A Novel Weighted Vehicular Network Clustering Scheme

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Abstract. In today's world of emerging success in trending technologies, one of the most open and vast area of wireless communication research is the Vehicular Ad-hoc Network (VANET). Incorporating the trending technologies with the growing internet services, and deploying these into Intelligent Transportation System(ITS) is one of the open challenges. Therefore, for efficient vehicular network in ITS, in the urban areas as the nodes are mobile therefore clustering of these nodes comes into the picture. Many clustering algorithms are proposed based on different metrics and different results are obtained. This paper attempts to proposed a new clustering procedure where direction, distance, speed and transmission range are considered so as to obtain stable clusters and a weighted value is computed to select cluster head. The simulation results were simulated in NS-2.

Keywords: VANET, Cluster, Mobility, DSRC, Cluster Head

1 Introduction

There have been huge improvements in the field of wireless communication in the last decade. Vehicular ad-hoc network (VANET) communications has been a recent research area where the researchers all around the world are excavating. In vehicular communication as the nodes are movable and illustrate a dynamic topology, communication may be feeble at times when there is huge density especially in urban areas and due to frequent node movements frequent link failures are observed. One of the solution to enhance communication in VANET (Vehicular Network) is to cluster vehicles based on some metrics or parameters such as speed, distance, direction, velocity etc. In this paper, our main motive is to employ clustering procedure in the vehicular network. By adapting clustering into the vehicular network scenario, scalability is obtained, longer range communication in addition with less overhead at the base stations due to the presence of cluster head in each cluster which can communicate directly with the cellular infrastructure and relay the information to the cluster members. Through clustering the following advantages are achieved like the increased in network connectivity which reduced message counts, less routing overhead, message delivery is augmented and appropriate usage of network bandwidth.

In real time traffic scenarios, the vehicles move at random speed and this movement affects the stability of cluster and reorganization of clusters has to be carried out. The cluster head has to be selected in such a way as to maintain stable clusters.

The rest of the paper is organized as follows.The next section reviews the related work based on clustering followed by a brief summary on the state of art focusing on clustering of mobile nodes with the system's design. Results are discussed and presented in section 4 and the paper is concluded in section 5.

2 Related Works

A few recent related papers on clustering schemes are studied which are described in this section. Clustering can be categorized based on the parameters considered for selecting a cluster head as different authors proposed various methods and chose different parameters for choosing of a cluster head.

2.1 Comparison Table of different Clustering Algorithms

The following table shows the comparisons between different Clustering Algorithms based on their different metrics considered along with their merits and demerits.

Algorithm	**Metrics Considered**	**Advantages**	**Disadvantages**
N. Maslekar et al. [1]	Based on the direction which the vehicle will take after crossing intersection.	Overcome the influence of overtaking within the clusters and formed stable clusters	Overhead is added due to the exchange of messages and the density information amongst the nodes due to cluster-head switching.
Mohammad S. Almalag et al.[2]	The vehicle holding the highest Cluster Head Level (CHL) value	Able to select the most stable and longer lifetime cluster-head	It applies the knowledge of each vehicles lane and the flow direction of each lane
LORA-DCBF [3]	Makes use of member direction to form the cluster in which cluster head and cluster members moves in the same direction.	Minimizes flooding of its control traffic, more effective and results in more stable clusters.	Only gateway nodes can transmit information to neighbour clusters within a specified period of time.
AMACAD [4]	Destination, location, speed, relative destination and final destination of vehicles as a parameter to arrange the clusters.	Decrease the delay of communications,bottlenecks, overhead and temporary fragmentation.	the performance may decrease due to the speed difference among the members.

APROVE [5] [6]	Elects cluster heads periodically, by using affinity propagation.	Decreases relative mobility and distance between the cluster head and its member nodes.	Performance may degrades in terms of number of clusters formed.
MOBIC [7]	Uses mobility metric for selection of cluster heads.	More stable clusters and thus better performance.	If few neighbour nodes move differently, this method results in dramatic increase in the variance.
Zhenxia Zhang et al. [8]	Vehicle nodes having low aggregate mobility can be selected as the cluster head nodes .	It avoids unnecessary re-clustering.	It does not provide secure authentication and balancing security
CBLR [9]	A new node entering the network can either join an existing cluster or create a new cluster by acting as a cluster head.	Enables dynamic, self-starting, and multi-hop muting between participating mobile nodes.	Performance is better when speed is less than 30 m/s, therefore limited.

Table 1: Comparisons of different Clustering Algorithms

3 Proposed Approach

Our proposed algorithm is based on Figure 1. The depicted scenario presented the proposed architecture for VANET communication consisting of Road Side Units (RSUs) or infrastructure based communication and on board units (OBUs) or mobile nodes.

Clustering in VANET means systematizing vehicles into small sets based on some common traits or characteristics such as vehicle's direction, speed, velocity etc. Due to the dynamic topology changes, cluster's stability is weak and cluster head changes are unavoidable. The main criterion for cluster formation is to minimize the overhead and increase cluster's stability. Cluster's stability can be achieved only if the cluster head duration is augmented and cluster reorganization is minimized. The formation of clusters and usage of bandwidth are the most important tasks in any clustering algorithm.

3.1 System Design

A novel architectural scenario is proposed in this paper for vehicular communication pictured in Figure 1. It is assumed that all vehicles are fitted with GPS (Global Positioning System) for locating a vehicle.

The Base Stations can be any cellular infrastructure based technology and the OBUs are the vehicles with DRSC capabilities antennas. There are specific

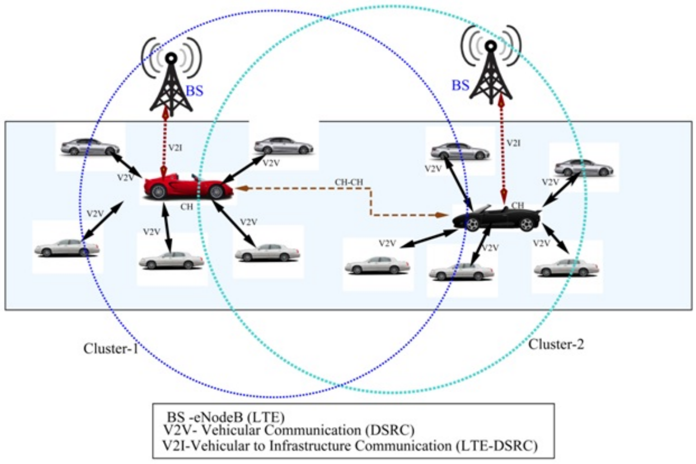

Fig. 1: Vehicular Network Scenario

terms during cluster formation and in this paper some terms are discussed as follows for cluster formation.

1. Cluster Head (CH)
   A cluster head will act as a relay for disseminating data to the cluster members from the base station and from the CMs to the BS. CH can also communicate with other clusters through the cluster head of another cluster which can be termed as inter- cluster communication.
2. Cluster Member (CM)
   Cluster members are the vehicles belonging to a particular cluster which are under the proximity of a particular BS. CMs can communicate with the BS through the CH, where the CH will relay the information. In addition to this, the cluster member can also communicates with each other in 1- hop communication but when the same message needs to be relayed in 2- hop the messages should not be delayed else the second CM might get stale messages.

From Figure 1 it is clearly seen that the clusters might overlap. The coverage range of DSRC is 1000 meters; hence vehicles within this proximity can communicate with each other. Within each cluster there is one vehicle which acts as a cluster head (CH) and as discussed earlier can relay information to the cluster members within the cluster. For a vehicle which falls into two cluster, the decision as to which clusters will it belong will be determined by its distance with the cluster heads of both the clusters and it will be with the one which is minimum.

3.2 Formation of clusters

In real life traffic scenarios, vehicles in the same lane moves in the same or in a particular direction to the vehicles moving in the opposite lane. Therefore based on mobility and direction clusters are formed. The question arises as to how the vehicles formed clusters? As the nodes are mobile, when a vehicle enters a particular area that vehicle will first calculate it's distance with the base station to make sure whether it is under the proximity of the base station or not. If yes, then the vehicles belong to that particular cluster and then proceed in calculating its distance with the cluster head which is depicted in the flowchart in Figure 2. . If the new vehicle receives an acknowledgement within 5s then a CH is already present in the proximity and the new vehicle will send a request message to join, then the CH will update the BS about the new cluster member. Otherwise, the new vehicle will send HELLO message to BS and it will elect itself as the cluster head.

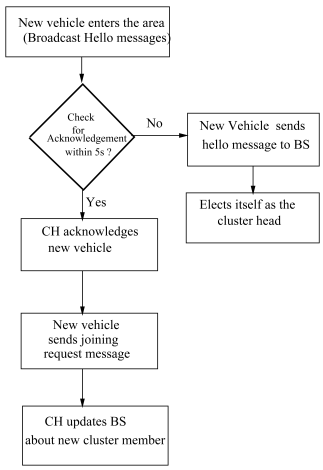

Fig. 2: Flowchart for Cluster Formation

During cluster formation, cluster head acts as access points for the cluster members belonging to the same cluster hence formed intra-cluster communication and cluster head of one cluster communicates with the CH of another cluster therefore, inter-cluster communication takes place.

Algorithm for forming clusters and election of cluster head: The following procedure is carried out for forming clusters and cluster head election. Let V = V1,V2, V3,............Vn be a class or set of vehicles moving in a road, where these vehicles have DSRC transceivers. Let C=C1,C2,C3,.............Cn be the cluster head classes.

The first step is to calculate the distance and the direction of a particular vehicle when it enters a particular area. Before calculating the direction, distance should be calculated first which can be computed as follows.

1. Calculating the relative distance between the vehicles:
   The distances between the vehicles are computed considering one vehicle with its neighboring vehicle which can also be termed as 1-hop neighbour. The most popular distance algorithm is adapated i.e., the Euclidean distance which can be computed by the following equation.

$$D_v = \sqrt{\sum (X_i - Y_j)^2} \tag{1}$$

   Where, D_v is the distance between vehicles X_i, Y_j are the coordinates of the X and Y axis.
2. Calculating direction between the vehicles:
   For calculating the direction of the vehicles (V1, V2), beaconing message transmission is taken into consideration. A vehicle V1 will broadcast two beaconing messages (M1 , T) and (M2, T+1) to its neighbor vehicle V2 in time T and T+1, and the distances (D1, D2) are computed with these respective timing. The following algorithm is carried out

```
If D2 > D1
{
Then V2 is moving in the opposite
direction,
Cluster_members= false;
}
else
{
V2 is moving in the same
direction as V1
Cluster_member= true;

}
```

3. Transmission Range:
   The next step is to calculate the transmission range for determining the distance of the vehicles with the base station.

$$R = C_0 * t/2 \tag{2}$$

From the above calculated distance and transmission range a weighted value is computed for all the vehicles and the vehicle with the minimum weighted value is considered to be the cluster head. The weighted value can be computed as follows:

$$W_0 = \sum (D_v + R) \tag{3}$$

Hence, from the above computations clusters can be established and cluster head can be selected.

4 Results and Discussions

In this section the simulated results are described which was simulated in network simulator using NS-2 and SUMO which is a traffic simulator using Open Street Maps for real time environment taking up Guwahati city in Assam. Figure 3 depicts the broadcast of messages from the cluster head to the cluster members. The vehicles within the cluster can communicate among themselves in 1000 meters range as specified for DSRC. Here,the vehicles joining the cluster as well the vehicles leaving the cluster are being noted.

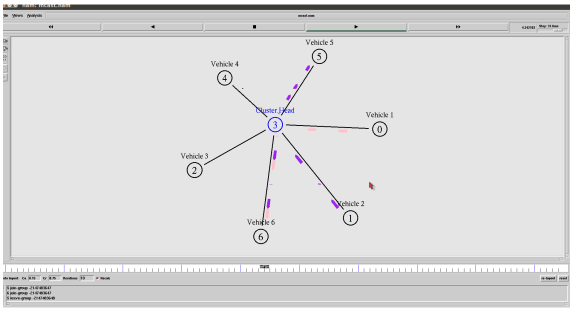

Fig. 3: Cluster Head communication with cluster members

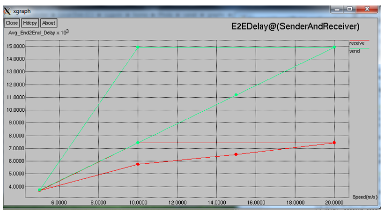

Fig. 4: End-to-end delay between Receiver and Sender

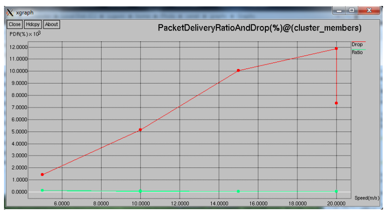

Fig. 5: Packet Delivery Ratio rate and Packets Drop

From Figure 4 end-to-end delay between receiver and sender is portrayed and in Figure 5 Packet Delivery Ratio (PDR) and packet drops are shown. With this approach, data dissemination is increased as clusters formed reduced congestion and bottleneck towards the base station. The improvements also include the reliability of message broadcast from the cluster head to the cluster members. In our approach clusters are formed such that any pair of nodes can either communicate directly with its 1- hop neighbor also termed as 1-hop cluster.

5 Conclusion

VANETs becomes a widely used promulgation technology in the recent years. In this paper, a brief review has been done on the various vehicular communication clustering algorithms proposed so far. A novel clustering procedure based on direction and distance the clusters are formed and based on a weighted value the cluster head is selected. Future works includes computation of performances with the previous proposed related clustering algorithms and to improve security as well as reliability of safety messages being delivered to vehicles.

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