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Analysis and Comparative Study of Clustering Algorithms in Vehicular Ad Hoc Network (VANET)

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ABSTRACT: Vehicular AD Hoc Network (VANET) emerge as a solution to many issues that arise on the road during travelling. For the smooth working of VANET, there is various hurdle like instability of a network, high speed nodes etc. To make the network stable, a high topological change in network is the biggest challenge. To minimize the effect of high topological change in the network, the clustering technique is invented as a big solution. Clustering is a logical group of nodes having similar type of features lead by some special node called cluster head (CH), and another normal member is called cluster members (CM). Many Clustering techniques for VANET are suggested in the literature. The performance of clustering is mainly calculated through CH and CM duration. Here the objective of this paper to analyze the various clustering algorithms and find some conclusions that helps the researcher to carry the work at more advanced stage.

KEYWORDS: VANET, Clustering, Routing, Traffic scenario

I. INTRODUCTION

The road accident happens on the road is the biggest problem in the current scenario. There are various reasons for such accidents like driver fault, fog, and blind spot. To minimize such accidents, there a requirement of such network in which each vehicle should communicate with other nearby vehicles. And vehicles should take instant actions based on the information received by others vehicle. To fulfil this requirement, researchers working on VANET from last many years [1-3]. VANET is an important category of Mobile AD Hoc Network (MANET). The primary difference between these two is that in the VANET, the nodes are high-speed moving vehicles, and vehicles' movement pattern is restricted to some defined path. In the smooth implementation process of VANET, there are various issues like the frequent disconnection, signal fading, and highly dynamic scenario. In handling such issues, there are many challenges, but the biggest challenge is the fast topological change in the network due to high-speed vehicles [4]. Timely and efficient data delivery is the primary requirement of VANET. After analyzing these issues and challenges, researches find that clustering technique can handle such issues efficiently. So with this objective, the various clustering technique is described in the literature [5-7]. The general cluster-based architecture is shown in Fig. 1. Detailed analysis and comparative study of clustering protocols in VANET may help the researchers to make more robust clustering protocols for VANET. So the detailed study about clustering and comparative study of important clustering protocols is given in further section.

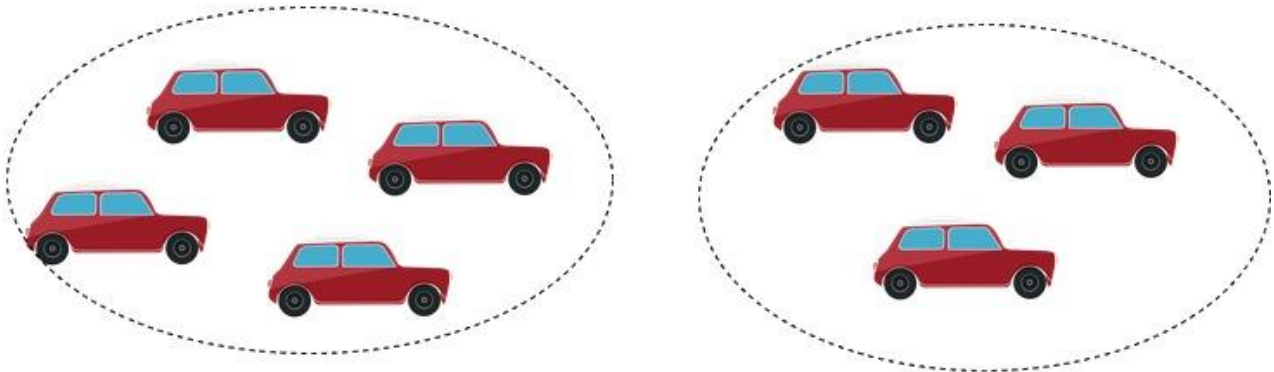


Fig. 1. Cluster based architecture in VANET

II. CLUSTERING

Clustering is a technique to form the logical group of vehicles in the geographical vicinity based on some conditions. In the clustering process, one of the following roles is assigned to a vehicle.

1. Cluster Head (CH): The most appropriate vehicle in a logical group that is expected to sustain a cluster for a long time.
2. Cluster Member (CM): The other vehicles of a logical group that logically connect to CH and that do not have any inter-cluster link.
3. Cluster Gateway (CG): The vehicle that is capable of connecting two or more cluster for inter-cluster communication.

In VANET each vehicle shares the information with the nearby vehicles. Among this information, some information is used by each vehicle to form a primitive group. In this primitive group, the most appropriate node is selected as CH. The nearby vehicles search the most appropriate CH in their vicinity. After searches, the most appropriate CH the vehicle requested and made a CM of a group. Among such CM, the vehicle that provides the inter-cluster link for establishing inter-cluster communication is called CG.

III. COMPARATIVE STUDY OF CLUSTERING ALGORITHMS

There are many clustering algorithms for VANET are suggested in the literature. All of them have different design and objective. Clustering algorithms use the different parameters for forming the logical group, and many different techniques are used in CH selection. The important clustering algorithms of VANET is concisely describing one by one for understanding the basic motive of designing.

1. To handle the frequent link breaking issue, the density based clustering is suggested in [8]. In this, the network portioned is done on the basis of dense and sparse part. The connectivity level decided that weather vehicle belongs from a dense or sparse part. The relative speed and link quality are two important parameters that are used in forming the group and in CH selection.

Merits:

- (i) The algorithm helps to maintain the strong connectivity between vehicles to establish reliable communication.
- (ii) This algorithm is very much suitable for maintaining routing in a network.
- (iii) The communication overhead forming in the clustering procedure is significantly less.

Demerits:

- (i) The node participation in the clustering process is very low.
- (ii) In the different traffic density condition, the clustering behaviour is drastically affected.

2. AMACAD clustering algorithm [9] published in the further year. Here, cluster formation is based on the mobility pattern model. The destination of a vehicle is the important parameter which is considered in cluster formation and CH selection process. Here relative destination is considered based on the network region, and the final destination is considered based on GPS registration.

Merits:

- (i) The mechanism adapted to exchange mechanism is very advanced.
- (ii) The algorithm avoids global re-clustering
- (iii) This clustering algorithm is very useful for channel access management.

Demerits:

- (i) As the speed difference among cluster member's increases that impacted the performance of the clustering algorithm in a large manner.
- (ii) This algorithm based on the destination of a vehicle.

3. In a further year, Ren et al. [10] suggested another advanced clustering algorithm based on dynamic mobility metric based parameters. In this algorithm authors focus to optimize the cluster size, that impacted to enhance the cluster stability to a large extent. The performance of an algorithm is much better than other previous important algorithms.

Merits:

- (i) The frequent cluster member disconnection is reduced by maintaining a safe distance threshold.
- (ii) Cluster head duration and cluster member duration is increases even in case of increasing speed of vehicles.

Demerits:

- (i) The state change high in a low-speed lane in compared to other algorithms.
- (ii) The algorithm is very much suitable for the urban scenario.

4. The network scalability is a big issue in VANET due to high communication overhead and dynamic scenario. To handle the scalability issue, IBCAV clustering algorithm [11] is suggested by authors. Here RSU was chosen as a CH of the formed cluster that is in their range. The algorithm's performance is computed by packet delivery ratio, end-to-end delay and throughput, and it is much better than previous algorithms.

Merits:

- (i) The algorithm design specially for routing purpose.
- (ii) The control packets for efficient communication is reduced significantly.

Demerits:

- (i) Packet delivery ratio decreases as the speed of vehicle increases.
- (ii) The scenario considered for performance evaluation is a very small size.

5. To handle the routing in non-uniform traffic condition the authors suggested the cluster-based routing for a sparse and dense network (CBRSDN) [12]. Here the base station partitioned the whole network into small partitioned and collected the position information of each neighbor vehicle. Cluster is formed based on the position information of vehicle near to the center point of partition.

Merits:

- (i) The data delivery rate is very high in comparison to previous algorithms.
- (ii) In a data delivery algorithm minimizes the delay.
- (iii) Link sustainability also increases.
- (iv) More scalable approach

Demerits:

- (i) Vehicle speed is taken very low in performance evaluation.
- (ii) The scenario is not very realistic

IV. ANALYSIS & IMPORTANT OUTCOMES

The vehicular network is a very dynamic network. So the network becomes unstable frequently due to such high topological change. Reliable data delivery is a very challenging task. To handle such issues, the clustering technique

comes in the scenario as a solution. The designing of clusters depends on the issue for which it is designing. So with the different objective, the clustering technique is suggested in the literature. For example, some clustering technique is suggested for routing purpose, where some for channel access management. The clustering algorithm design for three different types of traffic scenario, i.e. urban, highway or hybrid. The different parameter is considered for cluster formation and cluster head selection. The relative speed, relative position, direction, are some important parameters are considered in the cluster formation process.

V. CONCLUSION

The clustering technique in VANET used as a major solution against different major issues like providing stability, scalability in a network. For this objective different clustering algorithms in VANET are suggested in the literature. In this paper, we have considered some important clustering algorithms. The parameters used for cluster formation and cluster head selection are discussed in detail. The merit and demerits of clustering algorithms are discussed to describe the strength and weakness of clustering algorithms. The analysis and important outcomes section are discussed to conclude the discussed clustering algorithms. This analysis of clustering definitely helps researchers to build more robust clustering protocols. In future, we will provide more advance experimental study about clustering and their uses in various domains.

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