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An Efficient Clustering Algorithm for Vanet

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Abstract

Vehicular Ad hoc Network (VANET) is a subclass of mobile *Ad Hoc* network. VANET has become an active area of research to improve the safety of vehicle and road, traffic efficiency, and also to increase the comfort to both drivers and passengers. Due to the high mobility and dynamism, routing the messages to their final destination in VANETs is a challenging task. These issues can be addressed by clustering techniques. Clustering is a mechanism of grouping of vehicles based upon some predefined metrics such as density, velocity, and geographical locations of the vehicles. Clustering in vehicular ad hoc networks (VANET) is one of the control mechanisms for dynamic topology. Many of the VANET clustering algorithms are derived from mobile adhoc networks (MANET). However, VANET nodes are characterized by their high mobility, and the existence of VANET nodes in the same geographic proximity does not mean that they exhibit the same mobility patterns. Therefore the clustering schemes of VANET should consider the speed and velocity of nodes to construct a stable clustering structure. In this paper, we introduce a new clustering technique suitable for the VANET environment with the aim of enhancing the stability of the network cluster. This technique takes the distance and velocity as a parameter to create relatively a stable cluster structure. We also developed a algorithm for super cluster-head selections.

INTRODUCTION

Vehicular Adhoc network is a challenging research area where many researchers focus challenges in vehicular communication. In VANET vehicles exchange data frequently to facilitate route planning, road safety and other non-safety applications. A vehicle can communicate with another vehicle directly or vehicle can communicate to Roadside Unit. VANET insist cooperative communication with peer nodes in a operation environment of high mobility and dynamically changing topology. These challenges can be addressed by clustered network.

Clustering is a technique to group nodes. Each cluster has cluster member (CM), cluster head(CH) and cluster Gateway(CG). Cluster head is leading node of a cluster and it is responsible for coordinating all cluster members in the cluster. A CG can communicate to nodes belonging to different clusters. The major challenge for clustering algorithms is to ensure stability in a highly dynamic environment. The efficient clustering algorithms should focus on forming a minimal number of clusters and to maintain the current cluster structure and keep the overhead at the minimum level. Most of the existing VANET clustering algorithms are derived from the MANET clustering schemes. These algorithms do not consider the mobility characteristics of VANET. For efficient clustering stable clustering is required. Therefore the main goal is to enhance cluster stability where vehicles change their speed and direction normally. In this work, we introduce a new clustering approach with the aim of increasing the stability of the network topology and a optimal super cluster Head selection algorithm to improve the network life time.

The rest of this paper is organized as follows. Section II presents the literature Survey. Section III describes proposed VANET clustering algorithm and super cluster Head selection algorithm. Section IV presents our simulation results, and finally this paper concludes with Section V.

RELATED WORK

In the recent literature survey much research has been made on the cluster based VANET of which many presents low maintenance clustering algorithm. In [1] the cluster-based location routing (CBLR) is proposed by the authors. HELLO messages are used by the nodes to distribute their states. When a node enters the system it registers with the cluster head to become a cluster member, otherwise it enters the undecided state and then announces itself as a CH if it does not receive a HELLO message within a period of time from other nodes. The VANET topology changes are managed by maintaining a table containing a list of the neighboring nodes with which they can exchange information. Each node knows their position and the position of their destination and forwards the packets directly towards the destination.

In [3], the same algorithm in the CBLR for the cluster formation is adopted. A Node can be a member in more than one cluster. In this case they are called Gateways and used to route packets to their destination. Nodes track changes in the topology and adapt their states to the situation using two tables; one for the neighboring nodes and the other one for the adjacent clusters. The media access control in the cluster-based VANET environment to improve the QoS support is also focused. According to the needs of the cluster member the time slots are assigned to them.

The clustering algorithm proposed in [4] is basically the lowest ID used in MANET with a new modification. The leadership duration and the direction in the lowest ID algorithm are used to determine the node to be a cluster head. The leadership duration (LD) is defined as the period the node has been a leader since the last role change. The cluster-head rule is to choose the node with the longest leadership duration and then choose the one with the lowest ID. The formation of clusters is based on beacon signals. Each node announces itself as a cluster head and broadcasts this to all neighbors. If it receives a reply from a neighboring node with a lower ID and higher leadership duration, then the node changes its state to a cluster member. When a node leaves its cluster, it looks for another cluster in the neighborhood to join. If none of the neighboring nodes or the neighboring cluster head satisfy the cluster head election rules, then the node claims itself as a cluster head.

In [5] addition to the LD and the moving direction (MD), the authors introduced the projected distance (PD) variation. Each node is associated with a utility weight (UW) of three parameters (LD, PD, and ID), where the ID is the identifier of the node. The LD parameter is given the highest weight. To define the total utility weight, a lexicographical ordering of the three parameters (LD, PD, and ID) is used

In [6], the authors proposed a distributed cluster based multi-channel communications scheme for QoS provisioning over V2V-based VANET. The goal is supporting the QoS for timely delivery of the real-time data like e.g., safety messages, road condition, etc. and increasing the throughput for the non-real-time traffic over the V2V networks.

In [7], cluster-head elections method is proposed by using a heuristic clustering approach. This approach is called position based prioritized clustering (PPC) and uses geographic position of nodes and the priorities associated with the vehicles traffic information to build the cluster structure.

In [8] a new clustering algorithm was proposed which classifies vehicles into groups based on the speed range of vehicles.

In [9] cluster based routing methods in VANET was proposed. The data is forwarded to the next hop by using geographic information after calculating the optimal neighbor cluster header. The routing overhead is reduced. The cluster header broadcasts a LEAD message to its neighbors. If there is a road side unit (RSU) in the grid it will become a cluster header. Whenever the header is leaving the grid, it will broadcast LEAVE message containing its grid position. An intermediate node stores it until a new cluster header is selected. The new cluster header uses this information for data routing. This protocol does not consider velocity and direction which are important parameters in VANET.

PROPOSED METHOD

The vehicles and Roadside unit are considered as nodes in the VANET. The vehicles move with diverse speed. The vehicles of a VANET are equipped with the DRSC (Dedicated Short Range Communication). Vehicle positions are provided by the GPS. In proposed algorithm the vehicles that move in the same direction are considered to be neighbors. Vehicles can move along the same road way and transmit information or receive information. Communication from the source node can either directly reach the destination or through an intermediate node which may be a router or a road side unit. In vehicle to vehicle communication (V2V), vehicles are enabled in a common range to communicate among themselves. But, in vehicle to roadside (V2R) vehicles communicate through access points on the network which causes a lot of additional overhead and delay.

The fundamental idea of Affinity Propagation is used in the proposed algorithm for clustering and the Cuckoo search (CS) optimization algorithm is used to discover the super cluster head. Each node in the network transmits the responsibility and availability messages to its neighbors, and then makes a decision on clustering independently. The node mobility is determined by the equation (1) while creating a cluster. It is a combination of the negative Euclidean distance between current node positions and node positions in the future.

$$s(i,j) = -(\left|\left|x_i - x_j\right|\right| + \left|\left|x_i' - x_j'\right|\right|) \qquad (1)$$

$$x_i = \begin{bmatrix} x_i \\ y_i \end{bmatrix} \; x_i' = \begin{bmatrix} x_i + v_{x,i}T_f \\ y_i + v_{y,i}T_f \end{bmatrix}$$

Where x_i is current position and x_i' is the predicted future position of node i. The function predicts each node i's future position in τf seconds from now, Based on node i's current velocity $v_{x,i}$in the x direction and velocity $v_{y,i}$ in the y direction the future position of node i is predicted in T_f seconds. The self-similarities are initialized to the same value to minimize the number of clusters. The velocity of the RSU are defined to be zero as it is immovable node.

Message Transmission and the Neighbor List

Each node will maintain a neighbor list for every neighbor, N_i^j is the neighbor list entry of node i for its neighbor j. Each neighbor list entry, N_i^j contains the following fields: position of node j as $(x,y)_j$, velocity of node j as $(v_x,v_y)_j$, similarity for I,j as $s(i,j)$, last availability received from j as $a(i,j)$, last availability send to j as $a(j,i)$, last responsibility send by j as $r(j,i)$, last responsibility transmitted to j as $r(j,i)$, cluster head converge flag for node j as $CH_{cnvg,j}$, Index of j's current cluster head as CH_j and time that node j expires as t_{expire} [10].

Broadcast and Reception of Hello Beacons

Each node j will periodically broadcast a HELLO beacon containing its ID, position, velocity and current cluster head. The hello beacon broadcast period is defined as T_H, where we have used T_H = 1s in our simulations. Upon reception of a HELLO beacon from node j, node i will calculate its current similarity s(i, j) with j, using (1) and update its neighbor list with the new information. This is outlined in the following procedure

1) Each node j broadcasts HELLO beacon:

2) If receiving node i, travells in the same direction of j, i calculates similarity with j, s (i, j)

3) Node i add or updates j's neighbor list entry N_i^j

Broadcast of RESP and AVAIL packets

The broadcasting period for availability and responsibility messages is defined as T_M, and it is set to 1s in the simulation. The responsibility with each neighbor j is calculated by node i using (2). This value is damped with the previous responsibility (where λ = 0.5), and stored as r(i, j). Node i then add r(i, j) for each neighbor j in the responsibility array, Ri , and broadcasts RESP packet. Each node i will calculate the availability with each neighbor j using equation (3). Node i will store j's damped availability in a(j, i) and adds all a(j, i)'s in the availability array, A_i and broadcasts in the AVAIL packet.

The formulas for responsibility and availability are :

$$r(i,j) \leftarrow s(i,j) - \max_{j' \neq j}\{a(i,j') + s(i,j')\} \quad (2)$$

$$a(i,j) \leftarrow min\left\{0, r(j,j) + \sum_{\forall i' \notin \{i,j\}} \max\{0, r(i',j)\}\right\} \quad (3)$$

The AVAIL packet also includes the flag CH_{cnvg}. Due to the nature of the AP algorithm, A node's self-responsibility plus self-availability will become positive when it has converged to cluster head status. In every iteration of the algorithm, each node i check this condition to set the CH_{cnvg} flag. This flag is used by the neighbor nodes of i to consider i as a potential cluster head. The broadcast of responsibility and availability packet is outlined in the following Procedure.

1) Calculate responsibility, $r(i,j)$ for each neighbor j

2) Update the responsibility with damping factor:

3) Store responsibilities, $r(i,j)$, in the array R_i

4) Calculate availability, $a(j,i)$ for each neighbor j

5) Update with damping factor

6) Store availabilities, $a(j,i)$, in the array A_i

7) Determine if converged to CH status

8) Broadcast the RESP packet: $\langle R_i \rangle$

9) Broadcast the AVAIL packet: $\langle A_i, CH_{cnvg} \rangle$

Reception of RESP and AVAIL messages

On receiving a RESP or AVAIL packet from j, each node will search for its id in the R_j or A_j array to read its specific responsibility or availability message and to store the $r(j,i)$ or $a(i,j)$ of j's neighbor list entry, N_i^j. If the received packet is of AVAIL type, node i will also update the $CH_{cnvg,j}$ field for j according to the CH_{cnvg} flag received. This is outlined in the following Procedure

Upon reception of a RESP or AVAIL packet from node j, node i will:

1) Search for its id, i in the R_j or A_j array.

2) If a message addressed to i is found, update the $r(j,i)$ *or* $a(i,j)$ field in the neighbor list entry, N_i^j

3) Check if CH_{cnvg} flag is set, and update $CH_{cnvg,j}$ field in j's neighbor list entry, N_i^j

Super Cluster Head Selection

By using Cuckoo Search algorithm, a super cluster head is selected in the proposed work. Cuckoo search is a meta-heuristic algorithm inspired by the bird cuckoo, these are the "Brood parasites" birds. It lays its eggs in the nest of another host bird nest. If the host bird identifies the eggs that are not their egg then it will either throw that eggs away from its nest or simply leave its nest and build a new nest. Nest is an individual of the population and the number of nests is equal to the size of the population. Each egg in a nest represents a solution and a cuckoo egg represents a new and good solution. It is assumed that each nest may have multiple eggs that is multiple node converge to be a cluster head and the best solution in the form of cuckoo egg is to be identified. The cuckoo search algorithm is used in selection of super cluster head when more nodes converge to be cluster head. A super cluster head (SCH) is a node from chosen cluster heads which will be at an optimum distance, more network lifetime, minimum delay, high packet delivery ratio, higher bandwidth and energy. CHcnvg is also set. A fitness function is used to discover the SCH. The parameters are calculated based on the weight basis and D denotes the distance, E denotes the energy, P denotes the packets length and NL denotes the network lifetime.

$$F_i = W_1 * D + W_2 * E + W_3 * P + W_4 * NL \quad (4)$$

Where W is weight values, D is minimum delay, E is improved energy, P is packet length and NL is network lifetime

The Pseudo-code of Cuckoo Search:

Begin

Objective function f(x), x=(x1,x2,…,xd)T;

Generate initial population of n host nests xi i=1,2,…n

While (t< Max Generation) or (stop criterion)

Get a cuckoo randomly by Levy Flights

Evaluate its fitness Fi

Choose a nest among n (say j) randomly

If (Fi>Fj)

Replace j by the new solution;

End If

A fraction (pa) of worse nests is abandoned and new ones are built;

Keep the best solutions (or nest with quality solutions)

Rank the solution and find the current best

End while

Post process results and visualization

End Begin

Thus the selected super cluster head also improves reliability, reduces the algorithm complexity and improves the network life time significantly.

SIMULATION AND EXPERIMENTAL RESULTS

The proposed algorithm is implemented in NS2. All simulations are performed with 500 vehicles on a highway. Each simulations ran from 500s but only last 200s. The factors and the settings of the proposed technique are listed in the specified table 1.

Table 1: Simulation Parameters

Parameter	**values**
No. of Nodes	500
Area Size	3000 X 4000 m
Routing protocol	AODV
Beacon packet size	512 bit
Simulation Time	500 sec
Traffic Source	CBR
Packet Size	2500 bits
Transmission range	250m
Metrics	Cluster head duration, Cluster member duration and cluster life time
Destination node	10

To evaluate the cluster stability and overall performance of the proposed algorithm the following metrics are used:

1. Average cluster Head duration: Longer cluster Head duration is important for reliable and secured communication.
2. Average number of cluster member duration: This metric judges the overall stability of initial clustering.
3. Cluster Life Time: This metric measures the stability of a cluster
4. Reliability: Reliability is concerned with the ability of a network to carry out a desired operation such as "communication". If the system has higher reliability then the network has more security.

The performance of the proposed algorithm is compared with MOBIC. Cluster stability is achieved by the proposed algorithm. In a dynamic environment the mobility of the nodes is taken into consideration that improves the stability of the cluster, cluster member and cluster header and also increases the cluster performances. The cluster stability, cluster reliability and network life time are achieved in the dynamic environment.

The proposed algorithms stability performance far exceeds that of MOBIC. MOBICs lesser stability performance could be caused by error in the mobility metric and cluster member suitability. In addition, the MOBIC algorithm does not consider cluster member suitability when forming clusters. Although the CH will initially have the lowest relative mobility in its neighborhood, a cluster member with high relative mobility will enter and exit the cluster quickly, and will choose a new cluster head without regard for the mobility metric. Good cluster stability is due to large cluster CH duration and cluster member duration. This is achieved in the proposed algorithm. The packet delivery ratio and transmission efficiency is also increased as the proposed algorithm maintains super cluster Head. The reliability of the network and its life lime is also increased.

In our simulation the maximum velocity of the vehicles was 40m/s, the cluster interval was 60s and the Time Future-T_F was swept from 0s to 120s for measuring the duration of the cluster Head. The figure 1 plots the cluster Head Duration. The proposed technique has better duration of the cluster head than MOBIC. The figure 2 plots the average cluster member duration and proves it to be better than MOBIC

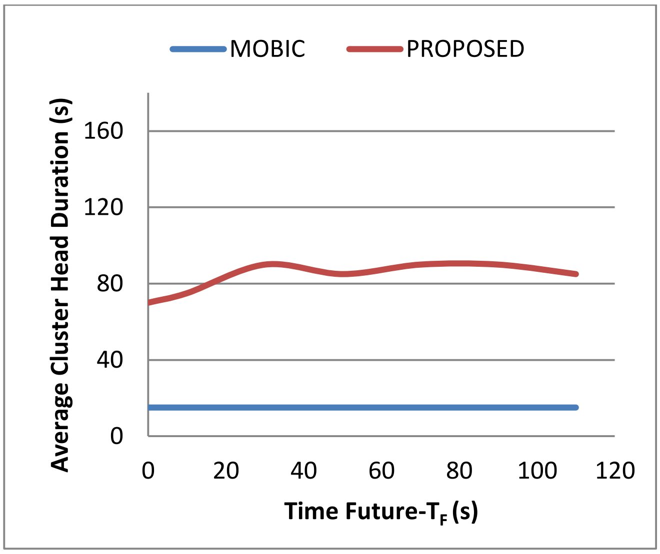

Figure 1

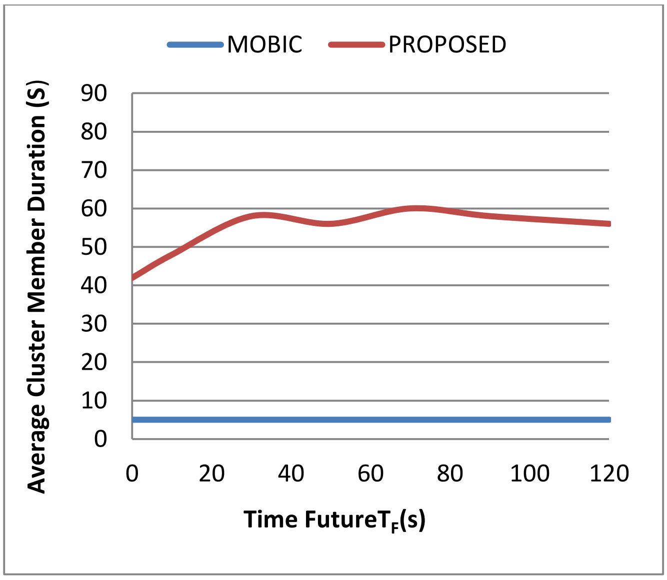

Figure 2

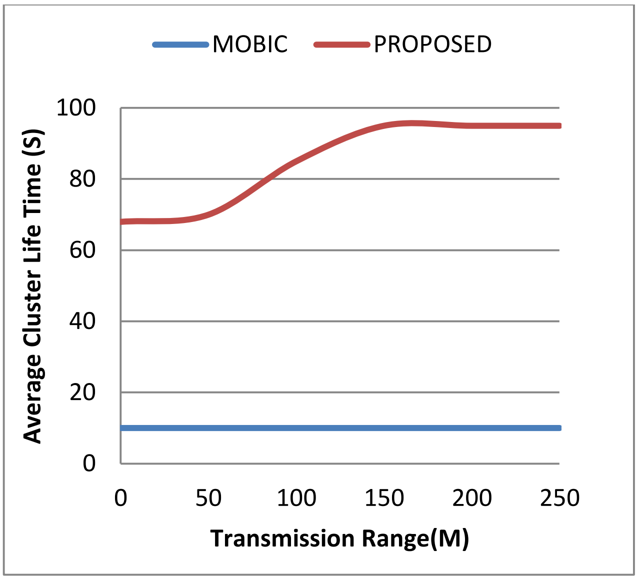

Figure 3

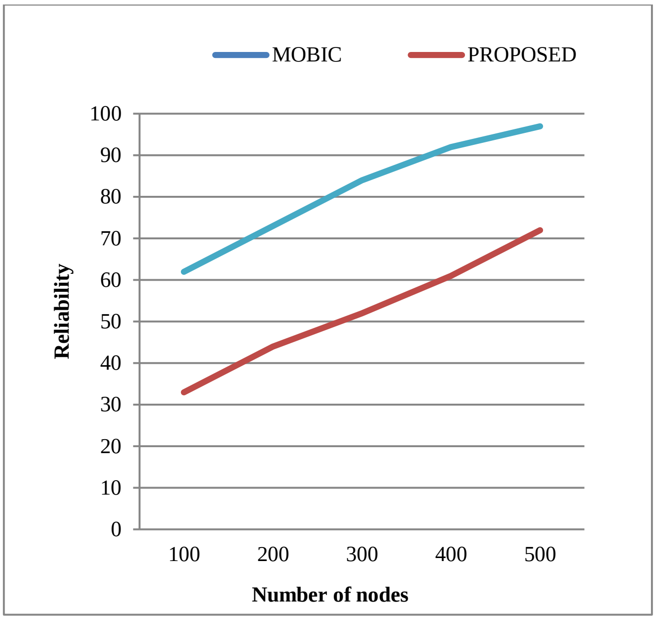

Figure 4

The figure 3 shows the Average cluster lifetime in a transmission range of 50m to 250m , the proposed algorithm shows better cluster life time MOBIC. The Figure 4 shows reliability of the network which is also achieved better than the MOBIC by the proposed algorithm.

CONCLUSION

Motivated by the ample research in cluster-based routing schemes for VANETs, we have proposed a novel clustering algorithm. Our algorithm forms the cluster and selects cluster heads periodically, by using affinity propagation and super cluster head selection method. The proposed algorithm has high stability makes it a suitable for clustering dynamic environment and achieves better stable, secured and reliable solution.

REFERENCES

[1] RA Santos, RM Edwards, NL Seed, 2004, “Supporting inter-vehicular and vehicle roadside communications over a cluster-based wireless ad-hoc routing algorithm”, in Proceedings of the Winter International Symposium on Information and Communication Technologies(WISICT’04), Trinity College, Dublin, pp. 1–6

[2] RA Santos, RM Edwards, NL Seed, 2003,” Inter vehicular data exchange between fast moving road traffic using ad-hoc cluster based location algorithm and 802.11b direct sequence spread spectrum radio”, Post-Graduate Networking Conference

[3] G Yvonne, W Bernhard, G Hans Peter, 2007, “Medium access concept for VANETs based on clustering”, in Proceedings of the 66th IEEE Vehicular Technology Conference (VTC), vol. 30. Baltimore, pp. 2189–2193

[4] P Fan, 2007,”Improving broadcasting performance by clustering with stability for inter-vehicle communication”, in Proceedings of the 65th IEEE Vehicular Technology Conference (VTC ‘07, Spring), Dublin, Ireland

[5] P Fan, P Sistla, P Nelson, 2008,”Theoretical analysis of a directional stability-based clustering algorithm for VANETs”, in Proceedings of the Fifth ACM International Workshop on Vehicular Ad Hoc Networks (VANET), San Francisco, CA

[6] H Su, X Zhang, 2007,”Clustering-based multichannel MAC protocols for QoS provisionings over vehicular ad hoc networks” IEEE Trans Veh Technol. 56(6), 3309–3323

[7] W Zhiagang, L Lichuan, Z MengChu, A Nirwan, 2008, “A position-based clustering technique for ad hoc intervehicle communication”, IEEE Trans Man Cybern. 38(2), 201–208

[8] O Kayis, T Acarman, 2007,” Clustering formation for inter-vehicle communication”, in Proceedings of the 10th IEEE Intelligent Transportation Systems Conference (ITSC’07), Seattle, WA

[9] Yuyi Luo, Wei Zhang, Yangqing Hu, 2010 ”A New Cluster Based Routing Protocol for VANET”, IEEE Wireless Communications and Trusted Computing, 2010.

[10] Shea, Christine, Behnam Hassanabadi, and Shahrokh Valaee, 2009, "Mobility-based clustering in VANETs using affinity propagation."*Global Telecommunications Conference*,