Semi-Passive Cluster Model for Vehicular Ad Hoc Network

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Abstract:

Vehicular Ad hoc Network (VANET) are made by applying the superset of Mobile Ad hoc Networks (MANET) the external stimulus creation of a wireless network for data exchange to the domain of vehicles. VANET plays a vital role in the intelligent transportation systems (ITS) framework. Target tracking is nodes around the target (which can detect the target) would be capable to gain information about the target.Vehicle tracking defined as the ability to detect a target vehicle based on its visual features and continuously track the vehicle by sending position information on it to a central entity. Therefore, grouping of vehicles by its information has been used to reduce data propagation traffic and to facilitate network management. The grouping of vehicles is done by using the clustering techniques and it can be classified into two based on its functions namely Active clustering and Passive Clustering. Clustering vehicles for target tracking is still a challenge response in VANET environment. Target tracking involves evaluating huge volume of data and it can easily conquer the wireless network in VANET. The Development of semi-passive cluster model for target tracking reduces delay and overhead in VANET simulation environment. In this paper, a novel semi-passive based cluster model is proposed for target tracking system which is aptly applicable to VANET environment.

Keywords: VANET, Target tracking, Clustering, Distributed Clustering, Semi-passive clustering, Tracking Failure Probability

I. INTRODUCTION

A Vehicular Ad hoc Network (VANET) contains smart vehicles on the road and provides communication services among nearby vehicles by using its infrastructure. Intelligent Transportation System (ITS) is used to exchange the information between the vehicles in VANET communications, with the purpose secured ride and provide comfortable journey to passengers [1,2]. Besides privacy concerns, vehicle tracking is useful for important applications. For instance, it allows calculating average travel times of vehicles across individual roads. This travel time is an excellent real-time indicator for traffic congestion which allows better route selection by drivers and better road management by road operator. Vehicle tracking defined as the ability to detect a target vehicle based on its visual features and continuously track the vehicle by sending position information on it to a central entity [3].

Target Tracking can be simply performed if the target vehicle has a Global Positioning System (GPS), with the location data communicated to external entities. However, that assumes such devices are not available or have been turned off on target vehicles. In order to solve rely on visual identification of target vehicle using the on-board cameras of neighbouring vehicles and reporting the location and visual information of the target to a control center. The Control Center is assumed to be a police station looking for a special vehicle based on its visual description and is interested to acquire location and visual information of the target.

In case the control center is located in a multi-hop distance from the target, there is a high probability of network congestion, packet collision and packet loss because of concurrent transmission of target's information by all the neighbouring vehicles in a multi-hop manner. Also, the control center might receive duplicate messages which are unnecessary and redundant [4, 5]. In order to address these problems, cluster based framework to organize the network. Therefore, target's neighbour vehicles which can detect the target join a cluster and select a leader node or Cluster Head (CH). The neighbour nodes send their target's information to the leader. So, instead of every node sending its information to the control center separately, there is only one node responsible for delivering the information to the control center. The challenges towards designing a high performance and efficient clustering algorithm mostly include clustering stability improvement and control overhead reduction.

Basically Cluster is a technique to group of node that has similarities according to some criteria together. Groups of nodes are made with respect to their units placed at fixed point along the roads or mobile units acting as mobile gateways closeness to other nodes. In short, the roles of node in cluster are cluster head node, gateway node, and ordinary node. After a cluster has been formed, cluster firmness is an important aspiration that clustering algorithm by to reach and is considered as a measure of performance of clustering algorithms. Basically cluster has Inter-cluster Communication, Intra-cluster Communication and Cluster to Cluster Communication between objects [6, 7].

Clustering communication techniques uses the received signal strength, position of the node from the cluster head, velocity of the nodes, direction and destination of node [8, 9]. Considering the above concepts, the detailed taxonomy of various clustering algorithm are Predictive clustering, Backbone clustering, MAC based clustering, Traditional clustering techniques, Hybrid clustering, and Secure clustering are used. Based on the role of nodes the Traditional clustering techniques are subdivided in to Active and Passive Clustering in VANET [10].

Active clustering uses Hello packets to collect information on the network topology. Low Energy Adaptive Clustering Hierarchy (LEACH) active clustering algorithm arbitrarily selects cluster heads nodes and assigns this role to various nodes to ensure fair energy dissipation between the nodes. This algorithm has two phases such as Neighbour discovery and Cluster formation phase. The success of these algorithms depends on node location and synchronization between the nodes. Weighted-metric, precedence and timer-based clustering techniques are active approaches and it uses a common channel for cluster formation and maintenance together with other network traffic. It leads conflict between clustering traffic and routing traffic, as both compete for finite channel bandwidth, even when clustering is used to facilitate routing. In addition, dynamic network topology degrades the stability of clusters [11].

Passive Clustering (PC) is an on demand cluster formation protocol that does not consider any protocol specific control packets or signals. It allows cluster heads and gateways to forward packets and restrains the nodes with other roles from delivering data packets. The PC technique can lower the control overhead in packet flooding, as it uses on-going data packets instead of extra explicit control packets to construct and maintain clusters. In this technique each node can be act as initial or ordinary or cluster head or gateway or distributed gateway node and represent the role in the cluster structure, aiming to maintain the cluster structure. In addition, the PC technique adopts two additional internal states, such as cluster head ready and gateway ready to represent the tentative role of a node, which will enter one of the external states when it sends out a packet.

The PC technique exploits two innovative mechanisms during the cluster formation that are First Declaration Wins and Gateway Selection Heuristic [12]. The First Declaration Wins (FDW) mechanism is based on the idea of contention. A node first claim to become a cluster head node will dominate the rest nodes within its communication range. The Gateway Selection Heuristic mechanism aims to determine the minimal number of gateway nodes to maintain the connectivity of cluster structure.

Applying passive techniques may decrease control overhead but clustering decision would not accurate and precise enough[13]. In passive clustering, nodes do not send control messages separately. In Semi-Passive Clustering attach required control information to data packets and send them during the data message transmission interval. Applying passive techniques to VANETs may decrease control overhead considerably. However, by employing passive techniques, clustering decisions would not be accurate and precise enough. Semi-passive clustering technique, assume nodes send data packets every time interval. The control message interval is supposed to be which is smaller than data time interval. At each control time, the member node checks the data time interval.If the current time is close to the next data delivery time interval, the CM will not send a control message. Instead, it will attach the required control fields to the data packet and will send the data packet at the next data delivery time. Elimination of unnecessary control messages decreases the control overhead due to reduction of some control message fields.

The clustering structure needed for tracking a moving target vehicle differs from other cluster based applications. The cluster should be formed around the target and move along with the target in order to track it continuously.Accordingly the clustering metrics and CH selection criteria would be different from other applications. However, in target tracking application all the metrics should be defined based on target's movement pattern. For instance, movement similarity between a node and the target should be used forcluster membership and CH selection decisions. Therefore, all nodes should compare their movement pattern to target and the most appropriate node should be selected as CH.

The organization of this paper is as follows. Section I provides Introduction of VANET along with clustering techniques. Section II provides a review on related works with emphasis on recent developments. Section III discusses the proposed method that is sSemi-Passive Cluster based Target Tracking algorithm. Section IV presents the simulation scenarios and results of our proposed algorithms and Section V conclude this work with future enhancement.

II. RELATED WORK

Multi-hop clustering scheme is presented in [14] to establish stable vehicle groups. In order to construct multi hop clusters, a new mobility metric is used to represent relative mobility between vehicles in multi-hop distance. Tested the clustering scheme is evaluated by using the Manhattan mobility model and the freeway mobility model for generate the movement paths for vehicles. D-hop clustering algorithm [20], called DHCV is presented which organizes vehicles into non overlapping clusters which have adaptive sizes according to their respective mobility. The D-hop clustering algorithm created clusters in such a way that each vehicle is maintain D hops distance from a cluster head. To construct multi-hop clusters, each vehicle chooses its cluster head based on relative mobility calculations within its D-hop neighbours. The algorithm can run at regular intervals or whenever the network formation changes. Using WAVE (Wireless Access in Vehicular Environment), vehicles periodically send their position information using beacon messages.

Passive Clustering (PC) [15] technique each node in a cluster possesses either the external or the internal state. It piggybacks the cluster state in order to allow a node to determine its cluster state when it receives the data packet. In PC technique, a node does not require to maintaining the cluster information and that reduce the overhead for cluster maintenance. This existing method has three PC based techniques, called Vehicle Passive Clustering (VPC), to determine the vehicles participantion in cluster structure formation. It operate at the logical link control sub-layer and can be associated with any on-demand routing protocol. The objective is that the cluster head or gateway candidate self-determines whether it requires changing the current state or not when receiving route request (RREQ) packets.

A Prediction Based Clustering Algorithm for Target Tracking was proposed [16] to predict the future location of a dynamical system based on its estimates and measurements. Object tracking system can be applied for visual tracking of specific vehicles or monitoring particular areas and reporting schemes. Tracking can generate large volume of data and is aim to monitor a specific target based on its visual features.

Nearest Neighbour Probabilistic Data Association (NNPDA) technique was suggested [17] to track vehicles through information sent in anonymous beacons. These beacons maintained different parameters like timestamp, a pseudonym, vehicle position, speed and heading. The vehicle density and the random noise in position are main disturbing factors of the vehicle tracking process. The Moving Target tracking through Distributed Clustering (MTDC) system was proposed [18] capable of tracking a target originating from anywhere in the monitored area, as well as entering into the terrain from outside. The cluster head-based location estimation and data processing reduces the network contention and computational overhead of energy-constrained sensor devices and ensures accuracy. The results of MTDC system achieves better performances compared to state-of-the-art mechanisms in terms of tracking accuracy, active sensor nodes, standard deviation of residual energy and network lifetime.

A Distributed Clustering Algorithm for Target Tracking [19] was designed for the purpose of vehicle tracking in VANET. It assumed that vehicles have front and rear cameras and can perceive visual features of a target vehicle. In this method, a central entity is finding help to spot a specific target. This entity is called Control Centre (CC) and located in multi-hop communication distance from target. CC broadcasts details of target's in the network with the purpose of identifying and informing vehicles about target's existence. This process decreases re-clustering, cluster changes and results in creating more stable clusters.

The limitation of DCTT has giving some control overhead in which cluster formation, controlling clusters and communication between clusters. Therefore need to design efficient algorithm to transfer the information from CH to control center with high delivery ratio and low control overhead. High probability provides network congestion, packet collision and packet loss because of concurrent transmissionof target's information by all the neighbouring vehicles in a multi-hop manner. Finally vehicle tracking define as the ability to detect a target vehicle based on its visual features and continuously track the vehicle by sending position information on it to a central entity. The detection process may be based on any visual processing algorithm including license plate detection, logo, and color recognition algorithms. However, focus on communication framework for continuous tracking based on ad hoc communication which is a new topic to the best of our knowledge.

III. SEMI - PASSIVE CLUSTER BASED TARGET TRACKING USING DCTT ALGORITHM

The Semi-Passive Distributed Cluster based algorithm for Target Tracking (DCTT) uses visual features of a target vehicle in order to identify the target. Localization of the target is performed by visual processing. In this algorithm, a central entity has responsibility to find a specific target and receive its visual and location information periodically. In order to obtain the re clustering in environment the Semi-passive algorithm is designed to help in building a cluster, with the cluster head responsible for collecting target's information from all vehicles that can detect the target, aggregating the information, and forwarding the information to the CC. Here assume each data time interval is equal to four

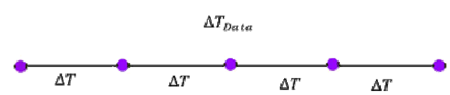

Figure 1: Data and Control Time Interval

control time interval as displayed in Figure 1.

A member node checks the current time and defines whether it should send a control message or not. If $Tcurrent < \frac{3n\Delta t}{4}$ then, cluster head send control message to correspondence cc otherwise $Tcurrent \geq \frac{3n\Delta t}{4}$ then, cluster head do not send Control Message to cc.The equation will be changed according to the forming of no of node in Semi-Passive Cluster techniques. The purpose of Target Tracking is that the nodes around the target would be able to get information about the target and do not drop track of the target. Thus, these nodes join a cluster which moves along with the target. The member nodes send their information about the target to the CH instead of sending it to the central entity. The CH should be a node which has the most similar movement pattern to the target to be able to track the target for the longest time interval.

Tracking Failure Probability (TFP) is a mobility metricwhich represents movement similarity of a node relatively to the target. In order to calculate TFP between a vehicle Cand the target vehicle Tat time t, it is required to have the distance between node Cand Tand their velocity vectors at that time. Let assume the effects of velocity and distance are the same on TFP calculations. The TFP value of node C at time thas been represented as $TFP(C)_t = 100 * (\alpha D_{CN_t} + \beta(|\vec{V}c_{N_t}| - |\vec{V}T_{N_t}|)$. A node's TFP value indicates its eligibility to become the CH. A node with lowest TFP value is selected as the CH. Observation Time (OBT) is a cluster head selection metric represent the duration of time the target spends in the field of view of a cluster member. The highest OBT value is eligible to be the cluster head.

Control Center Functions

Command and Control Center (CC) is a central in mobile entity that searching vehicle for a particular environment. This entity is interested in receiving location information such as its location and visual information. The Control Center share the information of the target in the entire network in the form of Control Center Message (CCM) until to receive the information of target vehicle. If the CC does not receive data messages, it will start broadcasting the target's information again in the network.

Control Center procedure:

Function:

$SendCCM\ (Node\ id, PacketID, TargetInfo, Tcurrent);$

Action:

$if\ !receiveCHM(\,)\ then$
$SendCCM\ (Node\ id, packetID, TargetInfo, Tcurrent);$
$end\ if$
$if\ !receiveData\ (\,)\ then$
$SendCCM\ (node\ id, packetId, TargetInfo, Tcurrent);$
$end\ if$

Initialization Procedure

A vehicle that collects a CCM from the CC then it starts the initialization process. That initialization process defined a flag called Target Detection Value (TDV). Any intermediate vehicle that can detect the target sets its TDV as true. The vehicles that detect the target are called as "Observer Nodes (OBN)". The OBNs broadcasting Cluster Member Message (CMM) and receive response messages from their N-hop neighbors. OBNs ensure the TDV field in the reply messages as set to true, the sender node will be added to a list called "Member List (ML)" with the TDV value. If TDV field is false and the node is in the communication range of OBNs, it is also added to ML and the Tracking Failure Probability (TFP) is calculated.

Function:$sendCC\ (\,);$

Action:$CalculateOBT\ (\,);$
$receiveCHM\ (\,);$
$ML.update\ (nodeid(\,), OBT));$
$if\ (hopCount!\,maxHops)\ then$
$forwardCHM(\,)$
$end\ if$
$if(convergenceTimer\ ==\ 0)\ then$
$searchML(\,);$
$end\ if$

Tracking Phase

The tracking process is carried out by all OBNs and the CH. This process includes collecting visual and location information of the target and forwarding to the CC within specified time intervals ($\Delta T_{Data)}$ based on Semi-passive Clustering. CMs send target's information to CH not to CC. CH should integrate all the information received about target from other nodes and send it to the CC. This phase includes two procedures related to CMs and CH. The CM-L1 nodes capture target's information and send it to CH ever. As soon as the target goes out of FOV (Field Of View) of a particular CM, the corresponding CM stops the tracking task. But it needs to send its unsent data to the CH. The information received from all members the CH estimates the target position and reports its accurate coordinates to the control center.

Cluster Member Tracking Procedure:

Action:

$While\ (TDV\ ==\ True)\ do$
$SaveVideoData\ (\,);$
$SaveTargetLocation\ (\,);$
$SendData\ (\,);$
$end\ while$
$SendData\ (\,);$

Cluster Head Tracking Procedure:

Action:

$receiceData\ (\,);$
$IntegrateData\ (\,);$
$estimateTargetPoisition\ (\,);$
$sendCC\ (Data);$

IV. EXPERIMENTAL RESULTS

NS-2 is a discrete event driven simulator developed at UC Berkeley [20]. Network simulator 2 is used to generate the vehicle traces and create the communication framework. Semi-passive cluster model for target tracking displays the effect of number of nodes on the CH lifetime metric. This algorithm used a threshold for changing the CH lifetime.

Table 1: Simulation Environment

Analysis	**Throughput (Kpbs)**	**Packet Delivery Ratio (%)**	**End-to-End Delay (ms)**	**Control Over head(%)**
Cluster based DCTT	93.87	93.01	15.56	27.76
Semi-passive Cluster based DCTT	108.02	94.54	12.42	20.15

The threshold is defined in a way to decrease changes as much as possible. Therefore, unlike other algorithms, when the number of nodes increases, the CH lifetime will not decrease. Besides, the CH lifetime may increase when network density is higher.The evaluation results displays that increasing the number of nodes has a positive effect on the CH lifetime. The reason is appropriate CH selection metric which is not affected so much by cluster structure changes because the selected CH is a node with the most similar movement pattern to the target. The table 1 describes the simulation environment for semi-passive clustering for target tracking.

A. Performance Metrics

In Semi-Passive Cluster each node can maintain the transmission history about the neighbour node based on performance metrics. Transmission history give and classify the Cluster behaviour depend on node behaviour whether the Cluster good or bad. Performance metric calculated as follows,

Packet Delivery Ratio: Packet delivery ratio represents successful delivery of target's information from every cluster member to cluster head and from the cluster head to the control center.

End to End Delay: End to end delay represents successful delivery of target's information from every cluster member to cluster head, cluster head to cluster head and from the cluster head to the control center.

Parameter	**Value**
Simulation environment	NS2
Simulation Time	600 sec
Number of nodes	25, 50, 100, 150, 200
Data packet length	1000 Byte
Data packet frequency	0.5 Hz
Control packet frequency	1 Hz
Transmission rate	1 Mbps
Communication range	50, 100, 250, 500 meter
Vehicle speed	25 - 35 m/s
Traffic type	UDP
Number of base stations	2-50
Mac protocol	IEEE 802.11

Throughput: Throughput is the total amount of data that a vehicle transmits during the entire course of the simulation.

Control Overhead: The control overhead metric represents the percentage of control packets to the total transmitted packets in the cluster. The lower value of control overhead shows better performance of a clustering algorithm.

B. Performances Analysis

Simulation results under the scenario with high Throughput, Packet delivery ratio, low End-to-End delay and less Control Overhead. The Table 2 shows the Performance analysis of Semi-passive cluster based DCTT with cluster based DCTT and Figure 2 depicts the corresponding performances analysis.

Table 2: Performances Analysis

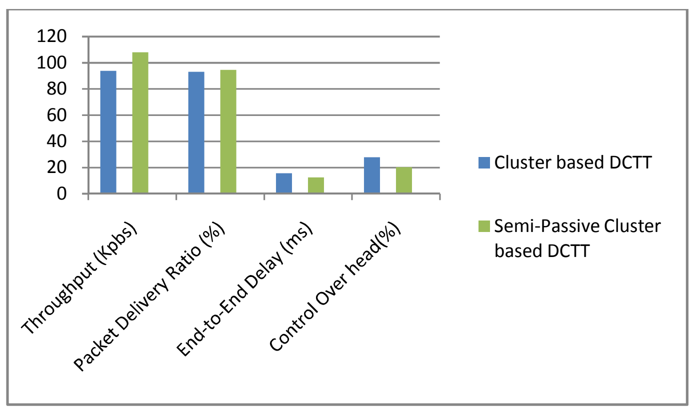

Figure2: Overall Performances Analysis

The Figure 3 shows simulation NAM window based on Semi-Passive Cluster based Target Tracking. It depicts the basic setup of simulation. Here, vehicles are used to represent the whole scenario. The nodes are labelled as base station and Target tracking vehicle labelled as TT. In this Figure 3 the vehicle transmit the information about the target vehicle to the base station like control center with in cluster.

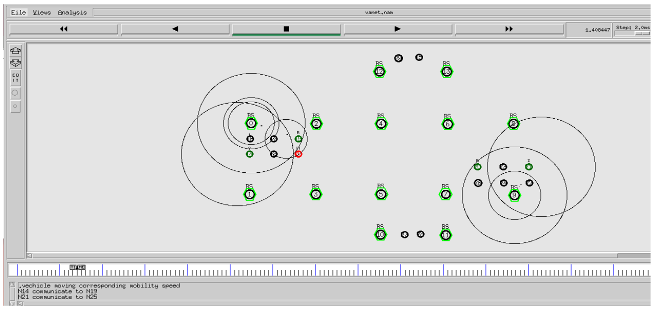

Figure3: Data transmission done from CH to Control Center

The cluster head vehicles manage the whole cluster information and transmit. The vehicle flows have different speed range and take different routes. In this case we make sure the cluster members and CH will not always be the same, and the cluster structure will change as it happens in the real world. This assumption helps in realistic evaluation of our proposed protocols. Finally Semi-Passive Cluster model for Target Tracking algorithm provide less control over head and cluster can formed periodically to compare with Distributed Cluster based Target Tracking algorithm.

V. CONCLUSION

A Semi-Passive cluster model based algorithm is presented for vehicle tracking in Vehicular Ad hoc Network. The objective of this work is to avoid multiple information broadcast and multi-hop data dissemination by each vehicle separately in order to inform the control center about the target. This information can congest the network easily if not managed properly by an appropriate algorithm. The Semi-Passive cluster based target tracking algorithm that is designed to work in a distributed manner. The performance of Semi-Passive clustering algorithm is represented in terms of clustering overhead, cluster head lifetime, and cluster member lifetime. The Semi-Passive cluster can be formed periodically. Semi-Passive performance results display significant stability and overhead improvement as compared traditional passive algorithm. . Finally Simulation results have shown that the proposed Semi-Passive Cluster based DCTT perform competitively against the cluster based DCTT in terms of packet delivery ratio, end-to-end delay, and network throughput. Furthermore, security of such a system should be taken into consideration as a future work in order to prevent malicious nodes from sending false information or disrupting the communication.

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