

Cluster Head Selection in MANET Using an Evolutionary Intuitionistic Fuzzy K-means Clustering Approach

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Abstract: Recent technological advances in sensors, low-power microelectronics and miniaturization, and wireless networking enabled the design and proliferation of Mobile Adhoc Networks capable of autonomously monitoring and controlling environments. One of the most promising problems existing is efficient data transmission with less resource utilization between cluster head and base station. This paper handles the most influencing factor to obtain such efficiency is energy consumption, density and distance. This proposed work implements two stages in the Clustering phase the sensor nodes are clustered using the intuitionistic fuzzy Kmeans clustering using the membership and non-membership value of each factors taken into the account. Once clustering phase is over then the cluster head is selected based on the highest fitness function obtained using the genetic algorithm here the node with highest energy consumption and lower distance from base station and neighboring nodes are considered as optimal cluster head. The data packets are aggregated and transferred using the cluster head to the base station. During each round the cluster is reframed using intuitionistic fuzzy k-means. The result shows that the proposed method well performed in the case of uncertainty in cluster head selection.

INDEX TERMS: MANET, Cluster Head Selection, Intuitionistic Fuzzy K-means, Genetic Algorithm, Energy Efficiency, Wireless Sensor Networks, Scalability, Network Lifetime.

1. INTRODUCTION

The scalability of Mobile Adhoc Networks (MANETs) can be improved through node clustering, where a leader, known as the Cluster Head (CH), is elected to manage communication within the cluster. The CH maintains details about its member nodes and their communication paths, ensuring efficient data transmission. It plays a key role in collecting, compressing, and forwarding data to the base station or other CHs, thereby reducing energy consumption and enhancing network performance.

Selecting an optimal CH is a challenging task, as multiple factors such as node position, mobility, energy availability, trust, and throughput must be considered. MANET nodes typically have limited battery life and processing power, so the CH election process should minimize overhead while ensuring stability. An inefficient selection process can lead to frequent re-clustering, increasing network instability and degrading Quality of Service (QoS). Thus,

ensuring a single, well-positioned CH per cluster is crucial for network efficiency.

This paper proposes an intuitionistic fuzzy-based clustering approach combined with genetic algorithms for CH selection in MANETs. By considering energy consumption, node density, and distance from the base station, the proposed method enhances clustering efficiency and network lifetime. Additionally, a comparative analysis of various CH selection techniques is presented, focusing on their selection parameters and the possibility of multiple CHs in a single election process.

2. LITERATURE SURVEY

2.1 Trust based clustering and secure routing scheme for mobile ad hoc networks:

https://www.researchgate.net/publication/41054969_Trust_based_clustering_and_secure_routing_scheme_for_mobile_ad_hoc_networks

ABSTRACT: In this study, we propose a clustering framework for adhoc network security that is based on distributed self-organising trust. Making sure the network is secure is crucial since mobile nodes are susceptible to security breaches. It's critical to assess nodes' reliability independently of central authority in order to improve security. Our solution effectively captures the evidence of trustworthiness from a variety of wider viewpoints, such as direct encounters with neighbours, monitoring neighbour interactions, and referrals. Our prediction technique computes the direct trust rating normalised as a fuzzy value between 0 and 1 at each node using a trust evaluation algorithm. A clusterhead's own evidence and suggestions from other neighbour nodes are

combined using the Dempster-Shafer evidence theory [7], [8]. Furthermore, we do not limit inter-cluster routing in our method to a single gateway node.

2.2 A Survey on One-Hop Clustering Algorithms in Mobile Ad Hoc Networks:

<https://www.semanticscholar.org/paper/A-Survey-on-One-Hop-Clustering-Algorithms-in-Mobile-Chinara-Rath/ee64d24c47c4a94d9d9e9e0c73f977e090f6dce4>

In mobile ad hoc networks (MANETs), clustering is essential for enhancing fundamental network performance metrics including throughput, bandwidth use, and routing latency. In a dynamic network where the network topology is continually changing, the one-hop clustering strategy uses a straightforward approach to create a logical division that leads to unstable clustering. In order to comprehend the research trends in this field, this study conducts a thorough analysis of a few benchmark one-hop clustering algorithms. The cluster formation logic for various algorithms in creating a linked cluster architecture is provided in the literature, along with a thorough simulation analysis of how well they perform on cluster maintenance metrics like cluster density, cluster reelection frequency, cluster node change frequency, and cluster head granularity. Before any routing strategy is implemented in the mobile ad hoc network, this study should help academics and practitioners select an appropriate clustering algorithm based on their formation and maintenance overhead.

2.3 ICICCD Proceeding

https://www.academia.edu/128035911/ICICCD_Proceeding

ABSTRACT: proudly announces the Fifth International Conference on Intelligent Communication, Control, and Devices (ICICCD-2020), which will take place from November 11–12, 2022. The integration of intelligent communication systems, control systems, and devices pertaining to all facets of engineering and science is the main emphasis of ICICCD. Researchers, academicians, scientists, and industrial practitioners are encouraged to present their original study, discoveries, and experiences with practical development at ICICCD-2022. The proceedings will be submitted for evaluation in order to be included in pertinent indexing databases, including Google Scholar, SCOPUS, CPCI, Crossref (by assigning doi), and others. The conference's overarching goal is to enhance global cooperation in research and education across all engineering specialities. For those who would want to showcase their initiatives and innovations, ICICCD-2022 will be an international forum that offers the chance to debate the key elements and the most recent findings in the fields of education and research. The writers from India and elsewhere who responded so well to the call for papers are greatly appreciated by the organising committee. A total of forty papers were chosen for oral presentations from over 80 papers that researchers, academicians, and students submitted on the three concurrent tracks of intelligent communication, intelligent control, and intelligent devices.

2.4 SEP: A Stable Election Protocol for Clustered Heterogeneous Wireless Sensor Networks

https://www.researchgate.net/publication/228885310_SEP_A_Stable_Election_Protocol_for_Clustered_Heterogeneous_Wireless_Sensor_Networks

In hierarchically clustered wireless sensor networks, we investigate the effects of node heterogeneity with respect to energy. Cluster heads are nodes in these networks that collect data from their cluster members and send it to the sink. We make the assumption that a portion of the sensor node population has extra energy resources; this might be the consequence of the initial configuration or change while the network operates. Additionally, we assume that the sink's coordinates and the sensor field's dimensions are known, and that the sensors are dispersed randomly (uniformly) and immobile. We demonstrate that, particularly when node heterogeneity is present, the behaviour of such sensor networks becomes extremely unstable when the first node dies. Conventional clustering algorithms are unable to fully exploit the presence of node heterogeneity because they presume that every node has the same amount of energy. For many applications where the sensor network's feedback has to be dependable, we suggest SEP, a heterogeneous-aware protocol, to extend the time interval before the first node dies (a term we call the stability period). Weighted election probability of each node becoming cluster leader based on each node's remaining energy form the basis of SEP. Through simulation, we demonstrate that SEP consistently extends the stability period in comparison to (and has a higher average throughput) the one achieved with existing clustering procedures. We wrap up by examining how sensitive our SEP protocol is to network energy imbalance-capturing

heterogeneity factors. We discovered that for larger quantities of additional energy provided by more potent nodes, SEP produces a longer stability area.

2.5 A mobility based metric for clustering in mobile ad hoc networks

<https://ieeexplore.ieee.org/document/918738>

ABSTRACT: For mobile ad hoc networks (MANETs), we provide a brand-new relative mobility metric. It is based on the power level ratio that results from each node receiving successive signals from its neighbours. Using this mobility metric to select clusterheads, we propose a distributed clustering algorithm, MOBIC, and show that it produces more stable cluster formation than the "least clusterhead change" variant of the popular Lowest-ID clustering algorithm (Chiang et al., 1997). We demonstrate that the application of the suggested approach can reduce the rate of clusterhead changes by up to 33%. The frequency of cluster reorganisation is closely related to network performance indicators like throughput and latency in a MANET that employs scalable cluster-based services. Consequently, we think that employing MOBIC can lead to a more stable setup, which will improve performance.

3. METHODOLOGY

a) Proposed Work:

In order to cluster the sensor nodes using the Intuitionistic Fuzzy C means based clustering method, this study suggests an improved evolutionary model of an energy-saving routing architecture. This work's primary goal is to lower energy consumption

and increase network lifespan in MANETs when cluster head selection is unpredictable.

b) System Architecture:

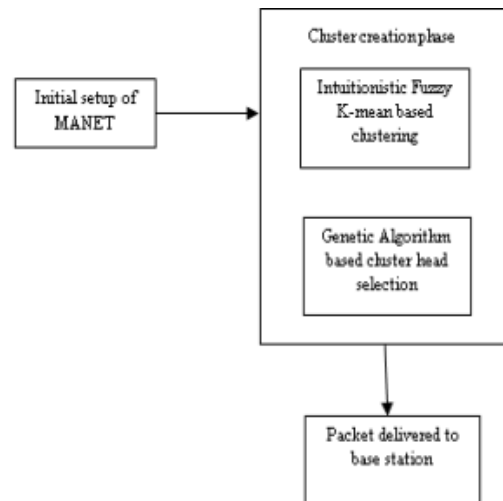


Fig. 1: Proposed Framework of An Evolutionary Intuitionistic Fuzzy K-Means based Cluster head Selection

Fig 1 Proposed system

Following node clustering, the best node is chosen from each cluster based on the ideal values of energy, density, centrality, and distance between nodes. In order to take into account intuitionistic fuzzy memberships of node characteristics in clusters during selection, a genetic algorithm approach is presented in this study. Each feature is first regarded as a member of the cluster with the highest membership degree. Member r represents the members of the r th cluster. Each feature's rank within its cluster is determined, and the candidate with the highest rank is chosen. The intuitionistic fuzzy approach technique gives a positive weight to the interdependency of features that belong to cluster r in order to determine the rank of each feature. Additionally, it penalises the interdependency of traits by giving them a negative weight, such as not

belonging to cluster r . The allotted weight is equivalent to the feature's cluster membership degree.

1.K-Means

K-Means [10] is one of the classical methods for unsupervised evolutionary DM algorithm that solves the well-known medical imaging, biometrics and other emerging fields. It automatically adapts the best understood clustering methods for observing the grouping objects. The K-Means algorithm to form a group a collection of vectors into K groups and find a cluster center in each group. Finally got constant cluster center in each group in an iterative way that a cost function shown in (1) is minimized.

$$J = \sum_{r=1}^k J_r = \sum_{r=1}^k \left(\sum_{x \in G_r} d(x, C_r)^2 \right) \quad (1)$$

Where, k is the number of clusters, and are the set of r th cluster and its associated center respectively. X presents a data point and $d(a,b)$ is the distance functional (usually Euclidean distance) between a and b.

In this method the value of k should be determined first. This value is fixed during the execution of the algorithm. The algorithm is summarized in the following steps:

Step1: Initializes the k cluster centers randomly

Step2: while the stop condition is not satisfied do the following:

- a) Assign each vector to a cluster with nearest center.
- b) Update cluster centers to the average of vectors belong to that cluster in order to decrease the cost function (2).

$$\text{Min}_{c_k} \sum_{i=1}^N \|x_i^k - C_k\|^2 \quad (2)$$

2 Fuzzy K-Means :

Fuzzy K-Means (also called Fuzzy C-Means, Hard or Crisp Cluster) is a simplified extension of K-Mean Clustering algorithm [11, 12]. Identifying the pattern structure and attempt to capture & quantifying the non-random imprecision are performed in this algorithm.

$$J(K, m) = \sum_{k=1}^K \sum_{i=1}^N (U_{ki})^m d^2(x_i, c_k) \quad (3)$$

Where K is the number of Cluster, m is the parameter, U_{ki} is the membership degree of in Cluster K , $d^2(x_i, c_k)$ is the distance from controls .The parameter in this equation are the centroid vector and the components of the membership vector . Evaluate shows the belonging ratio to a cluster K and centroid belonging expression cluster k .

In this method a data point can belong to several groups with a membership degree between 0 and 1 which is shown by a matrix where k is number of clusters and m is number of data points such that the condition in (4) is satisfied.

$$\sum_{r=1}^c U_{ri} = 1, \forall i = 1, \dots, n \quad (4)$$

Where, is the membership degree of ith pattern in rth cluster. The cost function used in this method is shown in the equation (5)

$$J(U, c_1, \dots, c_k) = \sum_{r=1}^k J_r = \sum_{r=1}^k \sum_i^n U_{ri}^m d(x_i, c_r) \quad (5)$$

In order to minimize the cost function, membership degrees and cluster centers, in each iteration, are computed and the equations are (6) and (7)

$$U_{ri} = \frac{1}{\sum_{l=1}^k \left(\frac{d(x_i, c_r)}{d(x_i, c_l)} \right)^{2/(m-1)}} \quad (6)$$

$$c_r = \frac{\sum_{i=1}^n U_{ri}^m x_i}{\sum_{i=1}^n U_{ri}^m} \quad (7)$$

Where, represents the ith pattern in dataset. Like K-Means, Fuzzy K-Means [34] [39] works on those objects which can be represented in n-dimensional vector space and a distance measure is defined. This method performs the following steps.

Step1: Initializes the k fuzzy cluster centers randomly

Step2: while the stop condition is not satisfied do the following:

a) Compute the membership matrix U according to the equation (6)

b) Update fuzzy cluster centers according to the equation (7)

c) Modules:

i. Generate & Load U-Net Model

A "Generate & Load U-Net Model" button is provided to load the pre-trained U-Net model. The U-Net architecture is widely used for medical image segmentation, particularly for retinal image analysis. Clicking this button initializes the model, making it ready for processing and segmentation tasks.

ii. Upload Retina Image

The "Upload Retina Image" button allows users to upload a retinal image for segmentation. Once the image is uploaded, it is processed by the U-Net model to extract relevant features. This step is crucial for identifying and analyzing retinal structures such as blood vessels, the optic disc, and other key regions.

iii. Retina Segmentation

After uploading the image, users can click the "Retina Segmentation" button to perform segmentation using the U-Net model. The model processes the image and generates a segmented output, highlighting important retinal structures. This segmented image helps in diagnosing and analyzing retinal diseases with greater accuracy.

iv. Accuracy Graph

The "Accuracy Graph" button displays a graph representing the model's accuracy during training and validation. This graph provides insights into the model's performance, showcasing how well it segments retinal images over different training epochs. A high accuracy value indicates effective segmentation and reliable results.

4. EXPERIMENTAL RESULTS

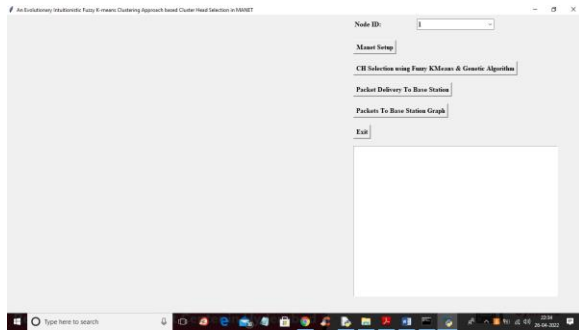


Fig2 Manet Setup

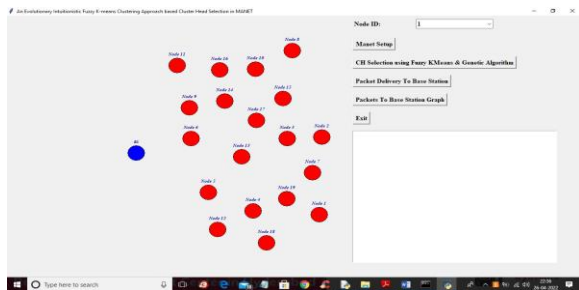


Fig 3 CH Selection

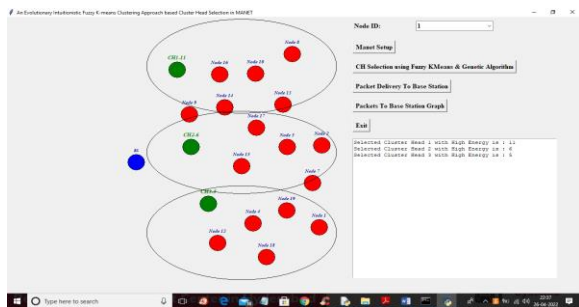


Fig 4 cluster members

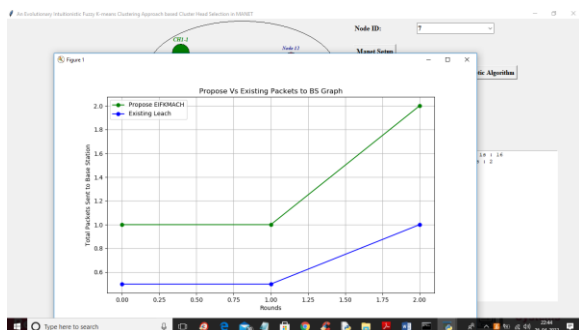


Fig 5 graph

5. CONCLUSION

Both beneficial and inefficient labour can contribute to energy consumption in mobile ad hoc networks. Forwarding data, querying queries, and sending and receiving data packets all result in useful energy usage. Collisions and the retransmissions they cause, idle channel listening, and packet header overhead are the main causes of wasteful energy use. According to simulation findings, the suggested algorithm EIFKMACH extends the network lifetime in MANET and uses less energy. An intuitionistic fuzzy k-means-based clustering architecture for sensor nodes is developed in the suggested scheme. The evolutionary algorithm is used to elect the cluster head based on each node's density, distance, and residual energy. Based on the membership and non-membership values of the factors, the node with the highest factor is chosen. The cluster head collects, compresses, and sends the data to the base station via gateway or other cluster heads; the data that passes past the cluster's nodes does not connect with the base station. Therefore, the suggested task works best in a challenging setting.

6. FUTURE SCOPE

Future developments of this study might include adding more factors to the cluster head selection process, selecting various clustering formats in a dynamic and hostile environment, and identifying misbehaving nodes that result in node failure. Other optimum algorithms, such as bat, swarm optimisation, and ant colony, can be employed for the best selection process to choose the cluster head.

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