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A Hybrid Backbone Based Clustering algorithm for Vehicular Ad-Hoc networks

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Abstract

In recent years, Vehicular Ad-Hoc Networks (VANETs) have become an active area of research due to their applications in Intelligent Transportation System (ITS). By creating a vehicular network, vehicles can send warning messages to alert drivers in other vehicles about the dynamically varying road condition thus further improving human safety on roads. VANETs exhibits unique characteristic like dynamically changing topology that should be managed for managing the network for applications related to timely delivery of sensitive messages. Clustering is a most effective way of managing and stabilizing such networks. A stable clustering algorithm reduces the overhead of re-clustering and makes the network management task easier. In this paper a hybrid backbone based clustering algorithm for VANETs is proposed. The concept of number of links and vehicular mobility is used for cluster formation and cluster head selection. During cluster formation, nodes with relatively higher degree of connectivity, initially form a backbone that is designated as leadership. The leadership than participates in cluster-head election and efficient cluster re-organization using aggregate relative velocity of vehicles in the leadership. Simulation results show that the proposed algorithm exhibits comparable cluster stability in urban scenarios.

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1. Introduction

A VANET is a type of Mobile Ad-hoc Network (MANET) whose objective is to provide efficient inter-vehicle communication. Through inter-vehicle communication many messages like abnormal road and traffic conditions, incident related messages can be broadcast with the intention of improving human safety[1]. The communication

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between vehicles usually take place over a short range of 300 to 500 meters and is accomplished using IEEE 802.11 protocols, based on Wireless Access for Vehicular Communication (WAVE) and the Dedicated Short Range Communications (DSRC) standard.

Even though VANETs are considered to be a subtype of MANETs, they have number of unique characteristics and requirements and because of this many solutions proposed for MANETs are not compatible with VANETs. VANET is characterized by its highly dynamic topology, high relative velocity of vehicles, and frequent network disconnections especially when vehicle density is low. Due to these characteristics topology management in VANETs became difficult even though vehicle movement can be predicted[2]. Topology management in VANETs can be done using clustering. Clustering is a most effective way of managing and stabilizing such networks. A stable clustering approach reduces the overhead of re-clustering and makes the network management task easier.

A cluster is a group of nodes that can communicate with each other without disconnection. Each cluster has a cluster-head (CH) that coordinates the communication among the nodes of the cluster and with the nodes in other clusters[3]. Clustering can help in improving node coordination, decrease the number of nodes interfering with each other and for removing the hidden terminal problem[4].

Many clustering algorithms were proposed in VANETs and most of them use mobility characteristics of nodes for cluster formation and CH election[5]. In this paper, a hybrid clustering algorithm is presented that uses aggregate relative velocity for CH election. The key component of this approach is the backbone known as cluster leadership which is formed on the basis of node's degree of connectivity as proposed in[6] and relative velocity. Set of nodes that possess high degree of connectivity and low relative velocity form a cluster leadership. The leadership then assists in CH election using the aggregate of node's relative velocity. This algorithm also incorporate contention based scheme proposed in[4] in order to prevent frequent cluster re-organization when two CHs come in each other's range.

This paper is organized as follows. Section 2 reviews the back ground and related works. Section 3 contains problem definition. Section 4 presents the proposed algorithm. Section 5 contains simulation and results. Section 6 concludes the paper.

2. Related Work

Dror et al.[7] present a Hierarchical Clustering Algorithm (HCA) which creates hierarchical clusters with at most four hop diameter. The algorithm also handles channel access and schedule transmission of messages with in the cluster to ensure reliable communication. The aim of this approach was to create clusters with diameter greater than 1-hop as fast as possible.

Almalag et al.[3] propose a clustering technique in which clustering is done on the basis of similarity in mobility pattern of vehicles. The CH is selected on the basis of the flow of the majority of traffic. Each vehicle computes its CH level (CHL) using its lane information and broadcast it along with other information like speed, location etc. Vehicle with highest CHL is selected as a CH.

Souza et al.[4] propose a clustering technique that uses the Aggregate Local Mobility (ALM) metric for initiating cluster re-organization. As described in[8], ALM is a relative mobility matric which uses the Received Signal Strength (RSS) to calculate distance between the sender and the receiver. The ratio of the RSS in two successive *hello* messages is used to determine the relative mobility between the two nodes. In the proposed work instead of RSS, authors use the location information present in *hello* messages to determine the relative mobility. If two CH come in each other's communication range, then one of the CH should give up its role and two clusters merge. However the process of merging is not immediate. One of the CH moves to contention state and start contention timer. If two CHs communicate with each other before the expiry of contention timer, then the node with smaller ALM becomes the CH. However, the nodes with no CH may not find nearby cluster to join and may become CHs at the same time. In such situation clustering process will become unstable due to frequent changes in CH.

Rawshdeh et al.[9] propose a clustering technique in which vehicles showing similar mobility pattern are grouped in same cluster. The vehicle with slowest speed among the non-cluster neighbours initiate the cluster formation