based on the required distances between vehicles. For this purpose, in this algorithm, the similarities of the 2-node in the same telecommunication range are examined and analyzed. In this regard, two main criteria are extracted for this algorithm, which includes the average speed and acceleration of nodes. Each node sends information about its movement pattern in the form of Hello packets to inform its neighbors on the network. In this way, the neighboring nodes find the same motion pattern from the point of view of speed and acceleration to communicate a step in the network. In this algorithm, the required distances between the vehicle are defined as the product of the velocity between the velocity and the acceleration of the nodes in the network. The nodes then examine the information received from other neighbors, and the nodes that have similar motion pattern parameters are considered as a cluster. The higher dependence parameters of a cluster, the closer pattern of its members is to that of its neighbors. Also, among the members of a cluster, the node that has the most similarity and dependence with the cluster parameters will be selected as the cluster head. The performance of this algorithm has been tested by NS-2 software and it has been determined that the mentioned algorithm has provided better results in terms of the life time of the cluster head as well as the number of clusters formed from the LID algorithm and the highest degree. However, due to the complexity of selecting clusters and cluster heads, in general, it is not a good choice for networks with a high number of nodes.

6) Stable Clusters on Highways Algorithm

Another algorithm that has been proposed in the field of algorithms based on motion patterns is the algorithm that has been introduced to form more stable clusters on highways in the VANET networks [16]. The nodes that are selected as members of a cluster are nodes that move in the same direction along each other due to the nature of highways. The important point in this algorithm is to consider the difference in velocity of the vehicles as a scale for selecting clusters. In order to create stability between the members of a cluster, the network is divided into different clusters due to the fact that the speed of vehicles in highway routes is different. In other words, high-speed vehicles are classified in one cluster and low-speed vehicles are classified in separate clusters. Each vehicle in the network notifies its neighbors of their speed and acceleration changes by transmitting information courses of their movement pattern as a whole section of the network, thus allowing each vehicle in the network to classify neighbors as stable nodes or it will be unstable. By comparing the state of the motion pattern of nodes with each other, the node with the lowest speed of movement among its neighbors in the same communication range is determined as a parameter for performing the clustering process. Other neighbors of the node, which have a velocity below the set threshold as the threshold are classified in a cluster, and nodes that have a higher threshold speed, as mentioned, set the node at the lowest speed and they do another clustering process. In these processes, the cluster head is determined by calculating the eligibility parameter among the members of the cluster. The competency parameter is calculated based on the information of the node motion pattern. Each node is responsible for determining its position and speed and comparing it to the average position and speed of its other stable neighbors in the network. The node with the highest degree of competency parameter is determined as the cluster head. The performance of this algorithm has been investigated by some C++ simulator software (such as NS-2), and higher performance shown from the point of view of lower number of changes in cluster formation and also higher life time of clusters than weight and position-based algorithms.

C. Direction-Based Clustering Algorithm

1) C-Drive Clustering Algorithm

Direction-based clustering, also known as C-Drive, is based on changing the direction of moving machines after crossing intersections [17, 18]. Accordingly, it imagines 3 different directions for each vehicle at intersections: straight, left, and right. A cluster must be formed for each of these directions. Before arriving at the intersection, each vehicle transmit a Hello package to check for possible clusters in a particular direction of motion after the intersection. In this case, if it receives a response from the head cluster for the desired path, it will be attached to the cluster in which the head cluster is located. Otherwise, it introduces itself as a redirect in the desired direction to move after the intersection. As soon as it selects the head cluster, it should calculates the density of the members within its cluster and transmit this information to the existing infrastructure. In this algorithm, it is assumed that the cluster is located at the beginning of the cluster. In addition, each member of the cluster must periodically transmit a message confirming their presence in the cluster at regular intervals. There are some challenges and disadvantages in this algorithm which is listed below:

- In this algorithm, the mechanism of selecting the cluster head is done only by considering the direction-based parameters of the vehicle, therefore, the cluster head selection has several shortcomings.

- The goal of this algorithm is limited to measuring the density of moving machines in each of the three possible directions of crossing intersections without considering other clustering indicators such as reducing the cluster head due to the exchange of messages between members.
- The considered of clusters life time in this algorithm is also very short due to the destruction of the cluster after crossing the intersection.

2) Modified C-Drive Clustering Algorithm

A modified C-Drive algorithm has been proposed to improve the problems and disadvantages of the C-Drive method. The purpose of this algorithm is to change the cluster head selection policy in the main algorithm [19]. For this purpose, a series of hypothetical points along the routes will be considered before approaching the intersections. These points are the starting points, the end points and the threshold points. The starting point is the moment of starting the formation of the cluster and the end points are the moment of the completion of the stages of formation and maintenance of the cluster. On the other hand, the threshold point is the point between the starting and ending point, at which point the selection process is over. Threshold distance is also considered as the optimal space for selecting clusters. Therefore, this parameter is very important for determining how the cluster is formed and selecting the cluster. By considering these values, moving vehicles, regardless of their speed, are allowed to be in a cluster before reaching the intersection. In addition, by the end of the cluster's life time, the head cluster can still perform its function using this information. Modified C-Drive Algorithm for cluster head election and cluster formation is shown in Fig. 3.

```
If Start Point == TRUE && Cluster ID ==NULL then
        Assign Vehicle = Header
        Gen: Generate and send Query Packet and wait
        till timer expires
   If reply received && Distance < TH_DISTANCE then
        Elect clusterhead: Vehicle farthest from header
        and within TH_DISTANCE
   Else
        If Header is at Threshold Point
                Elect self as clusterhead
        Else
                Goto Gen
        End If
   End If
End If
```

Fig. 3: Modified C-Drive Algorithm [19]

The simulations show that the changes made in the algorithm have improved the performance in terms of the number of changes in the selection of the head cluster as well as the overall network head cluster compared to the original C-Drive algorithm.

D. Leadership Duration-Based Clustering Algorithm

The criteria for designing this algorithm are based on inspiration from directional information, leadership time and clustering, as well as node ID values [20]. Leadership time means examining the duration of the general presence and behavior of a cluster head in a cluster and its relationship with other network nodes. The longer this time, the more likely it is that the nodes will be stable in the network. Therefore, the criterion for selecting the head cluster in this algorithm is the maximum of this duration (greater stability of the node in the network). In this algorithm, if the leadership time criterion is similar for two nodes, the node that has a lower ID number will be selected as the head cluster. If a network node notices a head cluster coming out of its cluster, it will ask the nearest head cluster in the network to perform the steps to select a new head cluster. If possible, these steps are performed and the new head cluster is added to the cluster, otherwise the requesting node will introduce itself to the cluster as a new head cluster. The main weakness of this algorithm is its over-dependence on leadership time, which is not very effective until one of the members of the cluster is selected as the head cluster. Therefore, in this case, the lead time is zero and the selection of the header will be based on the LID algorithm.

E. Route Losses Clustering Algorithm

Another algorithm presented in the VANET domain is the algorithm based on the physical limitations of the path which named as Route Losses Clustering Algorithm [21]. In this algorithm, two basic factors of the physical limitations of the path are examined. One of these factors, which is based on the distance between the vehicle and the station on the side of the cluster head is called route losses. The greater the distance between the vehicle and the roadside station, the greater loss of route and consequently, the lower the signal strength. The second parameter examined for physical constraints is the interference between moving vehicles due to the sharing between the transmission range and the signal received by each vehicle. When a new node joins a cluster, the node first looks for a cluster head in its telecommunications range, if it finds a cluster head in this area, its distance from the roadside station, as well as the distance from the corner to the roadside station. When a new node joins a cluster, the node first searches for the cluster in its telecommunication interval, and if it finds a cluster within that range, its distance from the roadside station as well as the distance from the head cluster to the roadside station examines and compares in which case if the distance from the node to the station on the side of the road is less than the distance of the head cluster present in the telecommunication range of the node, the node will declare itself as the head cluster. Experimental and practical research has shown that a very good compromise will be reached between the present node and the head cluster. However, the results show an increase in head cluster changes during peak times due to the high volume of vehicles. Also at peak times, the size and average of the cluster members will increase dramatically. In comparison between the stated algorithm and the direct communication algorithm between moving machines and roadside stations (V2R), due to the direct and separate connection of each member of the cluster with the roadside stations in the V2R algorithm, the end-to-end delay rate in this algorithm is more than the algorithm expressed in this section. The reason for this is that in the least loss algorithm, only the cluster head ones are in direct contact with the roadside stations, and the other members of the cluster send their information to the cluster head ones. Therefore, the probability of losing data packets in V2R mode will be higher.

3. COMMON DISADVANTAGES OF STUDIED ALGORITHMS

VANET's clustering algorithms which have been studied and analyzed in this article have many disadvantages and shortcomings that will generally have a negative impact on the overall performance of the system. For example, some of the algorithms described are based on parameters that do not provide valuable information about nodes in order to choose the right one, for example, LID algorithms and the Highest Degree. Also, in some algorithms, long-term and head cluster selection causes network resources to be lost. In addition, many of the mentioned algorithms, due to the lack of restrictions on the size of the cluster, reduce the efficiency of the cluster and also increase the loss of emergency messages in the system, which endangers the safety of drivers on the roads. In addition to all of the above, some of the algorithms mentioned have used unrealistic assumptions in presenting their algorithm. An example is the HCA algorithm, which assumes that the first three phases of the algorithm occur when the nodes are fixed. It is quite obvious that such an assumption is unrealistic, because this assumption violates the fact that nodes are mobile in the VANET network. In addition to all of the above, the mentioned algorithms have limitations in implementation, for example, the MOBIC algorithm only performs well in large and medium telecommunication ranges and in short telecommunication ranges, even from the algorithm. LID also perform this problem as worse as it can. Other algorithms, such as the WCA algorithm, are not optimal algorithms due to the waste of network and time resources. One of the notable points about the multiplicity of weaknesses of the expressed algorithms is that the providers of the algorithms have proven the efficiency of their algorithm in comparison with the simplest and most inefficient algorithms such as LID and the highest degree, which further the reason for the many weaknesses in existing algorithms.

In clustering algorithm in VANET literature, there are many other methods presented which can be notice to QMM-VANET [22] which is an efficient clustering algorithm based on quality of services and monitoring of malicious. This protocol improved the percentage of stability up to 14%. Also PSO algorithm as an evolutionary and swarm intelligence algorithm used for efficient clustering in VANET [23]. This clustering schema improved routing efficiency signally and increased packet delivery ratio by 20% and decrease delay by 47% at best. Another approach which presented in [24] presented fuzzy cluster management system in VANETs. The results represented fuzzy logic clustering can obtain efficient security and trustworthiness. Another powerful method named MCA-V2I presented in [25] which is multi-hop clustering approach over vehicle-to-Internet communication for improving VANETs performances. In this method, a mobility rate calculated based on mobility metrics to satisfy the mobility characteristics of VANET. MCA-V2I reduces the rate of control messages used in traditional clustering algorithms and its strengthens clusters' stability by electing a slave cluster head in addition to cluster head. In [26], efficient dissemination based on passive approach and dynamic clustering proposed in VANETs which implied an earlier division of the network into virtual sub-groups to ease management and data dissemination of messages.For the sake of better evaluation, a comparison is made in Table 1 which illustrates the methods performance parameters.

Based on some review presented in this article from [1-21], and also some new and combinational and optimized clustering methods in [22-26], a main problem of these algorithms is selecting head cluster without losing energy and optimize some criteria such as reliability and quality of services.

4. CONCLUSION

In this study, some of the most important clustering algorithms in the VANET domain were discussed. Each of these algorithms has tried to provide the best solution in order to select the most efficient source in different geographical conditions. The main categories performed are based on clustering based on ID number, node degree, node mobility, direction, civil time management, and path losses.

Table 1: Comparison of VANET Clustering Algorithms

reference	**method**	**simulator**	**Packet delivery rate (%)**	**Delay (s)**
Fatemidokht et al. [22]	QoS based clustering algorithm	NS2	89.5	0.9
Bao et al. [23]	Routing Based on Particle Swarm Optimization (PSO)	NS3	96.8	4.1
Senouci et al. [25]	Multi-hop Clustering method based on Breadth first search (BFS) algorithm	NS2	93.5	0.6
Abdelali et al. [27]	Mobility based clustering algorithm	NS2	75	0.2
Sondi et al. [28]	Chain-Branch-Leaf (CBL) clustering algorithm	OPNET	90.7	0.08

The strengths and weaknesses of these algorithms are also examined. Due to various geographical constraints, none of the algorithms proposed in the VANET domain are suitable for mountainous and tunnels areas due to the assumption of direct vision in these algorithms. Therefore, in this situation, practical solutions should be provided for routes that are not directly visible, as well as the possibility of using roadside stations.

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