A SURVEY ON CLUSTERING TECHNIQUES USED IN VEHICULAR AD HOC NETWORK

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Abstract—A vehicular ad hoc network (VANET) can be described as a special type of Mobile Ad hoc Network (MANET), which uses vehicles to create a mobile network. VANET is the future of transportation system as all the vehicles in network communicate with each other and thus, avoid a sheer amount of accidents on roads. The communication in VANET is at greater risk because the messages are broadcasted and a wireless medium is used for data propagation. For secure communication among these vehicles, clustering algorithms are preferred. Formation of stable clusters withstanding the mobility pattern of the vehicles is important key factor for clustering algorithms in vehicular networks. Cluster formation in VANET is highly challenging as there is no global topology and even the nodes are highly mobile. Many clustering schemes have been proposed by the researchers which can be classified into either mobility based clustering or non-mobility based clustering algorithms. This paper focuses on the survey of clustering algorithms proposed for stable cluster formation and more secure communications.

Keywords—Clustering in VANET, Classification of clustering techniques, Vehicular ad hoc network

I. INTRODUCTION

With the fast emerging collaborative and transformative technologies in the current digital age, Connected is a buzzword today. The Connected Era is a world consisting of Internet-connected cars, TVs, refrigerators and shoes that can tweet. The Internet-connected cars are result of a new emerging technology called Vehicular ad hoc network (VANET). It is a network formed by vehicles on road. VANET can also provide driver-less vehicles which will be safer, causing fewer accidents and less congestion. The advantages of using driver-less vehicles are that they will be more energy efficient, reduce the driving time and can park themselves in parallel. Vehicles implementing this technology can easily identify the spots already taken by other vehicles in a parking area. This reduces the time and fuel unnecessarily wasted on finding a vacant spot in a parking lot. The main intention behind this technology is that vehicles can actually communicate with each other, perceive risks and respond more quickly than human reflexes allow. The VANET technology can avoid accidents on road to a major extent and still if accidents occur, it makes vehicle crashes survivable. Statistically, VANET could prevent 80 percent of accidents that are not caused by drunken drivers or mechanical failures.

In VANET, all vehicles participating in the network turn themselves into a wireless node. This enables vehicles around 100 meters far from each other to communicate and create a network on road. Nodes can detect each other with the help of sensors inbuilt in vehicles and having the ability to detect vehicles around them. Even when vehicles become unreachable to others or leave the network, other vehicles can join the network resulting in a mobile network with nodes as vehicles connecting to one another.

When vehicles are in network, they send messages regarding their personal information, road information, unnatural activities on road, etc to other components of the network. These communications are done through the wireless medium provided by the WiFi's. Communication in VANET includes Inter-vehicle communication (IVC), Inter-roadside unit communication (IRC) and Roadside unit to vehicle communication (RVC). In IVC, vehicles communicate among themselves. Roadside units communicate among themselves in IRC. In RVC, vehicles communicate with the fixed devices installed on either sides of roads, called as Road Side Units (RSU). This technology was initially developed for police, fire and emergency departments.

As the vehicles pose dynamic nature, vehicular network is likely to face stale entries and congestion. In order to avoid these kind of problems many solutions have been proposed of which clustering is one of the solution technique. Clustering reduces the messages count and increases the connectivity in the network.

The remainder of this paper is structured as follows. Section II provides a discussion of the recent literature on the clustering techniques in VANET and a brief classification of protocols using clustering techniques in the VANET. The last Section III concludes the discussion.
II. CLUSTERING PROTOCOLS FOR VANET

Researchers all across the globe proposed many clustering schemes for VANET. These clustering techniques focus on various topics and even use clustering schemes proposed for MANET for cluster formation. Hence in this paper, we attempt to classify these schemes according to the parameters used in the respective technique. Classification of the clustering schemes in vehicular network is summarized below.

A. Mobility Based Clustering Schemes

Protocols under this category consider mobility characteristic of vehicles as one of the parameters for selecting clusters and cluster heads in the network. The other characteristics of a vehicle are position, direction, speed, etc. The mobility based clustering techniques can be further classified into two types depending on the direction taken by the vehicles on road. They are direction based clustering schemes and non-direction based clustering schemes.

1) Direction Based Clustering Schemes

Some of the direction based clustering schemes focus on direction of vehicle for selecting effective clusters for the vehicular network. However, some of these schemes focus on direction of vehicle or lane for selecting clusters or cluster heads for the respective network. So according to these differences the direction based clustering schemes can be further classified into two types: Lane based clustering schemes and Vehicle based clustering schemes.

a) Lane Based Clustering Schemes

The lane based clustering schemes consider the direction of traffic on road as one of the parameters for calculating efficient and comparatively stable clusters in VANET. The advantages of a stable clustering scheme are that it reduces the overhead of re-clustering which results in an efficient network topology. Cluster head changes and cluster reconfigurations cannot be avoided in varying networks like VANET. This affects the stability of the network. For more stable clusters in the network there needs to be fewer cluster head changes. To achieve less number of cluster head changes, cluster members should select a node among the cluster members which can meet all the requirements of being a cluster head for a relatively long period of time than rest of them.

Mohammad S. Almalag et al. Discuss a technique where cluster head is selected depending on the lane having the maximum traffic flow. Vehicles have the knowledge of the lane of traffic on road and they broadcast this information to the nearby vehicles. This helps in determining the efficient cluster head. All vehicles in the network compute and broadcast their Cluster Head Level (CHL), speed, position, etc. CHL is calculated using lane weight, average distance level, network connectivity level and average velocity level of the traffic. Using the periodic beacons, a vehicle broadcasts the calculated CHL and the general traffic data in the network. Then the vehicle holding the highest CHL value is selected as the cluster head. This process of cluster formation is repeated for every 20 seconds.

In dynamic environment like VANET, cluster re-configurations and cluster head changes are must and unavoidable. But, these affect the stability of the network. N. Maslekar et al. Discuss a scheme which aims for better stable clusters and accurate density estimation in a cluster. This scheme proposes that the formation of clusters occurs before the road intersections and uses predicted traveling path for cluster formation. Using Global Positioning System (GPS), every vehicle knows its location in the network. But the direction information at an intersection is calculated prior. The formation of clusters is started near the intersections and depends on the direction taken by the vehicle after crossing intersection. Overtaking by vehicles affects the stability of clusters in the network. Every vehicle computes its relative distance with the CH constantly in order to avoid them overtaking the CH. When any vehicle wants to overtake the vehicle acting as the CH, a notification regarding the overtaking is sent to the CH. After receiving the message if the density information is not sent by the existing CH, it is checked whether the overtaking vehicle can act as the new CH till an intersection is reached by the cluster. If the overtaking vehicle has the potential to become a CH, the cluster head changeover procedure is initiated by the existing CH. In contradiction to this, if it doesn't have the potential then the existing CH notifies that there is no effect of overtaking on the cluster and also on the density estimation.
b) Vehicle Based Clustering Schemes

Protocols using the direction of vehicles for selection of clusters and cluster heads are classified under vehicle based clustering schemes.

LORA-DCBF is a routing algorithm based on position of the vehicle. It uses both GPS and direction of vehicles for cluster formation. This scheme enables two or more cluster heads for a cluster, provided that the cluster heads are in opposite directions. It enhances traditional routing techniques by using local information. Routing of packets is done in a hop-to-hop fashion. Nodes use the most recent location information of the neighboring nodes for packet routing in the network. Thus the system can sustain some packet loss. As vehicles are highly mobile in the network, transmission of data is prone to stale entries and loss of data. This can be avoided since all the intermediate nodes transmitting the information are using the most recent information. The control traffic is reduced due to the usage of only selected nodes, which are also called as gateway nodes, for message dissemination. This strategy is more effective and results in more stable clusters as there different directions nodes have different cluster heads.

AMACAD is proposed to represent the behavior of vehicles and their mobility patterns in groups for vehicular network. To increase the lifetime of clusters and to reduce the global overhead, AMACAD uses mobility pattern of the network. The important aspect for modeling group mobility and behavior of vehicles is the destination of vehicles in the network. This helps in improving the stability and lifetime of clusters. The metrics considered for stable cluster formation are current location, speed, relative destination and final destination of vehicles in the network. This protocol manages the mobility, improves the cluster lifetime, decreases the cluster head changes, decreases the cluster re-affiliations and also avoids group re-clustering. The cluster size in the AMACAD is variable. The messages are transmitted by groups which aids in increasing the communication delay, low data delivery, reliability and congestion issues, enabling the vehicular networks to be more efficient and accurate.

APPROVE is a clustering algorithm that emphasizes on typical vehicular movement for formation of stable clusters. It mainly focuses on stability of clusters. Generally, stability of clusters is defined by longer cluster head duration, longer cluster member duration, and lower rate of cluster head changes. In this technique, each node transmits information to all its neighboring nodes and then eventually each node independently takes a decision on clustering. Hence, only one-hop clusters are possible in this algorithm. In this scheme, clusters are formed in such a way that there is a minimum distance and minimum relative velocity between the cluster head and the cluster members by considering information regarding the position of vehicles. Thus, it successfully decreases relative mobility and distance between the cluster head and its member nodes.

VWCA is an effective clustering algorithm using a complex metric for more stable clusters and increased connectivity in the network. It is a weighted clustering algorithm proposed for highway scenarios for improved stability, security and connectivity of VANET. The metric used for stable cluster formation includes the number of neighbors, the direction of vehicles, the entropy, and the distrust value parameters. Stability and connectivity can be enhanced and overhead can be reduced by considering these parameters for cluster formation in the network. For electing cluster head, this algorithm uses weighted clustering value, which is weighted sum of distrust value of a vehicle, entropy value of a vehicle, number of neighbors of a vehicle and direction measure of a vehicle. Vehicle having the minimum weighted clustering value in the neighborhood is elected as the cluster head. If vehicle cannot identify any cluster head in its neighborhood, it simply declares itself as a cluster head. But if there are two or more vehicles with same minimum weighted clustering value, the vehicle holding higher entropy or lower distrust value is selected as the new cluster head.

2) Non-Direction Based Schemes

The protocols using mobility without direction as the metric for selecting cluster and cluster heads are classified under non-direction based schemes.

VMaSc is a clustering technique which selects a cluster head by considering the least mobility function. The least mobile node can be identified by using the speed difference between neighboring nodes in the network. In VMaSc the key metric is average relative speed. Clustering depends on changes in relative mobility of vehicles by calculating average of relative speed of all the neighboring nodes moving in the same direction. In cluster maintenance phase, timers are used for controlling the connections between cluster head and cluster members. If a cluster head does not get any packet from connected members in a predefined amount of time, it assumes that member vehicles are lost. In N-hop clustering, member election is based on cluster information reception, and thus the connection between head member pair is weaker than the multi-hop clustering.

KCLS protocol is a location service protocol which combines both connectivity and mobility of vehicles in the network. Thus clusters can be selected with
trade-off between communication overheads and vehicle locations. Clusters formed by KCLS protocol are quite stable as the mobility of vehicles is considered as per the average link expiration time. This can increase the life time of cluster head upto 50 percent in comparison to other clustering schemes of VANET. While creating a new cluster in the network, a Cluster State (CS) packet is been broadcasted by cluster head to all other existing cluster heads in the network. Depending on the received CS packets, a cluster head updates the location information of cluster or even establish a Location Service table with location information of cluster in the network. A CS packet holds location information of a corresponding cluster, including cluster ID, the cluster heads coordinates, cluster member list and neighboring cluster list.

To attain stable clusters, node having high mobility compared to its neighboring nodes cannot be elected as a cluster head. If such a node is elected as cluster head, the probability of cluster breakage and even re-clustering is high. Hence, MOBIC proposes that a node with least mobile nature compared to neighboring nodes should be selected as the cluster head. MOBIC is basically designed for mobile ad hoc network but also works for VANET. It uses mobility metric for selection of cluster heads. It depends on lowest ID clustering algorithm. But it utilizes signal power levels mobility metric derived from successive reception. The clusters formed by using this technique are more stable when compared to the Lowest-ID clustering with least cluster head changes. The rate of cluster head changes is reduced by 33 percent when compared to the Lowest-ID clustering algorithm. It results in more stable clusters and thus better performance.

Zhenxia Zhang et al. Discuss a novel clustering scheme where clusters are selected based on the relative mobility between vehicles at multi-hop level. This technique uses packet transmission delay to represent the logical distance between two vehicle nodes in the network. It is obtained from beacon delay on each node transmitted and received to other nodes. Vehicle nodes having low aggregate mobility can be selected as the cluster head nodes. After receiving two beacon messages, the vehicles can calculate the relative mobility between the vehicles. In scenarios where two cluster heads are in same range, the re-clustering of nodes is postponed for a small amount of time which helps in improving cluster stability. One of the advantages of this technique is that it avoids unnecessary re-clustering. Vehicles can calculate the aggregate mobility metric similar to MOBIC.

As the vehicles are highly mobile on road, it is quite difficult to find the exact route in VANETs. In ALCA, agents communicate with each other and calculate mobility of vehicles depending on learning vehicle clustering. Agents are deployed on moving vehicles, and they have sensing capabilities. Agents are used to decide the itinerary of the vehicles and share this information with the other agents. The agents decide the path and are also useful in calculating the density of the vehicle on the road in an interactive manner which they share with the other agents for taking the decision about routing. The reason for selecting the agent technology is that they are autonomous and adaptive in taking the decisions.

ASPIRE is a scheme proposed for vehicular ad hoc network where clustering is done in a distributed manner. This scheme helps in creating large clusters and also providing high network connectivity. The scheme lowers cluster head durations and increases the number of cluster head changes. It reduces the infrastructure costs in the network by using mere vehicles on roads. ASPIRE architecture consists of vehicles that form clusters with relatively lower mobility. In these clusters few nodes act as Cluster Members (CM) while the other act as Cluster Heads (CH). Every cluster has a single cluster head. These clusters in turn form Mobile Networks (NEMOs), each with a Mobile Router. ASPIRE provides caching potentials between clusters formed by vehicles and NEMOs, reducing the overhead and cost of accessing the fixed service provider network for each vehicle request or binding update due to a topology change.

B. Non-Mobility Based Schemes
The non-mobility based schemes are the vehicular ad hoc network schemes which use clustering technique but don’t use mobility as one of the metrics. The following are few of the non-mobility based schemes. Keisei Okano et al. Proposed an autonomous clustering scheme which selects network gateway nodes dynamically according to network topology change in heterogeneous mobile ad hoc network environment. When a network gateway node is to be selected, a cluster head takes a decision on whether to select the network gateway nodes or to wait for a specified amount of time. In order to avoid oscillation of network gateway nodes between two adjacent clusters, the waiting period is calculated by comparing its own network address with the network address of the neighboring network. If the network address of a cluster head is more than that of the neighboring network, it waits for a specified period until the gateway nodes of the neighboring network are elected by the cluster head.

The goal of clustering algorithm discussed by Slawomir Kuklinski et al. Is to form long living and stable clusters for reliable communication. This technique can also be referred to as density based
clustering in VANET. This is a clustering scheme with complex metric which is a function of density of connection graph, traffic conditions and link quality. Prerequisite of the scheme is that a node having knowledge about its current position, position of the node connected by the link being evaluated and velocity vectors of itself and the other node. Cluster formation in this technique is based on several factors like connectivity level, link quality (SNR), relative node position and the prediction of this position in the future, node reputation.

Zaydoun Y Rawashdeh et al. Discuss a scheme which aims for a stable network topology. It considers speed difference among the neighboring nodes as a parameter for stable clustering structure. Vehicles moving in a same direction always form clusters. In this technique, vehicles having higher mobility group in to one cluster where as vehicles having lower mobility group in to another cluster. The challenge in this technique is to divide the network into minimum number of clusters. This is based on their mobility patterns and is achieved with high probability. Therefore, all neighboring nodes used for speed difference calculation are limited to those vehicles traveling in the same direction.

A CBLR (Cluster based location routing) is discussed by R. A. Santos et al. CBLR implements clustering technique in evaluating inter-vehicular traffic of data on a motorway using a multi-hop network. The nodes in vehicular network uses HELLO message to distribute states. A new node entering the network can either join an existing cluster or create a new cluster by acting as a cluster head. It is assumed that all the nodes know location and position of other nodes in a cluster. In this technique each cluster head maintains a cluster table which contains the address and geographic locations of its member nodes. A cluster neighbor table is also maintained by the cluster head which contains information about its neighboring clusters.

C. Certificate Based Schemes

The protocols which use clustering scheme for certificate generation or revocation approach are classified under certificate based schemes. The following are few protocols which fall under this category.

Tahani Gazdar et al. Discuss a dynamic public key infrastructure for VANETs that aims to distribute the role of the central certification authority among a set of dynamic chosen Certificate Authorities (CAs). Election of dynamic CAs is based on a clustering algorithm where cluster heads perform the role of certificate authorities. The dynamic demilitarized zone (DDMZ) formed by confident nodes which are located at 1-hop distance from cluster head of the same cluster. These confident nodes are intended to perform as the registration authorities (RA).

In, Qingwei Zhang et al. discuss a certificate revocation status validation scheme. It uses the concept of clustering in the realm of data mining. In VANET, certificate validation is more time sensitive as every vehicle is prone to receive large number of messages in a minimum amount of time. The discussed scheme employs the k-means clustering technique to boost up the efficiency of certificate validation. There by, this enhances the security of vehicular ad hoc network. Credibility and the issued date are added to certificates to improve the security of the system.

Ghassan Samara et al. Discuss a new security mechanism that achieves secure certificate revocation. Revoking some or all the certificates of the problematic vehicles is called as certificate revocation. This enables other vehicles to avoid any information from those vehicles that can cause problems. Certificate re-vocation is done in situations where any misbehaving vehicle having valid certificate (VC) is discovered, or where an RSU replaces old valid certificate with new invalid certificate. Generally, an RSU replaces VC with an invalid certificate. This is done in order to warn other vehicles about avoiding this vehicle. This happens when more than one vehicle reports to RSU with the same VC and broadcasts wrong data.

CONCLUSION

Traditional clustering algorithms developed for mobile ad hoc network are difficult to implement for vehicular ad hoc network as the nodes in this network are highly mobile. Further, nodes of vehicular ad hoc network do not pose power challenges as posed by nodes of mobile ad hoc network. Hence, new clustering algorithms are developed for vehicular ad hoc network which aim for stable and effective clusters in the network. In this paper, vehicular ad hoc network protocols using clustering schemes are classified into three major categories as mobility based clustering schemes, non-mobility based clustering schemes and certificate based clustering schemes. This categorization is based on the parameters used to form stable and effective clusters in the network. For first two categories, mobility of nodes is the main parameter for classification. The mobility based clustering schemes can be further classified based on direction of vehicles namely direction based clustering schemes and non-direction based clustering schemes. The direction based clustering schemes use direction of the vehicles or traffic as one of its parameters for cluster formation. The non-direction based clustering schemes use parameters other than direction. Direction based clustering algorithms are further classified into lane based clustering schemes and
vehicle based clustering schemes. Lane based clustering schemes use direction of traffic as one of the clustering parameters where as vehicle based clustering schemes use direction of vehicle as one of the clustering parameters. Protocols classified under non-direction based clustering schemes use speed difference and density based metrics as the clustering parameters. The certificate based clustering algorithms use clustering technique for certificate generation and revocation in the vehicular ad hoc network.

REFERENCES