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Comparative Study of Data Dissemination Algorithms based on Cluster Forming Parameters in Vehicular Ad-hoc Network

Arvind Kumar[#1], Sudesh Rani[#2]

[#]*Computer Science Department, PEC University of Technology*
Chandigarh, India

***Abstract*— Vehicular Ad-hoc Network (VANET) is a way of providing data communication for high speed vehicles and provides safe and secure driving and reduces traffic deaths and injuries. In VANETs, cluster based data dissemination proves to be the most efficient method with less propagation delay, high delivery ratio and bandwidth fairness. The terms like average number of clusters formed, average cluster member duration, average cluster head duration and average cluster head change rate are used to measure the performance of cluster based data dissemination. But high speed mobility and difference in behaviour of drivers challenges the formation of stable clusters. In this paper, various data dissemination algorithms are compared which can be used for clustered VANET.**

***Keywords*— VANET, Cluster, Data Dissemination**

I. INTRODUCTION

Vehicular Ad-hoc Network (VANET) is a form of wireless network in which vehicles connect to each other through an ad-hoc formation. VANET provides an efficient way of communication between vehicles and vehicles can exchange information like their state, real time traffic, obstacles on road etc. with each other. This information sharing increases the driver safety and reduces the chances of road accident. VANET have three architectures named vehicle to vehicle, vehicle to roadside and hybrid architecture [4]. In vehicle to vehicle (V2V) architecture, one vehicle communicates with other vehicles in a common network. In vehicle to roadside (V2R) architecture vehicles exchange the data with roadside access points. In hybrid architecture both V2V and V2R used in integration. Hybrid architecture is most beneficial because using hybrid architecture vehicles can communicate among themselves and also with road side access points. Clustering is one of the data dissemination approaches that are used in VANETs. In the cluster-based transmission, some vehicles form a group called cluster. A representative called Cluster Head (CH) is selected for each cluster. The CH receives data packets from its cluster members and then forwards the packets outside the cluster and vice versa. Cluster-based scheme improves the efficiency of resource utilization and increasing network capacity. Channel contention can be limited using clustering which provide fair channel access. Clustering increases the network capacity by the spatial reuse of the network resources [13]. Due to highly mobile and fast changing nature of the VANET it is a very tough task to select CH and maintain stability of a cluster. Clustering algorithms in MANET cannot be used directly in VANET as VANET has higher mobility and the trajectory of the vehicles is constrained by road and the driver's behavior.

In recent years, clustered VANET has been studied in many literatures. A number of algorithms have been introduced to form clusters with greater stability and good efficiency.

II. PROPERTIES AND TECHNIQUES OF VANET

This is an overview of properties of VANET and their management mechanisms.

In [1], VANET is used by the author for a better understanding of the traffic jam formation. VANET can be used as a effective method to reduce road accidents, traffic jams, fuel consumption and pollution. In [2], authors explained the security features of VANET. It can be used to get information about a stolen vehicle by getting information from all vehicles that have crossed that stolen vehicle. Another application of VANETs is safe driving that is proposed in [3] which proposed a method to send alert messages in case of emergencies.

A. *Various Issues in Data Dissemination*

In VANET, a large number of vehicles communicate with each other. Due to this it become a complex task to exchange information in such a dense network. Vehicles compete with each other to send data over network.. Followings are important issues during data transmission [4]:

1) *High Mobility*: Vehicles moves with high speed and they can move to different parts of the area therefore this is main concern in data dissemination techniques.

2) *Data Delivery*: Data delivery becomes a tough task when a large number of nodes are requesting for the same data at the same time. In VANET, due to large quantity data delivery is a main issue.

3) *Data Transmission over Multiple Networks*: To distribute the data efficiently, a number of networks can be connected to each other through wireless connections. In that case it would be difficult to transmit data over such mesh type networks.

4) *Collection of Data*: The data must be collected from different sources before distribution. Due to high speed of vehicles, it becomes very challenging to collect the data especially when quantity of vehicles is very large.

B. *Data Dissemination Techniques*

In VANET, data can be disseminated using one of the following approaches [4]:

1) *Opportunistic Dissemination*: This is a store and forward approach in which message is stored at each intermediate node and then forwarded to every intermediate node till it reaches the destination.

2) *Geographical Dissemination*: This approach is based on geographical position of the destination node. Message is sent to the node which is closest toward the destination till it reaches its destination.

3) *Peer to Peer Dissemination*: In this approach messages are not forwarded in the network, nodes store the data till another node request for it.

4) *Cluster Based Data Dissemination*: Among all the techniques of data dissemination this is the most effective technique. In this approach, nodes are grouped together to form cluster. In each cluster a representative called cluster head(CH) is selected. These cluster heads gather data in their clusters and send to cluster head of another cluster. This approach reduces the propagation delay and increases the delivery ratio.

III. Clustering Algorithms

A. Cluster Based Medium Access Control Protocol (CBMAC) [8]:

This algorithm introduces clusters and provides better scalability by minimizes the hidden station problem. In this algorithm, first a cluster head is selected for every cluster. Then CH of every cluster assigns a particular bandwidth to the members of cluster. Cluster members can send data only in assigned bandwidth which increases the reliability. This clustering algorithm first describes the methods of cluster formation and cluster head (CH) selection. After that Medium Access Control Protocol is used for data transmission.

Cluster formation algorithm is based on the regular transmission of beacons HELLO messages. These messages distribute the information about the state of the nodes. A node can be in one of the four states during its lifetime: Undecided, Member, Gateway and Cluster Head. Initially a node is in the undecided state mean not a member of any cluster. A node is in gateway state when it is member under two or more clusters.

After cluster head selection use of MAC protocol enables Collision free transmission of data as every node send data in the bandwidth assigned to it by cluster head.

The problem in this protocol is that waiting time for undecided node may become longer as it has to check whether it has received hello message from nodes in other state or not. Other problem is that one node can be associated with different cluster head in different clusters. Thus unnecessary messages are transmitted. Only the relative velocity and relative distance are used, therefore clusters are not very stable.

B. Clustered Gathering Protocol (CGP) [4]:

This algorithm focuses on a particular VANET architecture, where the ad hoc network is operated by a telecommunication/service provider.

CGP is a cross layer protocol based on hierarchical and geographical data collection, aggregation and dissemination approach. In this algorithm, clusters are formed by dividing the road into virtual segments each of same length. Each segment represents a cluster. Then in each cluster or segment a cluster head is selected. The node which is nearest to the end of the segment is selected as cluster head. When CH selected, it receives data from all node in its segment. It aggregates the whole data and sends the aggregated data to the next segment. The information about orientation, speed and geographical position of a vehicle is collected using IEEE 802.11 and Global positioning system (GPS) devices equipped with vehicle.

This algorithm provides relevant information to RSU with minimum cost without overloading the network because only cluster head of nearest cluster will send data. But cluster formed are not very stable because only geographic position of node is used for cluster head selection and other factors like velocity, node degree, available resource are not used. QoS requirements of Delay sensitive service are not fulfilled.

C. Affinity Propagation for Vehicular Networks (APROVE)[10]:

This algorithm forms cluster with high stability by considering the complex vehicular mobility during cluster formation. To check the similarities of two nodes i and j a similarity function s(i,j) is used. Similarities are calculated on the basis of current position of vehicles and their future positions. There are two types of messages responsibility and availability messages which are transmitted by every node. Every node passes these messages to its neighbors and makes a decision on clustering independently.

A HELLO message is sent by every node to start cluster head selection process. This message contains id, position, velocity and current cluster head of the sending node. Upon reception of Hello message the recipient node calculates its similarities with sending node and updates its neighbor list. Every node i calculate its responsibility with each neighbor j and broadcast this responsibility in the RESP packet. Then each node i calculate its availability with each neighbor j and broadcast it in AVAIL message. When node i receive a RESP or AVAIL message from j and if it finds its id in avail or resp list of j, it reads the message.

This algorithm forms clusters with high stability and provides good clustering performance. But the number of messages exchanged for cluster formation and cluster head selection are large and QoS requirements of Delay sensitive service are not fulfilled. Velocity is considered in cluster forming but change in velocity i.e. Acceleration and node degree are not considered, which can affect the stability. Also the available resources of nodes e.g bandwidth are not considered.

D. Mobility Metrics Based Dynamic Clustering Algorithm (DCA) [11]:

In order to create stable cluster DCA takes advantage of mobility metrics i.e. average velocity and average acceleration calculated over time period T0. Each node

calculates its average velocity and average acceleration over time period T0. Then it sends its average velocity and average acceleration to its neighbors through Hello messages. Then a node calculates its relative velocity and relative acceleration with respect to neighbor nodes. Using these relative metrics Spatial Dependency between two nodes and Total Spatial Dependency (TSD) of a node are calculated. Then Cluster Relation (CR) is calculated for each node as a average of TSD values. The node with highest CR becomes cluster head.

Average velocity and average acceleration metrics are used for cluster formation, so cluster's stability is high. But the numbers of messages transferred for cluster formation are high. Node degree and available resource such as bandwidth are not considered in cluster formation, which affects stability. If CR value of a node is smaller than smallest CR value of a cluster than it cannot become member of the cluster and has to wait for a time period.

E. Clustering Based Data Transmission Algorithm [12]:

In this a cluster head selection algorithm and a cluster switching algorithm are presented. The CH selection algorithm jointly considers node degrees, the available resources of candidate CHs and the velocity difference between candidate CHs and other cluster members (CMs).The following factors affect the optimal Ch selection:

- *Node Degree*: A cluster head should be a node with highest node degree
- *Vehicle Mobility*: Relative speed between CH and CMs should be smaller.
- *Available Resource*: for CH the available bandwidth to transfer CM's data packets should be maximum.

After calculating all these factors cluster head is selected.

In Cluster Switching Scheme a CM which originally belongs to one cluster may request to access a new cluster if its transmission performance will be enhanced depending upon Delay Sensitive Service and Throughput-Sensitive Service. On the other hand, a cluster may need to evaluate the impacts of accepting a new vehicle before making the accepting or rejecting decision because the cluster management and maintenance cost may increase if number of the cluster members increases. So the vehicles having relatively small velocity difference and distance with the cluster members are desired.

In this algorithm High Cluster stability is achieved than other algorithms. Number of Messages send for cluster formation is less than previous algorithms. Optimal Cluster Scheme stresses the QoS requirements of both throughput sensitive service and delay sensitive Service. But Cluster stability can be increased using acceleration Mobility Metric with Velocity Mobility Metrics.

IV. Comparison Table

The Mentioned algorithms can be compared on the basis of parameters that are used by different algorithms. There are six parameters mainly Distance, Geographical Position, Velocity, Acceleration, Node Degree and Available Resources.

In CBMAC algorithm velocity and distance parameters are used. In CGP only geographical position is used to form clusters. In APROVE algorithm two parameters geographical position and velocity are used. In DCA algorithm velocity and acceleration are used. In clustering-based data transmission algorithm three parameters velocity, node degree and available resource are used.

DCA algorithm and clustering-based data transmission algorithm forms clusters with high stability these use parameters that have a large impact on stability of clusters.

Parameters used by different algorithms to form clusters are shown in TABLE I.

TABLE II
COMPARISON BASED ON PARAMETERS

Parameters	CBMAC	CGP	APROVE	DCA	Clustering Based
Distance	Yes	No	No	No	No
Geographical Position	No	Yes	Yes	No	No
velocity	Yes	No	Yes	Yes	Yes
Acceleration	No	No	No	Yes	No
Node Degree	No	No	No	No	Yes
Available Resource	No	No	No	No	Yes

V. Conclusions

Vehicular Ad-hoc Network (VANET) is an emerging research area. Due to high mobile nature of vehicles and fast changing state and network topology it is a difficult task to control data dissemination process in VANET. Mentioned algorithms provide different methods and features for data transmission in clustered VANETs. A lot of progress has been done in this field but still more work can be done to improve the data dissemination.

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