International Journal of Electronic Devices and Networking

E-ISSN: 2708-4485
P-ISSN: 2708-4477
IJEDN 2023; 4(2): 05-09

www.electronicnetjournal.com
Received: 20-05-2023
Accepted: 25-06-2023

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An effective method for optimal IOV network clustering using FCM clustering algorithm based on node energy density

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DOI: https://doi.org/10.22271/27084477.2023.v4.i2a.48

Abstract
There has been a dramatic shift in automobile internet networks toward a new paradigm of intelligent transportation systems known as the Internet of Things because of its tremendous success (IoV). In addition to safety, entertainment, emergency response, and material exchange, VANETs may be used for a wide range of other purposes as well. For these kinds of applications, a lot of data has to be sent back and forth between various vehicles and central command and control stations. In these networks, managing this much data is a huge difficulty. Clustering is a technique for streamlining network administration and reducing the amount of data being sent. As a means of extending the network's nodes' useful lives, we provide a routing technique built on correct clustering in this study. As a result, the FCM clustering method is used in this study to demonstrate the optimum grouping of VANET nodes based on their energy density. The nodes in the network's energy density is first calculated in this study. Following this, the FCM algorithm clusters nodes depending on their energy density. Because of this, clustering happens around the nodes with the most energy in a network environment. According to the results, the cluster center's lifespan in the suggested approach is enhanced compared to previous proposed ways, and the network's lifespan increases between 30 and 100 milliseconds for different values of the number of nodes.

Keywords: Vehicle ad hoc networks, clustering, FCM algorithm, energy nodes

Introduction

An increase in the number of cars is leading to an increase in road deaths for thousands of people around the world. The number of people killed in road accidents in 2010 is estimated at 1, 240, 000, a figure that according to the World Health Organization (WHO) in 2030 will reach about 3.6 million people [1]. During the years 1382 to 1392, according to the country's statistics, the number of people killed in road accidents was 257 thousand and the number of injured has reached more than three million. Challenges of increasing the number of cars include problems in managing urban traffic, driving cars on suburban roads, and the heavy financial and human costs resulting from these problems. Hence, researchers have been exploring these challenges for decades. Research in this area has created a new field called intelligent transportation systems (ITS) in the world. With the development of wireless communication technologies, the use of ITS technology among researchers and experts has increased and as a result, wireless technology called contingent or occasional vehicle networks (VANET) for radio communications between vehicles has emerged [2]. The platform for the use of this technology and the necessary standards have been created with the initial agreements between the major automakers of the world and the transportation institutions in the United States, the European Union, Japan and South Korea [3, 4]. VANETs, as a subset of mobile contingency networks, provide road safety, comfort and convenience. VANET communications can be divided into two types of vehicle-to-vehicle and vehicle-to-infrastructure [5].

Using IoV technology, a novel node selection method was utilised to identify the best ambulance in article [6]. Several mobile doctors, patients, and ambulances are part of the IoT health care monitoring system that has been suggested. Each mobile ambulance's performance rating index (PR) is based on its medical capacity (b), the number of patients it is presently transporting (n), and the Euclidean distance from the nearest other mobile ambulance. The ambulance with the lowest PR index is deemed to be the best option for the patient.

The research [7] proposes the Energy Efficient Reasonable Edge Processing (OEE-SEP) model for IoV in smart cities for discharging vehicle activity over an approximated time period with decreased energy usage. An activity discharge methodology based on the number of jobs per unit time and the projected completion time for the same quantity of data entered is included in the sensible edge processing model. In order to shorten the overall transmission time and lower the amount of energy used during discharge, a new, more efficient model has been developed. When IoV processes and data loading activities are taken into account, OEE-SEP results in decreased energy usage during activity discharge.
For the sake of this essay [8], we'll refer to them together as the Internet of Everything (IoE) (IoE). Sensors, mobile phones, computers, PDAs, and other physical devices may communicate with each other via the Internet of Things (IoT). Sensors, actuators, and gates in automobiles, buildings, and other permanent objects may now communicate with one another via the Internet of Things. The Internet of Things (IoT) is a term used to describe the phenomenon (IoT). The Internet of Cars (IoV) connects vehicles, objects, and surroundings for the transfer of data and information. The human Internet, the digital Internet, and the Internet of Things are all forms of the Internet of Things.
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Internet networks for automobiles are examined, as well as the different problems they present. A new clustering method based on the behaviour of nodes is also suggested in this study [11]. This method begins by calculating a cluster fit point (CFS) for each car in the network and then selecting the vehicle with the highest CFS as the cluster's leader (CH).
As a way to improve the cluster's stability and connectedness, a weighted clustering approach termed VWCA is presented in [12]. Uncertainty, entropy and the number of neighbors are used in this criterion computation to account for the vehicle's journey as well as its active transmission area. One of the most critical points to remember is that most clustering designs use movement pattern or movement direction as a design parameter.
There are two techniques in [13] that have been tested and evaluated in the field of vehicle tracking: DCTT, which is a distributed cluster-based clustering algorithm, and PCTT, which is predictive clustering for target tracking in vehicle ad hoc networks. Distributed cluster-based target tracking algorithms were also compared to the performance of both algorithms in order to assess the performance of distributed algorithms.
Clustering stability is a crucial issue while developing an effective clustering method. Since the cluster topology in VANETs is constantly changing due to the high speed of the vehicles, it is critical to employ an appropriate clustering algorithm to pick the cluster in order to maximise the longevity of both individual cluster members and entire clusters. In this work, we will use a fuzzy clustering protocol to properly determine clusters so that we can increase the lifespan of the network and make the network more stable.
In the following, in section 2, materials and methods and in the section of simulation results, the proposed method is given. Section 4 also summarizes and concludes.

Materials and Methods

A node is chosen as the cluster head (CH) in the network clustering process in order to construct and maintain a data communication structure. Thread takes messages from other members of the cluster and collects them. Hence clustering divides the network into smaller parts and makes network management easier.
The proposed method diagram is shown in Figure 1, which we will explain in the following steps.

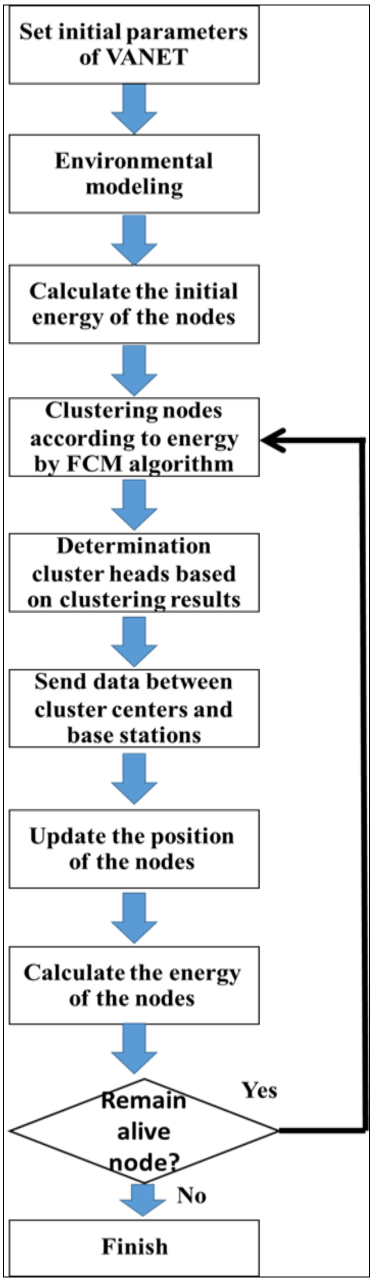

Fig 1: Flowchart of the proposed method.

Determining the parameters
In the first step, the basic parameters such as the dimensions of the environment, movement speed, number of nodes, etc. are determined.

Creating an environment
The network begins to function as soon as the nodes are put in place.

Determination of initial energy
In the next step, the initial energy of the nodes is determined according to the initial parameters.

Clustering of nodes
In this step, the energy of the nodes is clustered using the FCM fuzzy algorithm.

Determining cluster centers
In the next step, the centers of the clusters are determined according to the clustering results.

Ending, aggregating and receiving information
In the next step, the nodes send their information to the cluster centers. This reduces the energy of the nodes. In cluster centers, energy reduction occurs due to receiving data and also aggregating them and sending them to base centers or sinks.

Update the location of the nodes
After then, their position in the network is updated in accordance with the movement of other nodes.

Update the energy of the nodes
In the next step, the energy of the nodes is recalculated to repeat the above steps if live nodes are available. This operation will occur until all nodes are dead ;this depends on Fuzzy clustering method.
It is a well-known fuzzy clustering algorithm, the FCM algorithm. In this algorithm, each instance can belong to each of the clusters with different membership ratios from 0 to 1. In this algorithm, like the -K average algorithm, the number of clusters must be determined in advance. In this method, the objective function to be specified is as follows.

$$J_m(U,Z;X) = \sum_{i=1}^{c}\sum_{k=1}^{n} u_{ik}^m D_{ik}^2 = \sum_{i=1}^{c}\sum_{k=1}^{n} u_{ik}^m \|x_k - v$$

D_{ik}^2 In the above relation, the distance between data x_k and the center of the cluster is i. Also m ∈ [0, ∞) determines the fuzzy value of the algorithm (usually m=2). If m tends to one (m → 1), clustering becomes more difficult, and if m to infinity If you want (m → ∞), clustering will become more fuzzy, joining or assigning any of the data to each cluster, with the membership matrix $U = [u_{ik}]_{c\times n} = (u_1. u_1. \ldots u_l)$ where c is the number of clusters and n is the number of members, the values of the matrix U can be between 0 and 1, but the sum of the values of each column must be 1.
With the help of Equation (2) and with the aim of minimizing the objective function, we will have:

$$\sum_{i=1}^{c} u_{ik} = 1 \,.\, \forall\, k = 1.2. \ldots . n \qquad (2)$$

$$u_{ik} = \frac{1}{\sum_{j=1}^{c}\left(\frac{d_{ik}}{d_{jk}}\right)^{2/(m-1)}} \qquad (3)$$

$$v_i = \frac{\sum_{k=1}^{n} u_{ik}^m x_k}{\sum_{k=1}^{n} u_{ik}^m} \qquad (4)$$

The general steps of this algorithm are as follows.

1. Initialization of parameters *c*, *m* and *U*.
2. Random selection of primary cluster centers.
3. Calculation of new cluster centers (vi).
4. Calculating the membership matrix of clusters from clusters calculated in step two.

If the condition $\|U_{l+1} - U_l\| < \epsilon$ is met, the algorithm terminates, otherwise it returns to step two.
One of the advantages of this algorithm is the definite convergence and unsupervised data training. Also, high computation time and sensitivity to the choice of primary cluster centers are some of the weaknesses of this algorithm.

Results
The goal in a VANET system is to find the best path from the source node to the destination node. As shown in Figure 2, the proposed scheme consists of a dynamic clustering approach with the creation of a vehicle chain along the road.

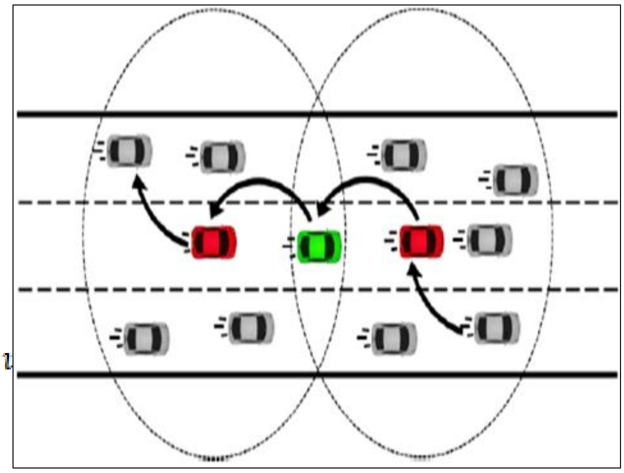

Fig 2: Comprehensive architecture in the proposed method

The proposed method includes the start-up phase with three steps of cluster formation, cluster selection and sending information. In this section, we describe the results obtained using the proposed method. A suitable programming environment is used to review the proposed method and the proposed system. In this work, modeling and simulation of the proposed method has been done with the help of MATLAB 2020 program. The characteristics of the system used to simulate the proposed method are given in Table 1. Also the simulation parameters of this algorithm are given in Table 2.

Table 1: System and software characteristics

Characteristics	Item
MATLAB 2020a	Simulation Software
Intel Core i7 (4210U) 2.7 GHz	Processor
8.0 GB	RAM
2 TB	Hard disk
Microsoft Windows 10	Operation System

Table 2: Simulation Parameters

Value / variable	Parameter
Highway	Simulation environment
30 km	The length of the simulation environment
100 km	Simulation environment width
20 ،50 ،100	Number of nodes
1 m/s	Vehicle speed
1	Number of base stations
0.5 j	Primary energy

In order to increase the lifespan of the cluster head, one of the criteria used in this research was the lifespan of the network head. Eclipse life in this work is the time it takes for the eclipse energy to run out. As can be seen in Figure 3, the lifespan of the thread in the proposed method is compared with DCT, Adapted MDMAC and PCT methods for the number of different nodes [13]. As can be seen in this figure, the proposed method has improved the lifespan of the headers by 5 to 20 percent (per number of different nodes) compared to other methods.

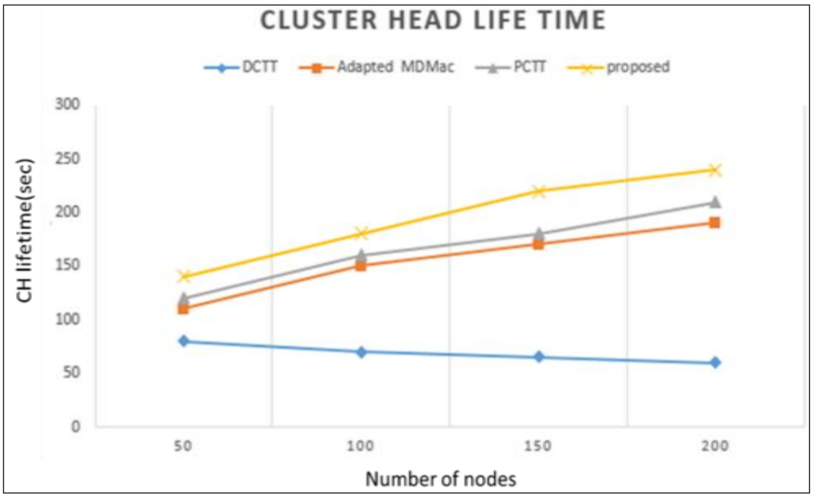

Fig 3: Comparison of the proposed method with previous methods from the perspective of network cluster head lifetime - DCTT [13] - adapted MDmac [13] -PCTT [13]

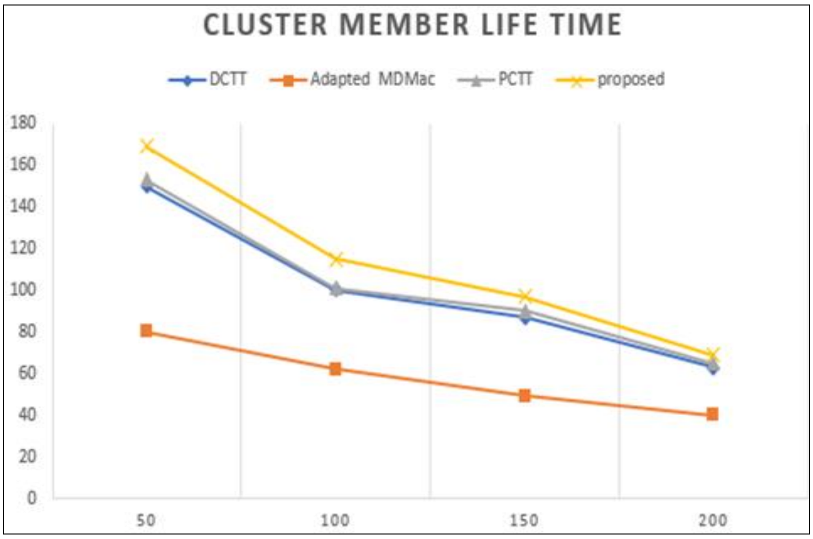

Fig 4: Evaluation and comparison of the proposed method with previous methods from the perspective of network cluster members-DCTT [13] -adapted MDmac [13] -PCTT [13]

Another criterion used in this work is the lifespan of network cluster members. The lifespan of cluster members in this work is the time it takes for the energy of the cluster members to run out. As can be seen in the figure below, the lifespan of the cluster members in the proposed method for the number of different nodes is compared with the mentioned methods. As can be seen in Figure 4, the proposed method has improved the lifespan of cluster members by 2 to 8 percent (per number of different nodes) compared to other methods.

Conclusion

Researchers in academia and business have lately become interested in vehicle-specific mobile Internet networks because of its potential use in activating numerous ITS applications for safety, entertainment, emergency response, and sharing of content. Is. VANET can easily be disrupted if the wireless network is not adequately constructed for such applications, which necessitates the transfer of a huge volume of data.

Clustering is one of the ways recommended for publishing and managing data in these networks, and it is intended to make network management easier and boost network stability. An FCM fuzzy clustering technique for the VANET network is presented in this paper. The proposed clustering technique for an FCM-based VANETs system is tested in this study. Clustering performance is considerably improved by using this approach. Fuzzy clustering was used in this study to determine an appropriate heading and grouping based on the energy of the nodes.

This resulted in a longer life cycle for the cluster's central node. When compared to other methods, results show that the proposed method's cluster centre has an improved lifespan of 30 to 100 milliseconds, depending on the number of nodes in the network.

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