A REVIEW OF STABILITY AWARE CLUSTERING ALGORITHM IN VEHICULAR AD HOC NETWORK

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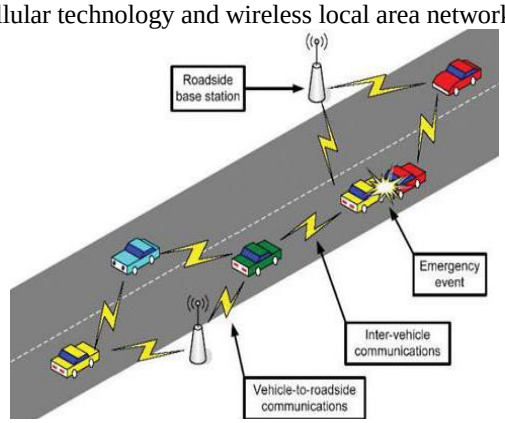
ABSTRACT

A Vehicular Ad hoc Network (VANET) is a special kind of Mobile ad hoc network, in which vehicle acts as a node (communication device) to create Ad hoc network. VANET is identified as the future transportation system in which vehicles communicate with each other and it ensures road safety by avoiding accidents on the road. Due to sparse distribution of vehicles in the network, communication between the vehicles is a challenging task. Clustering avoids this problem by grouping the geographically adjacent vehicles into a cluster. Clustering of vehicles can significantly improves the scalability of the network, but high mobile nature of vehicles in the cluster affects the network stability by dynamically changing the network topology. To create more stable network, clustering algorithm should consider mobility of the vehicles as one of the key factor for cluster formation and cluster head selection. Such a mobility aware clustering produces stable and secure connection between the vehicles in the network. Since most of the recent research papers were focused on stability aware clustering scheme in VANET. This survey paper focus only on stability based clustering algorithms instead of considering various clustering schemes available in VANET.

Keywords— VANET; Clustering; Stability; Relative Mobility; lane; Vehicles.

I. INTRODUCTION

Vehicular Ad hoc Network is an emerging technology to achieve intelligent- inter vehicle communication by combining the best features of ad hoc network, cellular technology and wireless local area network.



The Main application of VANET is Intelligent Transport system (ITS), in which each vehicle in ITS is equipped with transmitter, receiver and router to broadcast information to transportation office or vehicular network. From the knowledge of received information, ITS provides free-flow traffic and road safety. ITS uses WAVE [1, 2] standard for distributing information and data about the road conditions, weather forecast and road maintenance. Two main types of communication taking place in VANET is (1) Vehicle to Vehicle Communication (V2V) and (2) Vehicle to Infrastructure communication (V2I). In V2V communication, vehicles communicate among themselves and in V2I communication, vehicles communicate with Roadside unit (RSU). Dedicated Short Range Communication (DSRC) supports V2V and V2I communication by providing 75 MHz radio spectrum in 5.9GHz range offered by United state Federal Communication Commission(FCC). In VANET, DSRC provides High Data Rate and Low Communication Latency. A Short range Communication-DSRC have wide range of applications in VANET, which includes V2V safety messages, toll collection, information about traffic in a lane and drive through payment etc.

A. Clustering:

In VANET, Vehicles are highly mobile in nature, which dynamically changes the network topology. Due to frequent topology change, wireless channels are not stable due to frequent disconnection of wireless links between the vehicles. Hence VANET suffers from challenges like information transmission, design of efficient dynamic protocol, and stable networks. Clustering is the only way to overcome the above-mentioned challenges in VANET. In Clustering, geographically adjacent vehicles are grouped into some virtual groups based on certain rules and vehicle behaviour. Virtual groups are also called as clusters. In a cluster, vehicle can take any one of the state as Cluster member (CM), Cluster head (CH), Cluster Gateway (CG) or sometimes undecided state. Based on clustering algorithm, particular vehicle in the cluster is selected as Cluster Head. Selected CH is assigned with some additional responsibility for effective data transmission in the network by providing local co-ordination between the vehicles. Hence CH acts as a local co-ordinator for that cluster. Cluster member can able to communicate with the network through its CH. Thus clustering of vehicles in VANET, significantly improves the network scalability.

B. Stability Aware Clustering:

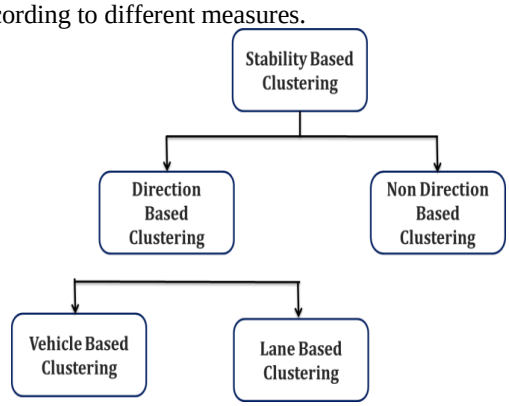
In VANET, vehicles are highly mobile in nature and it may move from one cluster to another cluster which leads to frequent link break, cluster re-organisation. This Frequent link break, cluster re-organization and CH re-affiliation makes the network unstable. Though scalability can be achieved through clustering, stability will be the main issue if mobility of the vehicle is not considered as the main factor for forming the clusters. In mobility aware clustering schemes, vehicles having similar mobility pattern or low relative mobility with its neighbours are grouped into same cluster. This kind of Mobility aware clustering scheme leads to significant

improvement in network stability by considering mobility of the vehicles as the key metric for clustering. Mobility aware clustering scheme involves two stage of clustering (1) cluster formation (2) Cluster Maintenance stage. In initial cluster formation stage, it divides the entire network into number of clusters and it will elect CH for each cluster. In cluster maintenance stage, it re-organizes the clusters by considering mobility behaviour of the vehicles for creating more stable network. Since Stability of the network is the important requirement in VANET, thus this review focuses on some important stability aware clustering algorithm in VANET.

The rest of the paper is organised as follows: Section II provides a brief classification and discussion of various stability based clustering algorithm in VANET. Each algorithm is explained with support of its cluster formation and cluster maintenance stage for creating stable network and Section III concludes the discussion.

II. Stability Based Clustering Schemes

Clustering schemes in VANET can be classified according to different measures.



The Stability based clustering in VANET can be classified into Directional and Non-directional based mobility aware clustering. Directional based clustering can be further classified into Vehicle based and Lane based clustering Scheme.

A. Vehicle Based Clustering Schemes

AROVE [3], uses new clustering technique called Affinity Propagation to produces stable clusters by minimize the rate of cluster head change and by increase the cluster member duration and cluster head duration. This Affinity propagation based algorithm is a distributed algorithm in which each node in the network periodical sends messages with availability, responsebility and similarity information to its neighbouring nodes. Node moving in same direction with less relative velocity gives positive similarity function value. From the similarity information, each node can find its cluster member. This self-similarity function reduces the number of clusters produced. Sum of self- availability and self- responsibility gives the clusterhead value of the individual node. Node having positive clusterhead value has more chance to become a clusterhead. In cluster maintenance stage, cluster decisions are made over every cluster interval for producing stable clustering. This affinity propagation based clustering algorithm forms clusters, which minimize relative mobility and distance between the cluster members to its cluster head. Thus, it improves stability and exhibits low rate of change of clusterhead.

Mildred, et al., [4] Proposed an Adaptable Mobility –Aware Clustering (AMACAD) in VANET. AMACAD enhances the cluster stability and cluster life time by consider destination of the vehicle as a key factor for managing the group mobility and model the behaviour of the vehicles. This algorithm uses final destination of the vehicle, speed, relative destination and current locations as key parameter to calculate its metric function. AMACAD is a distribution algorithm where each node maintains a table having information about its location, relative destination, final destination, speed and bandwidth and this information is collected (up-dated) in period interval. In initial cluster forming stage, each sends affiliation message to neighbouring nodes, from the reply message each node can calculates function F for all the neighbouring nodes in their trans-mission range, where F is a weighted function of current location, relative destination and final destination. AMACAD will construct the clusters by using the Function value F of the each node and node having minimum value of F will be selected as a cluster head for that cluster. This distributed destination based clustering algorithm enhances the clustering stability significantly by reduce the number of cluster re-affiliation and prolong the cluster life time.

Ahmad Abuashour et al, [5] proposed Cluster based life time Routing (CBLTR). CBLTR is two direction segmentation based clustering algorithm where cluster heads are selected based on maximum life time (LT). CBLTR first divides the networks into two-way directional segments and each segment is divided into multiple clusters, such that each vehicle must be assigned with one cluster. Each node in the cluster can periodically calculate its Life time cost value in its cluster. LT depends on distance between the node and its pre-defined direction threshold value; it also depends on current velocity of the node. Direction threshold can be obtained from the product of maximum velocity of the cluster and Handover time. LT is the time upto which a node is associated with that cluster. Node having Maximum LT will be selected as CH and it remains in CH until it reaches the direction threshold point. If CH achieves this threshold point then new cluster and CH selection have been invoked. Thus, this LT Based clustering in CBLTR improves the cluster life time significantly in the VANET.

Wei fan et al., [6] proposed a mobility metric based dynamic clustering (DCA) algorithm in VANET. In this algorithm, Spatial Dependency (SD) is considered as the mobility metric for forming stable cluster. In DCA, each node can take any one of the three state- cluster head, cluster member or normal node. In cluster formation stage, nodes are considered as normal node and broadcast HELLO messages to all the neighbouring nodes. Each node can find its own mobility information like velocity and acceleration at regular interval from the broadcast reply message from all the neighbouring nodes. From the knowledge of location information and mobility information, each node can calculate relative

velocity and relative acceleration. Product of relative velocity and relative acceleration gives the SD value of the node. Once SD is obtained, each node can calculate its Cluster Relation (CR) value by averaging the Total SD value. Node having highest CR value is selected as Cluster Head. In cluster maintenance stage, CR value of the node is compared with minimum and maximum CR values in the cluster for cluster re-election. This spatial dependency based clustering in VANET significantly improves the network stability by increasing the cluster life time, and reducing the number of cluster head change.

Multi-Agent based Mobility aware dynamic clustering have been proposed in VANETs [7]. In this algorithm, Dynamic clustering agency is assigned with responsibility to take decisions on selection of cluster head and cluster member. Dynamic cluster agency comprises of manager Agent (MA), Information Propagation Agent (IPA) and Cluster Knowledge base (CKB) to provide stable clusters through dynamic clustering. This algorithm involves two phases of clustering. First phase of clustering is Identification of cluster members, in this phase each vehicle broadcast its speed and location information to all the neighbouring nodes which are within its transmission range. Due to different direction of movement and high relative velocity, all the neighbouring nodes may not be suitable for cluster member of a lane. Based on relative speed and direction movement, MA will select the cluster members among the neighbouring nodes. In second phase of clustering called Dynamic cluster formation and Cluster Head selection, IPA provides information about Connectivity and Relative speed of each cluster member node to MA. MA uses IPA and CKB information to develop its cluster information table. MA identifies the Cluster head from the cluster information table and creates the stable clusters.

B. Lane Based Clustering Schemes

In Traffic flow for Cluster formation in VANET, Mohammed [8] proposed a lane based clustering scheme in which cluster election is based on maximum traffic flow on the lane. Each vehicle can find its exact lane through lane-detection system and digital street map. From this knowledge, each vehicle can find its flow of traffic at each intersection. Each intersection may have three kind of traffic flow (Left Turn, Right Turn and No Turn). Based on total number of lanes on the road and total number of lanes for each traffic flow, each vehicle can find its lane weight. After finding the lane weight, each vehicle can calculate its Cluster Head Level (CHL). CHL level of the vehicle depends on Network connectivity level, Average Distance level and Average Velocity level. Once the vehicle calculates its CHL level, it broadcasts this information to all the neighbouring nodes. The vehicle having the highest CHL level will be selected as Cluster head. Vehicle with highest CHL level yield stable clustering and long cluster life time. For cluster maintenance, each vehicle periodically updates its own CHL level and broadcast this message to its neighbouring vehicles. This improves the network stability in the cluster maintenance stage.

A Stable Clustering for Efficiency Application is proposed and it is a single hop communication protocol which uses direction as a prime metric [9]. In this algorithm cluster formation is initiated at initiating point. Initiating point is assigned distance of twice the radio range of the nodes from the intersection point. Once a vehicle reaches the initiating point, vehicle can send HELLO messages over a direction in which it travels. In that direction if it receives any reply message from Cluster Head then it will join with that cluster else it assumes itself as a cluster head and forms a new cluster. After successful formation of clusters, each vehicle in the cluster exchanges information with the clusterhead and with the neighbouring nodes. In each cluster, clusterhead is the leading vehicle which having the responsibility of cluster maintenance and density estimation. Density estimation is more accurate when CH is in front of the cluster. If any node which leaves the cluster before it sends the information to the infrastructure may leads to unstable network and inaccurate density estimation. To avoid this circumstance, this algorithm involves switching mechanism to constantly monitor the event of clusterhead overtaking by any cluster member. If overtaking of clusterhead occurs, then clusterhead initiates the cluster change over process. In this process if overtaking vehicle satisfy certain the condition then, Clusterhead will transfers the density information and Clusterhead role to the overtaking node which leads to stable network and accurate density estimation

C. Non Directional Based Clustering Schemes

A new stability based clustering in VANET (SBCA) is presented [10], which aims to improve the cluster stability, Cluster life time and to reduce the average number of CH change in the network. SBCA involves election of primary and secondary CH for each Cluster. Selection of Primary CH (PCH) is based on its velocity differences with the neighbouring vehicle and each PCH selects its Secondary CH (SCH) by mobility prediction based strategies. SCH in SBCA acts as a backup CH for PCH. SBCA involves two phases of clustering, Cluster setup and cluster maintenance. In setup phase, initially nodes are in Undecided State. If this node receives invite-to-join (ITJ) message from any CH, then it will join with that cluster by sending request-to-join (RTJ) message to that CH. A node having low velocity difference with all the neighbouring will be selected as PCH. In cluster maintenance phase, SBCA can able to achieve high stability and reliability by having two CHs (PCH and SCH) per cluster. PCH uses mobility prediction scheme for the SCH selection. Cluster member having to low average velocity with its PCH will be elected as SCH. Since nodes in VANET are highly mobile, SBCA improves the stability of the network by each cluster is assigned with two CHs. It also improves the reliability of the network by PCH to notify its SCH whenever PCH leaves the cluster, which also minimizes the cluster maintenance costs.

Seyhan et al., [11] proposed a multi-hop stable clustering algorithm in VANET. This algorithm aims to construct stable clusters with minimum number of

cluster heads. This algorithm forms stable clusters with one cluster head, one or more cluster members and one cluster guest. Nodes in a cluster can communicate with its cluster head in a hop-count less than a pre-determined value. The role of cluster-guest is enabled only in one-hop cluster and it is used to prevent the network from unnecessary cluster head election. In initial cluster formation stage, all the nodes are in INITIAL state. In this state, nodes can send or receive the HELLO packets from its neighbouring nodes. From the knowledge of HELLO packets, it received, each node can calculate average relative speed. In STATE-ELECTION state, clustering process is initiated and clusters are formed with cluster head, cluster members and cluster guest. Node having smallest average relative speed is elected as clusterhead in its cluster. Cluster members can associate with its corresponding clusterhead by sending JOIN-REQ to its clusterhead. Cluster member can associate with its clusterhead only by hop-count smaller than its predefined value. Since this algorithm is multi-hop, average relative speed based clustering algorithm, it produces stable clustering with least number of clusters in the network.

Aggregate local mobility based clustering (ALM) uses contention method to reduce frequent cluster- re-organization in high density traffic lane by avoiding unnecessary cluster head changes [12]. ALM is a beacon-based algorithm which uses node's aggregate local mobility as a key parameter for clustering. It also uses different method of aggregate mobility weight calculation by assuming all the vehicles know their geographical location from GPS. In initial clustering stage, each node broadcast HELLO message to its neighbouring nodes then each node can calculate its relative mobility with those neighbouring nodes from the HELLO message reply. Variance of relative mobility of a node with all its neighbouring nodes gives the Aggregate Local mobility for that node. Node having low Aggregate local mobility has more chance to become to a cluster head. In high traffic environment two cluster heads may move into each another's transmission range, then each cluster head wait for Cluster change interval (CCI) to enter contention. After CCI, if two CHs are not in the same coverage area then it escapes from cluster re-affiliation else CH having low ALM wins the contention and CH with low ALM joins with CH having high ALM as a cluster member. Thus, this contention based ALM reduces the number of cluster re-affiliation in high density traffic scenario and it uses low aggregate relative mobility to improve the stability.

DCEV is proposed to represent End-to-End Relative mobility based D-hop clustering in VANET [13]. In this D-hop clustering, each node has maximum of D-hop distance from its CH. In DCEV, Relative mobility between the node, with its neighbouring nodes is used as mobility metric for forming the D-hop clustering. Each node can find its one hop neighbouring nodes by sending beacon messages of WAVE Standard [2]. Once node finds its one hop neighbours, it can calculate mobility information from the one-hop neighbour node's beacon messages which have location and mobility information. Each node can start clustering by selecting single-hop neighbouring node with smallest relative mobility. With the help of selected one-hop neighbouring node, each node can find its 2-hop neighbouring node which has smallest relative mobility with single-hop neighbouring node. Each node continues this neighbour node selection up to D-hop. This D-hop selection gives end to-end low relative mobility and D–hop route to the node. Each node can select its CH by choosing a node with highest degree of connectivity and lowest relative mobility in its D-hop route. DCEV also involves some exception for CH election. Thus, DCEV provides stable clustering by consider end-to-end low relative mobility as mobility metric for finding the more stable route.

III. Conclusion

In VANET, Clustering is the typical hierarchical network structure. It provides more stable and secure network structure if it considers mobility of the network as the key parameter for clustering. Such kind of stability aware clustering in VANET requires efficient mobility prediction method. Hence this paper briefly presented the various stability based clustering scheme in VANET. It facilitates mobility aware clustering in VANET by clearly explains how network forms clusters and elect their CHs for creating more stable network. With this review researchers can have comprehensive understanding of stability aware clustering and mobility prediction methodologies in VANET. We hope this review may facilitate the researchers to provide more stable and secure network structure in VANET.

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