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Research Article

QoS Aware Optimized Clustering Algorithm for Reliable Transmission in VANET

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ABSTRACT

Introduction: The paper addresses the need for an efficient and reliable Media Access Control (MAC) protocol for Vehicular Ad Hoc Networks (VANETs) to support safety-related applications and reliable communications. The IEEE 802.11P standard lacks sufficient spectrums for reliable information exchange in congested channels.

Objectives: It aims to improve energy efficiency, channel utilization, subcarrier collision, and lossless data transfer for enhanced communication.

Methods: The paper proposes a Quality of Service (QoS) aware clustering algorithm (HOQC-MAC) for VANETs using an optimization algorithm. The proposed protocol utilizes the Tree-Seed Induced Coyote Optimization (TSCO) algorithm for clustering for enhancing the energy efficiency.

Results: Simulation results show that HOQC-MAC outperforms existing protocols in terms of latency, packet delivery ratio and bandwidth utilization, enhancing VANET communication.

Conclusion: The HOQC-MAC protocol demonstrates significant improvements over existing protocols, addressing challenges in VANET communication.

Keywords: Vehicular Ad Hoc Network (VANET), QoS aware clustering algorithm, Tree-Seed Induced Coyote Optimization (TSCO) , Reliable transmission.

INTRODUCTION

The framework for contemporary road transport infrastructure is the intelligent transport system (ITS). In the event of damage, automatic line elevation is activated; operations management works to prevent accidents and traffic bottlenecks. Having a variety of onboard sensors and vehicle-to-vehicle (V2V) communication facilities installed in a car can help us to make better decisions and take control of the situation in order to accomplish these objectives. A typical short-range communication network, handle seven distinct channels and provide multimedia support for cars of the future [1][2].

There are variety of QoS requirements exist for VANETs. Packet latency and data swelling grow greatly when corresponding to the number of vehicles [3]. Clustering is a useful solution for reducing overloading and ensuring QoS across various networks. It can be integrated with MAC protocols within a VANET framework [4].[5][6]. Road vehicles, in particular, can communicate with one other via brief multipurpose links [7][8][9]. RSUs, which are the primary goal of VANET, deliver the data from various vehicles to the server [10] [11]. When a car leaves the RSU range, it can be positioned in its coverage region of two adjacent RSUs and employed as a relay for other vehicles. The MAC protocol utilized in traditional networks is unsuitable for VANET due to its changing topology. In this case, VANET must develop a dependable and efficient MAC protocol to ensure successful packet delivery.

OBJECTIVES

The main objective of this work is to develop a QoS aware clustering technique integrated with MAC .protocol for reliable transmission in VANET.

RELATED WORKS

In order to address the VAT-MAC issue, Tianjiao et al. [12] introduced the game-based TDMA MAC protocol (GAH-MAC). Even though this protocol reserves a new slot, it tampers the reservation across the two nodes. As a result, the reservation can be opened and the period used in full, but at the base stations' speed. An asynchronous multichannel MAC to broadcast many channels simultaneously for a certain service, was presented by Tripti et al. [13]. One can listen and avoid using the control channel linked to the working channel by using the particular program that allows to dynamically control access to the lymphatic channel. A Dynamic Control Channel Interval (DCI) MAC protocol which effectively modifies the interval has been presented by Singh et al. [14]. The SCH time is now divided into time categories by this task according on the amount of network traffic that is present.

A Motion Parameter-based cluster MAC (MPMAC) protocol was presented by Chaurasia et al. [19]. The vehicles are arranged in headless clusters, all without any messaging. Members of the cluster might be allocated to various lines and are not migrated. A channel that can be used to utilize duplicate channels owned by other clusters is allotted to each group.

PROPOSED METHODOLOGY

Network model

The network model for the suggested HOQC-MAC protocol, includes roadside units (RSU) and high-density vehicles. Information include the amount of parked vehicles, waiting time, and average speed. There's an RSU traffic control system in front of the ads. Certain MAC techniques are effective in transmitting data from the cluster member (CM) to the cluster head (CH) of the RSU. Through the cluster channel, the CM forwards the data it has collected to the relevant CH. When referencing a vehicle at an intersection, the vehicle selects the CH with shortest distance. It is possible to forward data to CH neighbors using cluster passive routes. A vehicle's motion is influenced by a number of variables, including the topology of the road, speed of the vehicle and direction of the movement.

Clustering using Tree-Seed Induced Coyote Optimization (TSCO) Algorithm

One of the most crucial methods for analyzing vast volumes of crucial data is clustering. This technique can give planners of transportation useful information by helping them better comprehend groups and the characteristics of their travels. Simultaneously, classifying them based on their modes of transportation is a crucial approach to evaluating the effectiveness of particular cohorts within the vehicle's total population and within the trip profile. Here, we clustered the vehicles using the TSCO algorithm.

The population is split into two batches M_q, and M_d. In some cases, the number of coyotes in each pack is constant and uniform. Consequently, multiplying the number of packs by the number of coyotes per pack provides the overall coyote population. Moreover, in the T^{th} current time, the social status of d^{th} coyote in the forest q^{th} is specified.

$$soc_d^{q.T} = \vec{y} = (y_1, y_2, .. y_C) \tag{1}$$

where C indicates the number of decision factors. It shows that the coyote has adjusted to its surroundings, $fit_d^{q.t} \in S$. During the social situation' establishment of the d^{th} coyote in the forest, q^{th} a collection of i^{th} A vectors postulates the dimension.

$$soc_{d.i}^{q.T} = Wa + s_i.(va_i - Wa_i) \tag{2}$$

where Wa_i and va_i indicate the range's lower and upper limits of i^{th} variable of choice, respectively; s_i indicates a random number in the range [0, 1] with the help of a probability distribution with a uniform distribution. $M_d \times M_q$ gives their socioeconomic circumstances, coyotes in the environment for assessing every coyote's fitness function or adjustment to the scenario.

$$fit_d^{q.T} = f\left(soc_d^{q.T}\right) \tag{3}$$

During minimization issue, the solution q^{th} crams' alpha in T^{th} a moment in t.

$$alpha^{q.T} = \left\{soc_d^{\backslash q.T} \middle| \arg_{d=\{1,2...M_d\}} \min g\left(soc_d^{q.T}\right)\right\} \tag{4}$$

All the coyote's data are connected by the COA. Each pack's cultural tendency will be calculated as:

$$cul_i^{q.T} = \begin{cases} o^{q.T}_{\frac{(M_d+1)}{2}.i} & M_d \, is odd \\ \dfrac{o^{q.T}_{\frac{M_d}{2}.i} + o^{q.T}_{\left(\frac{M_d}{2}+1\right).i}}{2} & .otherwise \end{cases} \quad (5)$$

where oq T denotes all coyotes' social status in the area q^{th} cram T^{th} at every time instant i in the range of [1, C]. The alpha impacts coyotes simultaneously (δ_1) and by the pack's other coyotes (δ_2).

$$\delta_1 = alpha^{q.T} - soc^{q.T}_{ds_1} \quad (6)$$

$$\delta_2 = cult^{q.T} - soc^{q.T}_{ds_2} \quad (7)$$

The δ_1 influence represents a distinction between a chosen coyote Ds_1 and the leader coyote. Conversely, δ_2 signifies the difference between a chosen coyote Ds_2 and the pack's collective tendencies. In the basic TSA, two types of agents are used for effective solution space exploration: seeds and trees. The trees are randomly distributed throughout the search space at initialization.

$$t_{j.i} = W_i + s_{j.i} \times (E_i - W_i) \quad (8)$$

Where $t_{j.i}$ indicates j^{th} tree location on i^{th} dimension, W_i and E_i indicate the bottom and upper boundaries of the solution space, respectively. $a_{j,i}$ indicates a uniformly generated random number ranging between [0, 1].

$$A = \arg\min\left\{ g\left(\vec{t}\right)\right\} \quad (9)$$

There are two different formulas that can be used to produce new seeds from this stand.

$$R_{T.i} = t_{j.i} + \alpha \times (A_i - t_{z.i}) \quad (10)$$

$$R_{T.i} = t_{j.i} + \alpha \times (t_{j.i} - t_{z.i}) \quad (11)$$

This Eqn. is used to update the size of a seed which will be produced for a tree. Algorithm 1 describes how TSCO operates.

Algorithm 1 Clustering using TSCO

Input : Population
Output: Seed

1 Initialize the parameters
2 Estimate the objective function
$soc^{q.T}_{d.i} = Wa + s_i.(va_i - Wa_i)$
3 Determine the fitness function
$fit^{q.T}_d = f\left(soc^{q.T}_d\right)$
4 Compute the equation
$alpha^{q.T} = \left\{soc^{\backslash q.T}_d \middle| \arg_{d=\{1,2\ldots M_d\}} \min g\left(soc^{q.T}_d\right)\right\}$
5 Compute the alternative equations
$R_{T.i} = t_{j.i} + \alpha \times (A_i - t_{z.i})$
6 End procedure

For the purpose of the CH selection procedure, BS gathers vehicle data such as mobility, Received Signal Strength (RSS) and overload rate, once the cluster is formed.

The node's RSS, at a distance of D, with transmission energy $T(n, D)$ is represented as follows:

$$RSS = \frac{T(n,D)}{4\pi D_i^2} + T_{a,a_1/a_2} \tag{12}$$

Distance and relative velocity can be reliably determined at the selected sites that satisfy the strengths and limitations of the selected signal.

The distance $T_{a,a_1/a_2}$ divided by the node's velocity is how a mobile node calculates the movement duration from its current position a to the moved place a_1 a_2. This may be obtained via sin law as follows:

$$T_{a,a_1/a_2} = \frac{R \cdot \sin \vartheta}{\sin \beta \cdot v} \tag{13}$$

Extending Eq.(13) we obtain the mobility M as

$$M = T_{a,a_1/a_2} = \frac{\Delta t \cdot R \cdot \sin \vartheta}{\sin \beta \cdot \sqrt{\frac{\left(D_{i_1}^2 + D_{i_2}^2 - 2D_{i_3}^2\right)}{2}}} \tag{14}$$

The correlation between a vehicle and BS is determined by its cooperation rate. The vehicle (i)'s cooperation rate at time t is computed as

$$C(i,t,F) = disatnce(x_i(t), BS(t)) \tag{15}$$

The minimum fare for every automobile is determined as:

$$CR = v_i = \frac{\sum_{i=1}^{N} PI(P_i) - PI(P_i)}{\sum_{i=1}^{N} PI(P_i)} \tag{16}$$

where the vehicle's rate i is v_i and $V = \{v_i, 1 \le i \le m\}$;

For each vehicle, the rank will be computed by:

$$R_i = RSS + M + C + CR; \qquad i = 1, \ldots, n \tag{17}$$

Thus, the CH is selected using the following Eqn.:

$$CH = \max(R_0, R_1, \ldots, R_n) \tag{18}$$

RESULTS AND DISCUSSION

The urban mobility simulation (SUMO) creates the test conditions, while the Network Simulator (NS-2) implements the suggested HOQC-MAC. Network scenarios with network sizes of 4000x4000 m2 are used for testing. In the given network, there are 100, 200, 300, 400, and 500 vehicles. We changed a vehicle's speed from 10 to 60 kmph.

The performance of HOQC-MAC protocol is compared with the existing MAC protocols TDMA-MAC, GAH-MAC, AMC-MAC, SCMAC, CCHI-MAC, DCI-MAC, SDN-MAC, MP-MAC, SOM-MAC, OEC-MAC, CB-MAC and AHT-MAC in terms of carrier collisions, latency, packet delivery ratio, energy consumption and throughput.

Effect of node density

In this section, the number of vehicles is varied from 100 to 500 in an Intersection scenario.

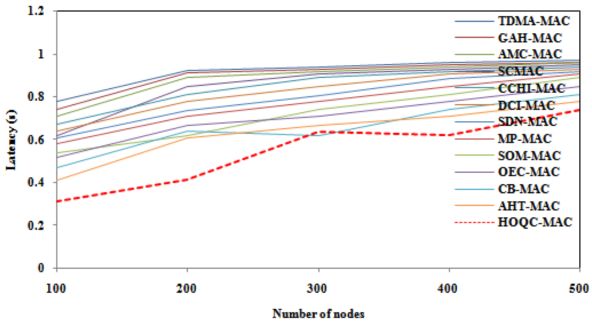

Figure 1 Results of Latency for vehicle density

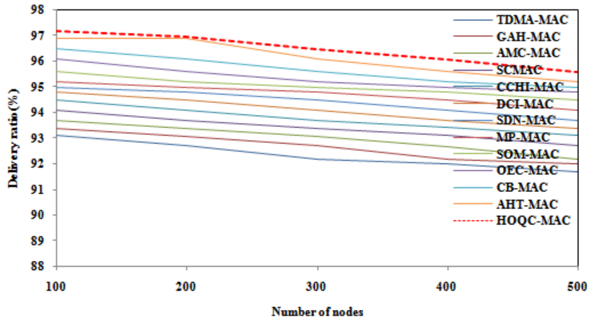

Figure 2 Result of Packet delivery for vehicle density

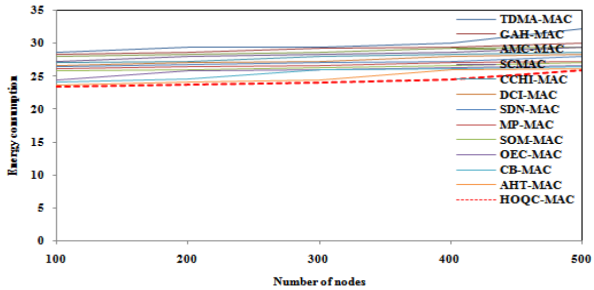

Figure 3 Results of Energy consumption for vehicle density

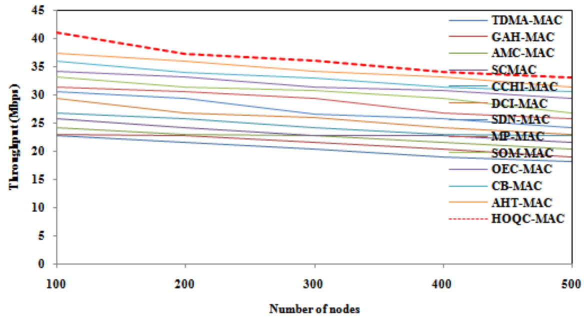

Figure 4 Results of Throughput for vehicle density

The comparative results of Carrier collision, latency, PDR, energy consumption and throughput are shown in Fig. 1 to 4, respectively.

CONCLUSION

The paper has proposed a HOQC-MAC protocol for VANETs using an optimization algorithm. By overcoming the difficulties encountered by current protocols, it offers effective communication for applications pertaining to safety. To increase energy efficiency, the protocol used the TSCO algorithm for vehicle clustering. Simulation results demonstrated the protocol's superiority, reducing carrier contention, lowering latency, and increasing packet delivery speed and throughput.

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