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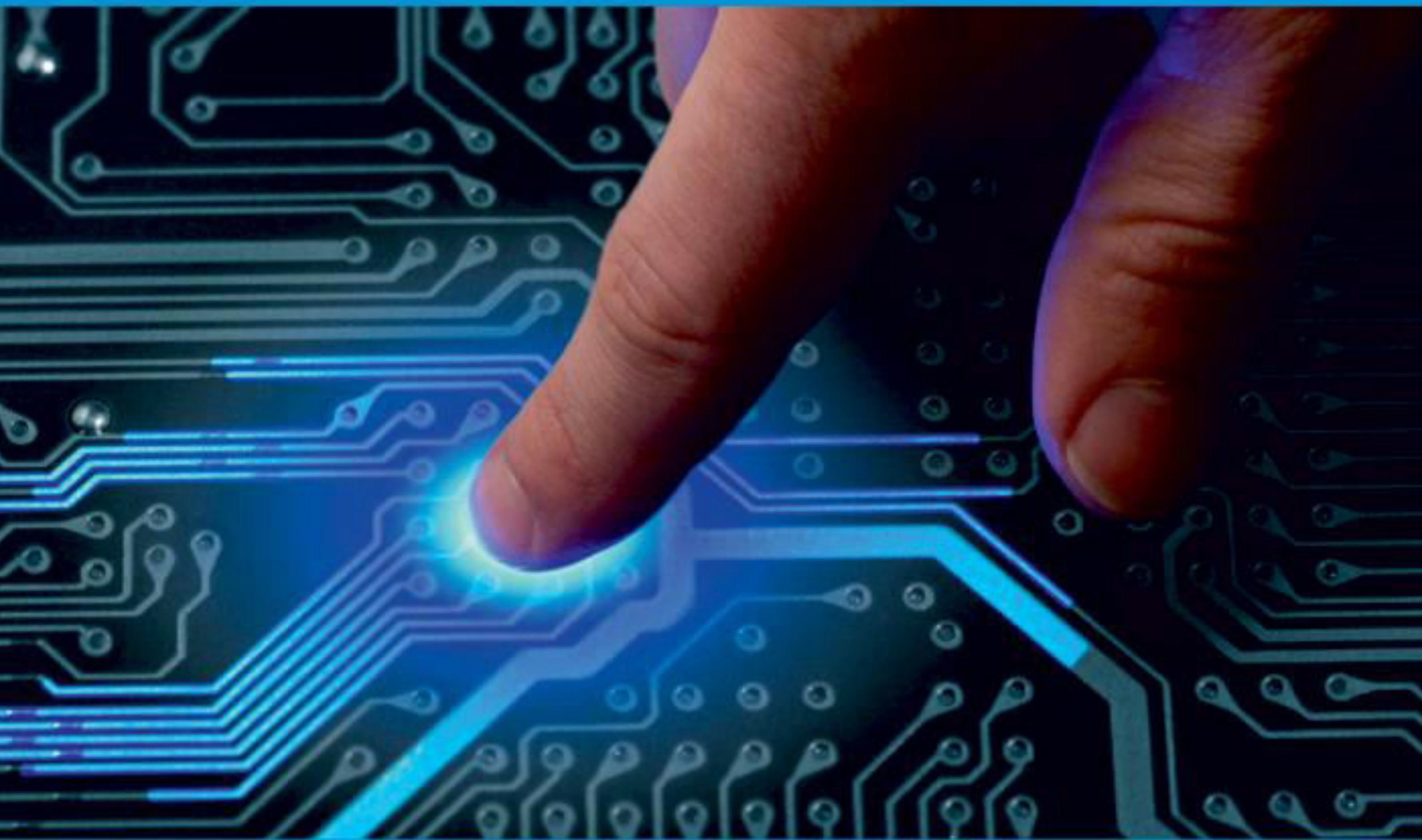

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Design of Novel Energy Efficient Clustering Protocol for Heterogeneous WSN

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ABSTRACT: In this paper, we developed a clustering protocol for a heterogeneous WSN network of 500 nodes in a 200200 m2 WSN field. On the basic DEEC protocol, we hybridised the different algorithms for the Clustering portion and Cluster Head (CH) selection in each cluster. We used the Optimised K-means clustering algorithm for clustering and the M-ICHB algorithm for CH selection. The simulation results prove that the results are superior to the MIDEEC protocol in terms of energy consumption, network lifetime, and data packets received by the Sink (BS) [4].

KEYWORDS: Energy Efficient; Optimised K-means Clustering algorithm; M-ICHB algorithm; Heterogeneous WSN; Network lifetime;

I. INTRODUCTION

Over the last few years, researchers have become more interested in deploying small sensor nodes (SNs) in a variety of applications via wireless sensor networks. Temperature, light, humidity, motion, vibration, and other natural events can all be detected by these sensor nodes, which are powered by low-power, small-size batteries [1]. These SNs' main characteristics are data detection in the real world, local data processing, and wireless data transfer capabilities [2].

When hundreds of SNs are placed in an unstructured design with the goal of monitoring a specific area, a wireless sensor network (WSN) is formed. These SNs are quite capable of carrying out their duties in hostile, demanding, and extremely sensitive environments with too little human interaction for extended periods of time. WSNs are used for a variety of purposes, such as armed services or battleground surveillance, target detection, traffic monitoring and control, natural disaster forecasting, environmental monitoring, and structural health monitoring.

Each SN has a finite amount of power, the lifetime of a WSN is limited. This entails developing energy-efficient protocols capable of extending the lifetime of each SN on the network. Clustering approaches are critical for developing such successful techniques in this discipline. Organizing these SNs into tiny sub-groups to generate network clusters has been widely done and praised by the academic community in clustering approaches over the last two decades. A cluster head (CH) leads each cluster and serves as a communication and data transmission link between SNs and base stations (BS). A good clustering strategy benefits the network's SNs by allowing them to spend less energy. Rather than wasting energy communicating directly with the BS, SNs send their sensed data to their CHs, who then combine the data packets into significant information using mathematical computations such as accumulation, combination, and so on, and then send these packet data to the BS via multi-hop or directly communicate. This method saves energy on each SN, reduces unnecessary message forwarding to the BS, and keeps the network active for longer periods of time.

II. RELATED WORK

In recent years, researchers have paid close attention to meta-heuristic optimization algorithms due to its ability to identify optimal solutions and resolve complex uncertainties in any discipline. These algorithms may provide competent solutions in the field of WSNs, such as improved routing pathways, proper coverage, fault-tolerant networks, cluster creation with the optimal number of clusters, and the creation of energy-efficient networks. To name a few, bacterial foraging optimization algorithm (BFOA) [6], artificial bee colony (ABC) [5], and ant colony optimization (ACO) [3] have all had a significant impact on performance with such issues and produced better results than existing algorithms. Based on these optimization methodologies, a number of clustering protocols were developed, the majority of which use a centralised approach. Concerns about scalability particularly affect centralised clustering techniques [8]. Using this knowledge to develop a distributed meta-heuristic-based clustering technique increased confidence in providing better answers to WSNs.

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The most critical issue in WSNs is network lifetime, which is managed either directly or indirectly by network energy. The most efficient use of network energy can be obtained by clustering sensors into clusters. Each cluster is made up of a leader node, also known as the cluster head, and several sensor nodes. The cluster head is usually in charge of unification and accumulation. The network must have enough energy to last for a longer period of time. To increase network energy, the number of sensors in the observing region can be increased. Although increasing the number of sensor nodes increases network energy, the cost is significant because installing each additional sensor costs ten times the cost of the batteries. As a result, extending the network's life by installing some high-battery sensors is more appropriate and cost-effective.

As previously stated, the authors of the MIDEEC protocol [4] used the M-ICHB algorithm for CH selection in the WSN network by removing the energy awareness problem for CH selection in the network. However, it suffers from a shorter network lifetime and a lower number of data packets received by the BS. This protocol employs various algorithms to extend network lifetime and make it more energy efficient.

III. PROPOSED ALGORITHM

First, in this study, we propose an optimised K-means clustering method, which is an improvement on the K-means clustering technique [7]. The Elbow approach, which depicts the graph between the sum of square distances (SSD) within the cluster and different values of K, aids in determining the optimal number of clusters. This K-means method clusters data in a confined manner as well.

Second, to address the problem of energy unawareness in distributed WSN models, M-ICHB (Modified CH election using BFOA) employs a distributed approach based on stability-based clustering algorithms to select CH in each cluster. In addition, we can use both techniques to find the best SNs (in terms of energy) in all clusters that could potentially serve as CHs, and then build an ideal collection of CHs that effectively covers the entire network field.

Third, on the DEEC protocol, we used optimised K-means and the M-ICHB algorithm. In comparison to the multi-level MIDEEC protocol, this proposed protocol improves energy efficient clustering formation in a confined manner and CH selection in every cluster without using estimation/randomized algorithm, provides elongated network lifetime, maintains CH selection in each round, allows for more data packets at the BS, and is fully distributive in nature.

Finally, we compared our proposed protocol to the multi-level MIDEEC protocol for 500 nodes in 200×200 m^2. The proposed algorithm's flowchart is shown in Fig.1 below:

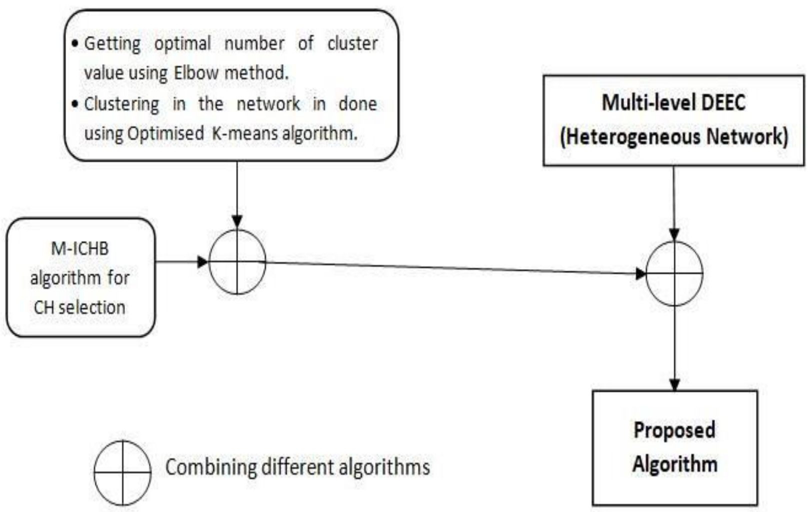

Fig.1: Flowchart of Proposed algorithm

Optimized K-means algorithm: Using the Elbow method [7] and initial random centroids deployment in the WSN network, we obtain the optimal cluster value using the K-means algorithm for clustering the WSN network.

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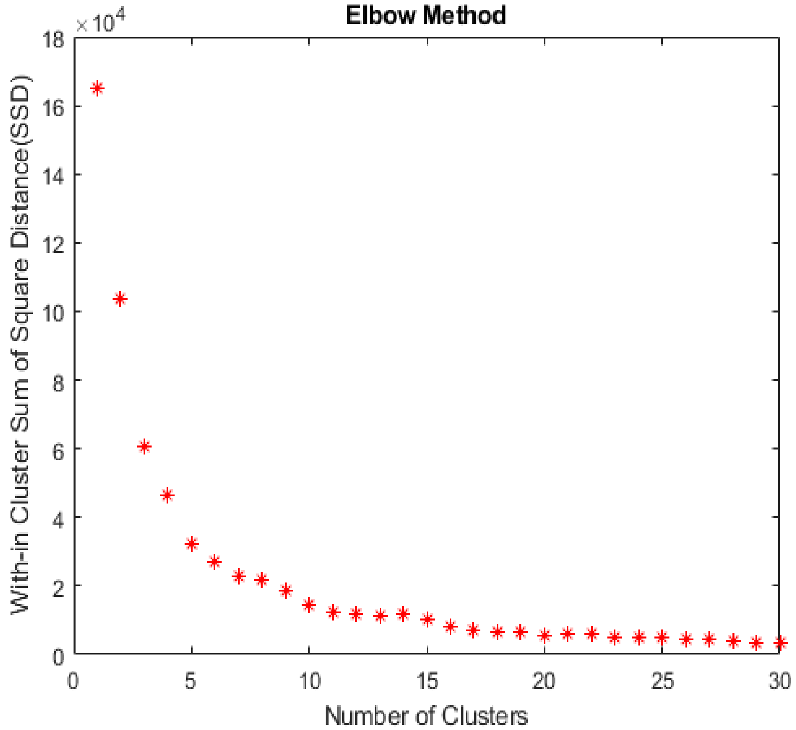

Fig. 2: Graph of Elbow method

According to the simulated graph above, the optimal cluster value is 20, as there is no discernible change in SSD value after K=20.The procedures involved in the WSN network fields optimised K-means algorithm.

- Step-1: K_{opt} = 20 must be specified.
- Step-2: To cover the entire WSN network, 20 arbitrary centroids are deployed at equal distances.

In Figure 3, the blue dot represents randomly placed sensor nodes, while the red cross represents the initial determined arbitrary centroids at equal distances to cover the entire network.

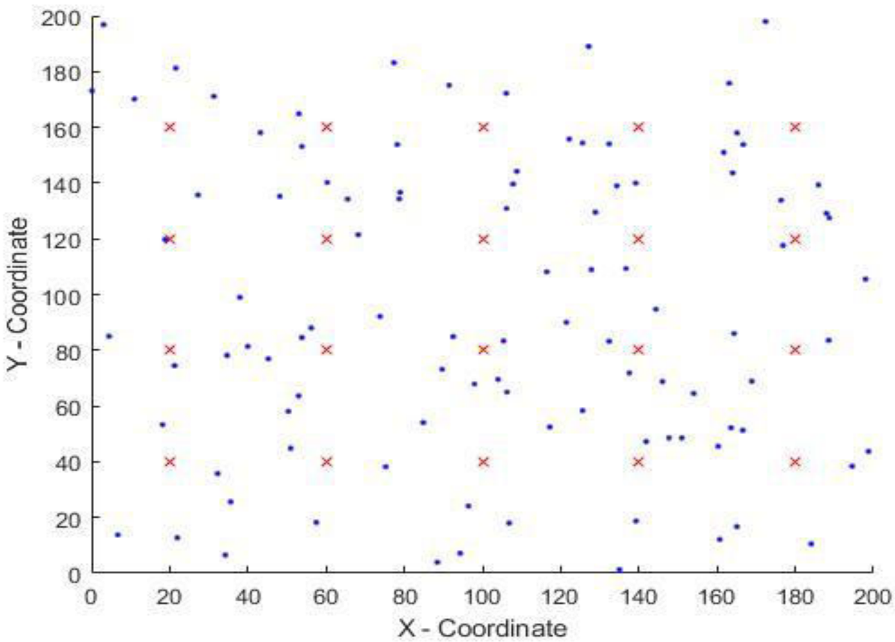

Fig.3: Arbitary initial defined centroids

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- Step-3: The Euclidean distance is used to calculate distance between sensor nodes with centroids.
- Step-4: The closest centroids of the sensor nodes are used to group them.
- Step-5: Find the new arbitrary centroids coordinate using the means formula.
- Step-6: When the new centroids' coordinates match those of the previous centroids, clustering is complete.

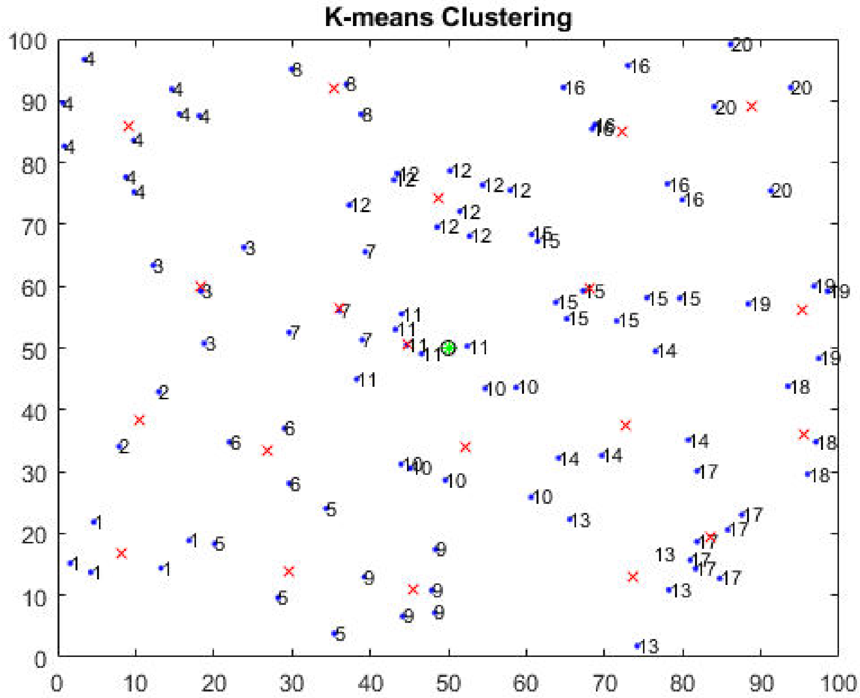

Fig.4: Optimized K-means clustering with final arbitrary centroids position

The position of the base station (100,100)m is represented by the green circle in the accompanying Fig.4. In the WSN network, sensor nodes with the same number belong to the same cluster. There are twenty clusters in the network, and this grouping will remain consistent throughout the rounds. The next section goes over the CH selection from the relevant cluster.

Modified Intelligent Cluster Head selection using BFOA (M-ICHB): We extend the M-ICHB method's capabilities [4] to find better CH nodes for producing longer network lifetimes in WSNs. The M-ICHB algorithm looks for SNs with higher residual energy that will act as CH nodes in that round's cluster.

After applying the aforementioned methods to the DEEC protocol for a multi-level heterogeneous network, an energy efficient clustering protocol is obtained. Our proposed protocol uses the same energy consumption model as the compared protocol.

The simulation parameters used to implement proposed protocol are mentioned in table-1:

Table-1: Simulation Parameters

Parameters Description	Value
Network field size $(M\times M)$	$200\times200m^2$
Value of Nodes (N)	100, 200 & 500
Base Station Location	(100,100)m for $200\times200\ m^2$
Initial energy to each node (E_{ini})	Varying between (0.5 to 2)J
Optimal distance (l_0)	87.7m

Other remaining simulation parameters are same used in compared protocol MIDEEC. For $200\times200m^2$ WSN field by varying number of nodes the c_{opt} value used by the multi-MIDEEC protocol is given below.

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N= number of nodes	c_{opt}= optimal cluster value
500	20

IV. SIMULATION RESULTS

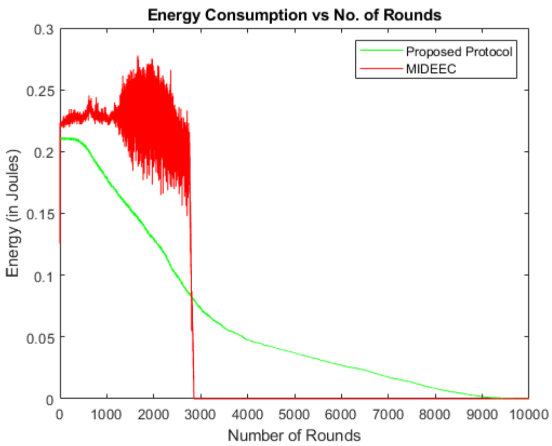

Fig-1: Energy Consumption v/s Round for 500 nodes

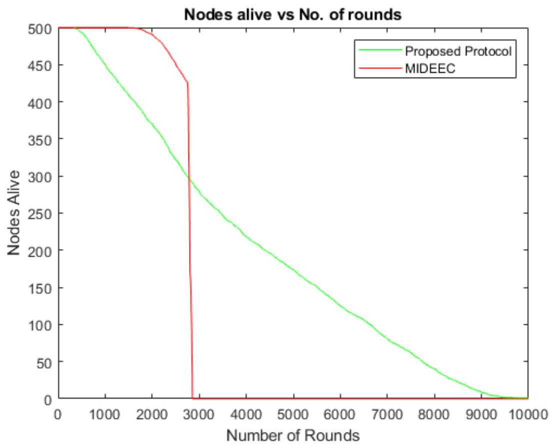

Fig. 2: Nodes Alive v/s Round for 500 nodes

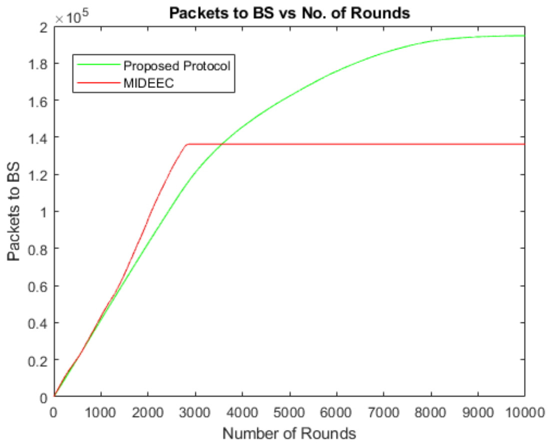

Fig. 3: Data Packets received by BS v/s number of rounds for 500 nodes

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From Fig.1, it is clearly depicts that our proposed protocol is more energy efficient for 500 nodes. Fig.2 depicts that network lifetime is also increased in our proposed protocol. The data packets received by base station (BS) are also increased in our proposed protocol and it is shown in Fig.3. The total initial energy, first node dead, last node dead and total numbers of data packets received by BS are represented in the Table 2.

Table 2: The O/P value of implemented and compared protocol

Total Initial Energy of all nodes (J)	Number of nodes (N)	First node dead (FND)		Last node dead (LND)		Total Data Packets received by BS	
		Proposed protocol	MIDEEC protocol	Proposed protocol	MIDEEC protocol	Proposed protocol	MIDEEC protocol
630	500	403	1647	9328	2826	177284	168623

V. Conclusion and Future Work

As shown in the table above, the suggested protocol has a network lifespan of 200×200m^2 field and is significantly more energy efficient than the Multi-level MIDEEC protocol. We have improve clustering in a more constrained manner with fewer iterations by using an optimised K-means method. The MICHB method is used to find the CH without using any estimates or randomised algorithms, resulting in a straightforward CH election. The proposed protocol is also resolves the scalability issue. In the future, we can try to improve the protocol's First node dead to make it more stable, as well as add any security features to increase the number of data packets received at BS.

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