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Clustering Techniques Used in Vehicular Ad-hoc Network: A Survey

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***Abstract*—** VANET has become one of the active areas of research and development these days. As communication among the vehicles is one of the challenging tasks in a highly dynamic environment. Many of the clustering algorithms have been implemented for providing the secured communication between vehicles within a cluster. Generally Clustering consists of different nodes like mobile devices, vehicles, sensors, etc. that are grouped together according to some predefined rules. A group of nodes within a cluster can communicate with each other securely and without disconnection. The important task of the clustering algorithm is to achieve the cluster stability. Here different categories of clustering algorithm are highlighted, such as the significance of various approaches with their objectives.

***Keywords*—** VANET, Classification of clustering, Clustering techniques

I. INTRODUCTION

Secured communication among the increasing rate of vehicles is one of the challenging tasks. Now vehicles are to fit out with wireless device that performs transmitting and receiving function to communicate with other vehicles. This enables them to form a special class of wireless networks, popularly known as vehicular ad hoc networks or VANETs. VANET is a type of Mobile Ad hoc Network that provide communication among nearby vehicles and between the vehicles and nearby roadside equipment [1] The main objective of the VANET is to establish a network where the group of vehicles can exchange information among themselves and with other nodes. The VANET is an extra ordinary deed for many applications which lies between the safe and non-safe applications. Every vehicle within a network has an obligation to transfer information with other vehicles or nodes in the network that may provide efficient services for which the secured network can be established.

The paper is organized as follows, Section I contains the introduction of Vehicular Ad-hoc Network (VANET), Section II contain the architecture of Vehicular Ad-hoc Network, Section III contain the introduction of clustering, Section IV contain the classification of clustering techniques and proposed algorithm based on these techniques, section V provides the conclusion.

II. ARCHITECTURE OF VANET

In VANET, the demands for communication between vehicle-to-vehicle and vehicle to roadside or vehicle to infrastructure are continuously growing. Assuming that each vehicles are equipped with the systems like Global Positioning System (GPS) which provide connectivity in the ad hoc network. Vehicular Ad hoc network consist of different sensors and on board unit that are installed in the vehicles and road side unit.
Classifications of VANET architecture are: [2]

i) *Inter-vehicle communication*: It is also termed as vehicle-to-vehicle (V2V) communication. In this category, the vehicles communicate among each other without the infrastructure support. In this type of VANET architecture information collected by one node with the help of sensor can be directly transferred to the neighboring node without the involvement of any other infrastructure

ii) *Vehicle-to-roadside communication***:** It is also termed as the vehicle-to-infrastructure (V2I) communication. In type of VANET architecture vehicles within a network uses cellular gateway, which connect the vehicular application to the internet and enables for the message transmission.

iii) *Inter-roadside communicatio**n***: It is also termed as the hybrid vehicles-to-roadside communication (VRC). Vehicles can use the infrastructure network to communicate with each other and exchange information received from infrastructure or from other vehicles through ad-hoc communication. Vehicles can communicate with infrastructure either in single-hop or multi-hop way.

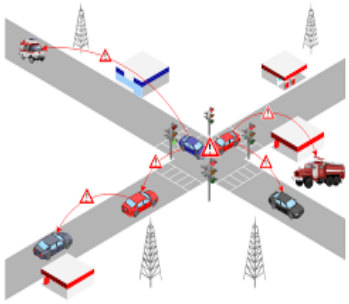

Figure 1. Architecture of VANET [2]

III. CLUSTERING

Clusters are the group of mobile devices or vehicles which can transmit information among themselves directly or via some infrastructure. Each cluster consist of one or more Cluster head (CH)which are chosen on the basis of predefined rule and all the other node except Cluster head within a cluster is known as cluster member(CM). Selection of Cluster head is usually depending upon the clustering algorithm used. The size of the cluster depends upon transmission range of communication equipment which is used by cluster node. In a highly dynamic environment stability of cluster is one of the challenging issues in a research field. Stability can be measured by frequency of CH changes or number of a CN changing its CH. The stability of clusters can be improved by selecting the CH and cluster nodes.

IV. CLASSIFICATION OF CLUSTERING TECHNIQUES

There are number of key factors on the behalf of that clustering algorithm can be implemented. Stability is one of the most important key factors for the clustering algorithm. Some of the key factors for the implementation of clustering algorithm are: mobility and non-mobility of vehicles, direction of vehicle or direction of lane, protocols used for the communication among the nodes within cluster etc. figure 2 shown the classification of clustering techniques.

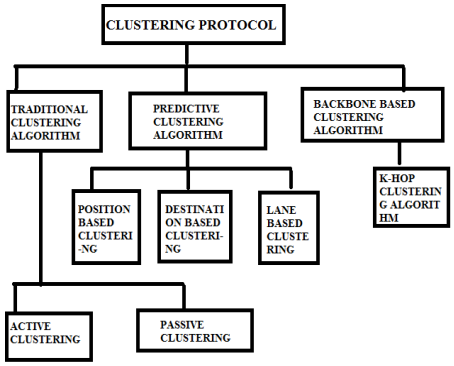

Figure2. Classifications of clustering algorithm

TRADITIONAL CLUSTERING:
In this type of clustering algorithm, clustering is depended upon the function of node in a network. Clustering can be active or passive. When the information of cluster and routing table are updated in a regular interval of time then it is said to be active clustering protocol. The various active clustering protocols are Beacon based clustering, Mobility based clustering, density based clustering and dynamic clustering.

i) Beacon Based clustering: In this type formation of cluster is depended upon the some network parameter identified by beacons. In Beacon based cluster node send beacon or hello message to the entire node within a transmission range of cluster.

ii) Mobility Based Clustering: This clustering protocol decreases the comparative mobility and distance between Cluster head and each of its cluster member and this result the improvement of cluster uniformity and cluster dynamics.

iii) Density Based Clustering: Density based clustering protocol provides a stable cluster. In this connection between clusters node is more durable and also the frequency of changing of cluster head is minimum. This results in improved cluster stability.

iv) Dynamic Based Clustering: In this type of clustering protocol structure of cluster formed is depend upon the dynamic feature of node like density, velocity of node, mobility pattern etc.

In the passive clustering mechanism at any moment cluster node can have internal or external state [3][4] In this while formation and maintenance of cluster control overhead is minimized i.e. the cluster state information is appended with on-going data. This results the reduction of control overhead of packets.

PREDICTIVE CLUSTERING:
In the predictive clustering, formation of cluster depends upon the information of traffic, future position of vehicles and predefined destination of vehicles. The cluster structure is formed by current geographic position of vehicles and its future behavior in Predictive clustering. The traffic information, future position and the intended destinations of vehicles are used in the cluster formation. The priorities are given to the vehicles with this information. Thus a prediction based clustering can be sub classified into position based, destination based clustering and Lane based clustering.

i) Position based Clustering: In this type of clustering technique the cluster structure is depend upon the geological

position of the vehicles. A New Aggregate Local Mobility (NEW-ALM) algorithms which is a position based clustering algorithm proposed by CH.

Salhi et al. [5] , Proposed algorithm uses earthly position of vehicles for the cluster formation and the Cluster head (CH) is selected on the basis of priorities of each cluster node. The vehicle having a trip is elected as Cluster head (CH), this result an improvement in stability of cluster. This also provides an improvement over the existing Aggregate Local Mobility (ALM) algorithm.

Wang et al. [6] proposed another position based clustering algorithm. Proposed algorithm is based on the information of topographical and network. The broadcasting mechanism is used by the author for the cluster formation. This is also known as cross layer algorithm. The performance of the algorithm is also changed by the possibility of having Roadside infrastructure. Controls overhead are greater in inter-vehicle communication and vehicle-to-roadside communication.

Maslekar et al. [7] proposed a direction based clustering algorithm with Cluster head switching mechanism. The proposed algorithm is focuses on to reduce the importance of overtaking of vehicles within the cluster. The proposed algorithm is also known as Modified Clustering based on direction in Vehicular Environment (MC-DRIVE). The algorithm is able to form more stable cluster. It can also determine the accurate density of vehicles within the cluster using basic parameter $TH_{distance}$. $TH_{distance}$ is depended upon the speed and radio range of the vehicles reaching at the intersection. The stability of the cluster can be achieved in terms of number of vehicles within a cluster.

Wolny [8] proposed a solution which makes effective to existing Distributed and Mobility Adaptive Clustering (DMAC) algorithm presented in [9]. The algorithm effectively determines the mobility over the road traffic. When vehicles moves in different direction then the re-clustering occur, by avoiding the re-clustering author improve the stability of cluster. That is by reducing the number of re-clustering the stability of cluster increases. In the proposed algorithm each message sent by the node has Time to Live (TTL) parameter, the status message is continuously transmitted at a predefined interval of time. With the help of parameter TTL, algorithm can able to form k-cluster.

Fan et al. [10], proposed a Dynamic Clustering Algorithm (DCA) by using mobility metrics of the vehicles. Authors extended the concept of spatial dependency which describe the mobility similarity between nodes initially proposed in [11] and improve the cluster stability or cluster lifetime. For the election of Cluster head (CH) the position and speed of vehicles refer as utility function is used. The previous traffic analysis is used to determine the threshold value. In the proposed algorithm status message of each node is transmitted periodically within a cluster and on the basis of utility function of vehicles Cluster head is chosen. This scheme is not very much effective in highly dynamic environment.

Wang et al. [12] proposed a Cluster chain algorithm for the construction of vehicular Ad hoc network. In the proposed algorithm the election of cluster head is performed on the basis of distance from the potential Cluster head (CH) to its neighbour cluster associate node. To estimate the relative distance between the potential cluster head and its neighbour cluster associated node is based on the relative angle (CERA). The number of Cluster head (CH) can be reduces by predicting the relative angle between the moving direction of current vehicle and its closest neighbour. Cluster chain stability is enhanced using the cluster merging algorithm, which has no effects on the topology of cluster. The algorithm constraints the number of vehicles within cluster by choosing clusters associate node. The formation of cluster and its cluster members is done on the basis of this geographical information.

Affinity Propagation based Algorithm (APA) proposed by Hassanabadi et al. [13] in a distributed manner for the formation of cluster in a vehicular Ad hoc network. The minimum speed and distance between the Cluster head (CH) and its member i.e. the mobility of the vehicles is used for the formation of cluster. The election of cluster head is done at a regular interval of time using the affinity propagation. In the proposed algorithm each node within a cluster has responsibility to facilitates messages to its neighbour node and have an independent decision making capability. By maximizing the similarities vehicles are made suitable for clustering. The Euclidean distance between the pair of nodes within a cluster determined the similarity between two vehicles whereas the future position of the node and cluster head (CH) is estimated by minimum similarity.

ii) Destination based Clustering: In this type of clustering techniques, formation of cluster is dependent upon the current geographical position, relative speed and final destination of vehicle. Destination of the node can be estimated by using navigation system.

Location Improvement with Cluster Analysis (LICA) is implemented by Farhan et al. [14] which is used to enhance the exactness of Global Positioning System (GPS). The real time information is collected by the vehicles and broadcasted to other vehicles. This will help the person to reach the final destination cautiously and competently. Exactness in distance estimation in LICA minimizes the location inaccuracy resulting in achievement of higher performance.

Tian et al. [15] proposed new position and direction based clustering algorithm. Formation of cluster is done by using the Euclidean distance. Vehicles relays beacon message in the network. The vehicles within network received beacon message and checks whether the hop count value of beacon message crosses the maximum value or not, if it is then the message will be discarded. Then sender vehicles update its geographical table by estimating the Euclidean distance between the vehicles. The vehicle with minimum distance is elected as the cluster head (CH) and rests of the vehicles are partitioned into cluster.

A new distance based algorithm defined as the Adaptable Mobility-Aware Clustering Algorithm (AMACAD) [16] exactly chases the mobility pattern of the network improves the clustering stability. The algorithm uses a special metrics called $F_{v,2}$ by transferring messages with its neighbour vehicles. The metrics can be estimated by using parameters such as final destination, approximate destination, velocity and current location of vehicles in a distributed manner. This support to enhance the stability of cluster and also reduces the Cluster head switching. The algorithm carries out an effectual message broadcasting process to acknowledge in a real time and also ignore the re-clustering. The proposed algorithm is dependent on some of the appropriation such as destination of every vehicle in a cluster is predefined and geologically based routing. Minimum value of $F_{v,2}$ is a condition for every vehicle to join the cluster. Consistent average speed of vehicles makes the algorithm works well.

A new destination based algorithm known as Cluster Based Location Routing (CBLR) algorithm presented by Santos et al. [17]. The algorithm is used to elect the Cluster head (CH) in Vehicular Ad hoc Network. Beacon message is used to broadcast the status of the vehicles in the network. In a proposed algorithm nearly vehicles select the relevant state and each node uphold a table containing the information about neighbour node with which it can communicate with neighbour node. Whenever the vehicles receive the beacon message, it updated the table.

iii) Lane based Clustering: In a Lane based clustering algorithm structure of formed cluster is depended upon the consideration of the lanes on which vehicles are running. Direction of the lane is important parameter for the formation of cluster.

Fan et al. [18] presented a new lane based clustering algorithm known as Broadcasting based Distributed Algorithm (BDA),which provide more stable cluster as compared to the existing algorithm. In the proposed algorithm vehicles need to have an information about single hop neighbour. This algorithm tried to improve the performance of existing clustering algorithm. For the formation of cluster Broadcasting based distributed algorithm gives more priority to the extent of leadership and convey to increase overhead.

Almalag et al. [19] proposed a lane-based clustering algorithm which provides an efficient way of selection of Cluster head. It is mainly based on the traffic flow of vehicles. In the proposed algorithm election of Cluster head (CH) is depends upon the maximum traffic flow of specific lane. Each vehicles must have prior knowledge of lane of traffic on road they telecast this information to single hop or multi hop vehicles. This makes the algorithm to determine the appropriate Cluster head. Author presented a technique in which each vehicle computed its Cluster Head Level (CHL), speed, position etc. and transmitted into the network. With the help of beacon message which transmitted periodically by the vehicles Cluster Head Level and the traffic information are broadcasted. CHL can be estimated by using the parameter such as lane weight, average speed, average distance and network connectivity level of the traffic and the vehicle holding the highest CHL is considered as the Cluster head.

BACKBONE BASED CLUSTERING

In this type of clustering technique exchange of message in a cluster can be achieved by forming a backbone. Selection of Cluster head (CH) and message transmission in a backbone clustering technique is dependent upon backbone.

i) k-hop Clustering: k-hop clustering is a backbone based clustering in which distance between the hop decided the cluster structure. Each cluster has on Cluster head. In this technique maximal of hops are computed earlier. It can be one or multiple hops. Maximal of hops limits the relative distance between cluster head and the cluster member.

Zhang et al. [20] presented an innovative multi-hop clustering algorithm aiming to form a stable cluster. The scheme is depends on the mobility matric which is used to depict N-hop mobility. Within N-hop distance each vehicle disseminates the beacon message at a regular interval of time. Approximate relativity is computed by the vehicle using two continuous beacon message admitted from the similar node. Using this aggregate mobility is computed by each vehicle which is equivalent to the addition of relative mobility and weight value of neighbouring vehicles within N-hops. After finding aggregate mobility, each vehicle disseminates this value and the nod having the least value of aggregate mobility is elected as the Cluster head and the remaining are considered as cluster member.

All the techniques of clustering in VANET uses different type of routing protocols [21].

V. CONCLUSION

In Vehicular Ad-hoc Network due to high mobility of vehicles in the network it was the challenging task to implement the stable cluster. Number of clustering algorithm

is implemented on the basis of parameter like current position of vehicles, direction, speed ,mobility of vehicles , information of lanes, traffic density etc. by the researchers. In this paper clustering algorithm is mainly categorized into traditional clustering technique, predictive clustering and backbone based clustering technique. The entire algorithm discussed under this categorization has different parameters to implement a stable and emphatic cluster. But the stability of cluster is still not achieved at higher level in a highly dynamic environment. In future new clustering techniques can be proposed for highly dynamic environment, which increases the cluster lifespan and also reduces the switching of cluster head.

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