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A Survey on Stable and Efficient Data Dissemination clustering algorithms for VANETs

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***Abstract*—** Vehicle Ad-hoc Network (VANET) is an emerging technology that ensures road safety by enabling wireless communications. VANETs have drawn greater attention due to their significant attractive features such as dynamic connectivity, self-management and no centralized administration. However, due to the high mobility and the large scale of the network lead to dynamic topology. The rapid and continuous changing topology causes frequent disconnections of the communication links, which results in an increased overhead of the communication protocols. To resolve such problems, many of the clustering algorithms have been proposed for providing an efficient communication among vehicles. In this paper, we are most concerned about to explore the different clustering algorithms for improving routing stability and reliability even with dynamic mobility and dynamic topology.

***Keywords*—** Clustering, VANET, MANET

I. Introduction

A VANET is a special case of a Mobile Ad Hoc Network (MANET) in which vehicles equipped with wireless and processing capabilities to communicate with each other and exchange relevant information through radio links[1]. VANET has basically three main fundamental units through which communication can be managed in the network. They can be classified as On-board units (OBUs), Road side units (RSUs) and the application unit(AU). VANET enables Communication between the Vehicles (V2V Communication) and the road-side infrastructure (V2I communications) [2]. In recent years, Vehicular Ad hoc Networks(VANETs) have attracted the interests of researchers due to its unique features such as improve road safety, increase the traffic efficiency, and offer entertainments. However, due to the extremely high mobility of vehicles, topology changes frequently [3]. Hence this will reduce the network life time and increase the routing overhead. The most common solution adopted for this problem is the clustering. Clustering techniques in VANET is a way of grouping nodes in geographical vicinity together based on some rules or criteria or some common characteristics. Typical cluster structure is shown in Figure. 1. It can be seen that the nodes are divided into a number of virtual groups (with the dotted lines). Under a cluster structure, mobile nodes may be assigned a different status or function, such as clusterhead, clustermember or clustergateway. A clusterhead (CH) is a special node responsible for assigning bandwidth and coordinating the members of the cluster. In each cluster, there must be at least one clusterhead (CH). Usually, nodes which have better features are elected as cluster head. A clustermember is usually called an ordinary node, which is a non-clusterhead node without any intercluster links.

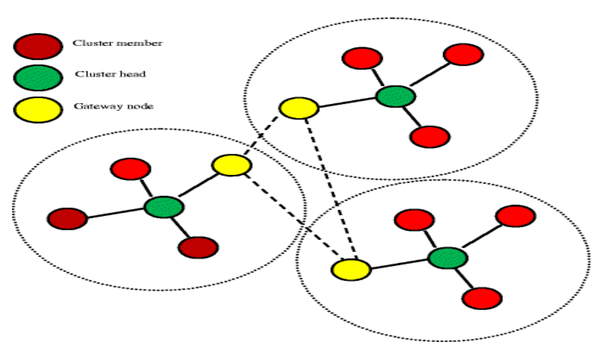

Figure. 1. Cluster Structure

According to [4], clustering has many benefits, such as optimizing the bandwidth utilization, efficient resources allocation, reduce communication overhead, high data packet delivery ratio and low delay. Generally, two different approaches for clustering are defined in VANET: First, static clustering based on Vehicle-to-Infrastructure (V2I) communication that Road Side Units (RSUs) play the role of static cluster heads. In this case, cluster works within the range of RSU. There is no need of cluster reconfiguration. These clusters are not scalable. Second, dynamic clustering based on Vehicle-to-Vehicle (V2V) communication that cluster heads are chosen from cluster members. These clusters are easily scalable, because the vehicles either join or leave the clusters at any time.

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

II. CLUSTERING ALGORITHMS IN VANET

Stability is the most important factor that clustering algorithms are try to achieve for efficient communication between the vehicles in the VANET. To form a stable clusters many researches has provided various clustering schemes. Thus here we classify and analysis various clustering algorithm for VANET.

A position based clustering technique is proposed in [5] where the cluster structure is determined by the geographic position of nodes and the cluster head is elected based on priorities associated with each vehicle. This algorithm is a beacon based whose objective is to prolonging the cluster life time in VANETs. A node’s ALM is the variance of the relative mobility over all its neighbors. The node with less variance relative to its neighbors is a better choice for cluster head. However since the vehicles are highly dynamic in nature the position of the vehicles change very fast and hence may induce an computational overhead in calculating the weight associated with the vehicles.

In [6], the author proposes another position based clustering algorithm. In this algorithm a node becomes a cluster head only if it satisfies two conditions. a) The node has the highest priority in its single hop neighborhood, and b) it has the highest priority in the single hop neighborhood of one of it s single hop neighbors. While designing the algorithm of computing priorities, author makes two reasonable assumptions. First, every vehicle has limited travel time and distance on highway. Second, two neighboring vehicles do not have the exact same instant speed along their journey. Though this solution gives a stable cluster structure its performance is not tested in sparse and jammed traffic conditions which are very frequent in traffic scenarios.

In the algorithm proposed in [7], each road is divided into segments and in each segment some anchor points are defined. Vehicles near the anchor points are selected as cluster heads. But this algorithm fails to address the cluster maintenance and stability issues.

In [8], the author proposes a cluster formation scheme based on direction of vehicle at the approaching intersection and the node which is the first vehicle moving in a particular direction is selected as the cluster head. It has a defect that more overhead will be created if the cluster head changes frequently due to nodes moving at variable speed. Then author proposes a new CH election policy for direction based clustering algorithm called as Modified Clustering based on Direction in Vehicular Environment (MC-DRIVE). The primary functioning of MC-DRIVE is based on the parameter THdistance. This value yields an optimal value of the cluster and is dependent on the speed and the radio range of the vehicles approaching the intersection. The cluster stability is maintained in term of the number of node within a cluster by this algorithm.

In [9], the author presented a modified distributed mobility adaptive clustering (MDMAC) algorithm to adapt the new features of VANET. This modified algorithm is distributed and mobility-adaptive, as well as traffic direction dependent, and thus, the cluster stability was increased by avoiding re-clustering when groups of vehicles move in different directions. The algorithm is based on periodical transmission of status message.

In [10], the author presented an algorithm for improving the accuracy of GPS devices called Location Improvement with Cluster Analysis (LICA). The real-time data is collected by the vehicles and relay the information to other vehicles. This will guide the driver to reach the final destination securely and efficiently. Exactness in distance measurement in LICA minimizes the location error, resulting in achievement of higher performance.

In [11], the author proposes an Adaptable Mobility-Aware Clustering Algorithm based on Destination positions (AMACAD) to accurately follow the mobility pattern of the network .This deals with prolonging the cluster lifetime and minimizes the global overhead. AMACAD operates in a distributed way with the final destination, relative destination, speed, and current location as parameters to calculate the metric function, within an urban scenario.

A Cluster Based Location Routing (CBLR) algorithm presented in [12] assumes all vehicles are able to achieve their positions via GPS. This algorithm is a beacon based, which are used to distribute the state of the nodes. Each node maintains a neighbor table, in which it lists the nodes with which it can exchange information. The table gets updated when node receives the beacon messages.

Author [13], presented Broadcasting based Distributed Algorithm (BDA), which stabilize the existing clusters in vehicular ad hoc networks that require only single hop neighbor knowledge. This method tries to improve the performance of existing clustering algorithms. However, broadcasting based distributed algorithm gives maximum priority to leadership duration for cluster formation and all nodes attempt to re-evaluate their conditions at a time which may cause traffic overhead and therefore consume more bandwidth.

In [14], proposed another lane-based clustering algorithm based on the traffic flow of vehicles. The proposed algorithm is based on the assumption that each vehicle must have prior knowledge of exact lane of traffic on road through some lane detection system and in depth dig-ital street map that includes lane information. Each vehicle computes its Cluster Head Level (CHL), speed, position etc. and broadcasted them into the network. The vehicle with the highest CHL will be selected as the CH.

In [15] set packet transfer delay as the relative mobility between multi-hop distanced vehicles and selected vehicles with the smallest aggregate mobility within multi-hop neighbors as CHs. In this scheme, vehicles must identify the aggregate mobility of all N-Hops distance neighbors. Consequently, numerous extra control messages are generated and broadcasted within the network, which eventually reduces the efficiency of cluster formation.

In [16] introduced a vehicular multi-hop algorithm for stable clustering (VMaSC) based on average relative mobility matrix. The vehicles with least aggregate mobility within multi-hop neighbors are selected as CHs. Mobility is calculated with the difference in speed among neighboring vehicles moving in the same direction in multi-hop. However, VMaSC requires the support of GPS or similar location services to obtain mobility data.

In [17], the author presented a distributed multi-hop clustering algorithm for VANETs based on neighborhood follow (DMCNF) to enable fast and stable network setup. In this technique, vehicle can choose its CH by following the most similar vehicle. The cluster has a CH, which is directly or indirectly followed by other vehicles.

In [18], presents an intelligent naïve Bayesian probabilistic estimation protocol to estimate traffic flow in the network. Cluster formation is performed based on direction of vehicles in the network and each vehicle follows following states: unknown vehicle, cluster head, cluster member, and conditional member. In cluster creation various control messages such as HELLO packet, Join invite, Join reply, and Acknowledgement packet are exchanged between vehicles. CH selection is carried out by naïve Bayes algorithm by considering traffic weight, vehicle density, connectivity level, speed and distance. However, Cluster formation considers only direction without speed of vehicles, which affects the stability of the cluster. Similarly, limited metrics involved in CH selection increases number of CH changes.

In [19], author introduces a hybrid VANET architecture that combines IEEE 802.11p and LTE. In hybrid VANET architecture, vehicles are clustered by VMaSC clustering scheme, which is involved with vehicle information base (VIB). In each vehicle, VIB is maintained to store all neighbor information. In hybrid architecture, vehicle-to-vehicle communication is carried out through IEEE 802.11p and vehicle to infrastructure communication is carried out by LTE. Data dissemination is involved with cluster member, cluster head, eNodeB, and EPC. Here emergency data transmission also follows same dissemination process, which increases delay for emergency data. VMaSC scheme increases control packet overhead within the cluster, which results in high bandwidth consumption.

In [20] paper, on-hop neighborhood follow based clustering method is presented. Here, all vehicles follow CH directly or indirectly. Each vehicle is allowed to select a stable target vehicle to follow from its one-hop neighbors. The selection of target vehicle is performed based on relative mobility metric. The vehicle, which has large number of following vehicles, is selected as CH. In addition, this method utilizes follow message and follow reply message for cluster formation. Cluster formation based on relative mobility alone reduces the stability of the cluster. CH selection based on limited metrics leads to frequent CH changes.

In [21], clustering is performed by affinity propagation algorithm in which distance metric a neighbor list, which consist of neighbor node details such plays vital role. In this method, each node maintains as position, velocity, similarity, last responsibility received, last responsibility transmitted, last availability received, last availability transmitted, log-odds of CH, CH status flag, and node expiry time. Here the similarity function refers to Euclidean distance between two nodes in the network. Cluster formation based on distance metric minimizes the stability of the cluster Limited metrics considered for CH selection affects the stability of CH.

In [22], data dissemination is performed based on clustering and probabilistic broadcasting (CPB) method. Initially, vehicles moving in same direction are clustered in order to improve cluster stability. Clustering process is involved with neighbor discovery, CH election, cluster formation and maintenance, and gateway selection phases. Clustering metric is formulated by utilizing link quality, direction, and number of neighbors. This method is not suitable for emergency data transmission.

In [23], presents an energy efficient geographic based routing protocol to improve link stability in VANET. In this protocol, average delay and packet loss are minimized by grouping vehicles accordance to packet header and packet forwarding. Then routes are selected from same clusters in order to assure the stability of the route. Here receive on most stable path (ROMSP) algorithm is utilized with grouping process to select optimal route. In ROMSP algorithm, packet flooding is controlled by detecting duplicate request packets in the group. Route selection considers link expiry time as routing metric. Here emergency data transmission also follows same route selection process (i.e.) transmission within group which increases transmission time. Route selection is inefficient since link expiry time only considered for routing.

[24], focused on both routing and emergency data transmission in VANET. In this paper, appropriate vehicular emergency dissemination (AVED) approach is presented to avoid redundant broadcasting in the network. This approach is supported by cooperative awareness message (CAM) which is broadcasted by each vehicle periodically. In this approach, emergency packet is included with vehicle IDs with ranking. When a vehicle receives the emergency packet, then it searches for its ID in that packet. If that vehicle ID is received then it broadcast the packet. Otherwise, it drops the packet. In addition, optimal route for data transmission is selected based on stability of the route. Stability of the route is computed based on transmission range and velocity of the vehicle, which is not sufficient for optimal route selection. Emergency data transmission increases the size of emergency packet by including vehicle IDs and ranks. When the packet size is increased then it also increases delay for the packet transmission.

III. CONCLUSION

Vehicular Ad Hoc Networks are being used in variety of applications. The various Clustering schemes in VANETs have been proposed. In Vehicular Ad-hoc Network due to high mobility of vehicles in the network it was the challenging task to implement the stable cluster, stability is the most important factor that clustering algorithms are try to achieve. But the stability of cluster is still not achieved at higher level in a highly dynamic environment. In the future, we would like to propose a new clustering technique based upon the discussion and analysis, which enhances the cluster life time and reduces the frequent change of cluster head.

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