ENHANCED ENERGY – EFFICIENT USING FUZZY LOGIC BASED CLUSTERING IN WSN

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***Abstract*— The primary challenges in defining and organizing the operation of wireless sensor networks are improving energy utilization and system life. Clustering is a powerful method for aligning the system to the associated order, adjusting the load, and extending the system's life. In a cluster-based network, the cluster head closest to the sink quickly depletes its energy, resulting in hot spot issues. Several algorithms for unequal clustering are being considered to solve this problem. The disadvantage of these algorithms is that nodes that join the same cluster head will overburden it. In this article, a fuzzy-based unequal clustering algorithm is proposed to improve cluster execution. The proposed research is put to the test.**

Keywords — *Cluster Head, Energy-Efficient, Sensor Nodes, Fuzzy Logic, Wireless Sensor Networks.*

I. INTRODUCTION

Wireless Sensor Networks (WSNs) have recently grown increasing popularity, due to the rise of Micro-Electro-Mechanical Systems (MEMS) innovation, which has energized smart sensor development WSNs can be found in a wide range of applications. Sensor nodes use energy by gathering, processing, and transferring data. In most situations, these sensor nodes come with non-rechargeable batteries and are installed in the residence. After then, the sensor nodes' power should be used to extend the network's life [1]. One of the techniques is used to deal with the use of cluster-based design which gains the sensor equipment's energy. In the WSN, Figure.1 there is clustering with a high number of sensor nodes, which ensures critical output it also enhances the WSN's scalability.

Sensor nodes are frequently packed together in clusters in a cluster-based architecture [2]. A cluster head (CH) is authorized to communicate with a base station (BS) or a sink in each cluster. Both sensor nodes submit their detected data to the cluster head, which analyses it and delivers it to the sink, which is a particular node. Most of the clustering convention utilizes two methods for selecting cluster heads with higher residual energy and matching cluster heads to the energy consumption of sensor nodes across the network regularly [3].

However, these algorithms are unaware of the distance to the BS, which appears to expire soon due to its remote location from the base station with the state purpose of avoiding this issue, some unequal technique for clustering (EAUCF). This research builds on previous work by adding a new variable called node degree to competitive range computing, where the competition range determines the cluster size. Furthermore, ordinary nodes join with the final cluster head to construct the cluster using fuzzy logic with two variables: Distance to the cluster head and cluster head degree [4]. The competitive range of the intended cluster heads is computed in EAUCF utilizing fuzzy logic, residual energy, and sensor node distance from the base station. The ultimate cluster head is determined by the residual energy of nodes competing in the same competition range.

Fig. 1. Characteristic of Clustering in WSN

Residual energy, distance to the base station, and node degree are three different fuzzy variables, which are employed in FBUC to compute the competition range [5]. It is critical to observe the node's degree since it improves the algorithm's efficiency, which in turn extends the network's lifespan. The non-cluster head nodes will be joined by the cluster head that is closest to them in EAUCF. When the final cluster heads are picked there are a few more techniques that combine non-cluster header nodes with cluster heads exclusively based on size. The cluster size near the base station is small in uneven clustering, whereas the cluster size distance from the base station is large [6]. As a result, if there is more number of nodes close to the cluster near the base station, the energy of the cluster head will deplete very quickly as additional nodes near the cluster head. A unique way to link non-cluster head nodes with the cluster head is to

tackle these issues. In this article, once the final cluster head is chosen, using fuzzy logic, the non-cluster head nodes will join the cluster head to form a cluster based on the distance between the cluster head. The cluster head degree is the ratio of the number of nodes to the total number of nodes within its competition range.

II. RELATED WORK

Clustering and routing are the two most important optimization problems in WSN. Some of the clusters in the region have been evaluated as routing techniques, and numerous statements have been issued. WSN uses digital intelligence methods such as neural networking, reinforcement learning, swarm intelligence methodologies, evolutionary algorithms, and fuzzy logic to solve a variety of design challenges including CH selection, routing, protection, data gathering, and synchronization. In situations when there is a lot of ambiguity, fuzzy logic is ideal. Hein Zelman proposed the LEACH (Low Energy Adaptive Clustering Hierarchy) technique to clustering, which is the most extensively used and acknowledged clustering technology. It is a distributing protocol in which each round's CHs are randomly selected [7].

The CH's aggregate data from its cluster members into a single packet and transfer it to BS in a single hop. It's useful where nodes broadcast data when a sensed price crosses a predefined level. It eliminates periodic transmission, which reduces the number of data transmissions, and energy conservation isn't theoretically feasible in any case [8]. When the threshold value is not achieved, nodes do not send data, and the consumer is ignorant of the current condition due to sensing. To address TEEN's flaws, a hybrid protocol named APTEEN was developed. As they react to changes in the real world, the Nodes in APTEEN will also provide data regularly in an energy-efficient manner [9].

Because the sensor node's life is limited by its battery life, energy is the most significant resource in the WSN's architecture. One technique to overcome the energy savings problem in sensor systems is to use cluster-based design [10]. In the literature, there are various clustering methods. Among the most well-known clustering systems, LEACH is the most important and widely used protocol. It uses a probability model to choose a cluster head. The network is separated into primary and secondary levels, with primary cluster heads chosen for transmission based on their proximity to the BS [11]. It considers the transmission distance between cluster head nodes and the BS to reduce energy depletion in cluster heads.

It also dynamically counts the number of cluster heads, as indicated by the number of active nodes in the system. The approach extends the network's life by applying fuzzy logic to determine the chance of becoming clustered heads []. As a fuzzy bundle, they used energy and local distance. Fuzzy logic is utilized to tackle LEACH faults in the situation of cluster header collection. Three fuzzy variables, namely concentration, energy, and centrality, are employed to pick the cluster head in their study. Most clustering techniques, by default, pick cluster heads with higher residual energy [13].

III. PROPOSED MODEL

The work's main device framework consists of sensor nodes that are deployed to identify potential problems. Below are the assumptions that are used in this study:

- A WSN is composed of sensor nodes that are of the same size have the same initial capacity.
- Sensor nodes are located randomly.
- When both the sensor nodes and the base station are stationary, they are deployed.
- Energy-constrained nodes are left unattended. The battery's ability to be recharged after this deployment seems unrealistic.
- The signal strength acquired is used to calculate the distance between the nodes.
- In WSN, the base station is placed the WSN's sensor nodes are arranged in a cluster of various sizes. The cluster header is present in each cluster. In relay mode, the cluster header collects information from its cluster members, encrypts the data, and sends it to the base station.

The transmission energy required for the l-bit message is more than the separation S, as per the separation S, as follows:

$$E_T(1, S) = \begin{cases} 1\,E_{elec} + 1€_{fs}\,S^2 & \text{for } S<d_0 \\ 1\,E_{elec} + 1€_{mp}\,S^4 & \text{for } S \geq d_0 \end{cases} \quad (1)$$

IV. FUZZY LOGIC IN CLUSTERING

In this section, the fuzzy logic-based uneven clustering algorithm is enhanced by the EAUCF, which is a fuzzy energy-conscious unequal clustering technique. The EAUCF algorithm's efficiency has been increased in three ways. First, instead of utilizing a predetermined threshold value, use a probabilistic threshold value [14].

Second, instead of utilizing a specified threshold value, use a probabilistic threshold value. It utilized three fuzzy variables instead of two in the cluster header. Nodes entering in the cluster head are also considered as the non-cluster head and then employed fuzzy logic with two variables. FBUC is a clustering technique that uses distributional unequal clustering. In these rounds, it behaves similarly to LEACH.

Initially, preliminary cluster heads are chosen in each round by randomly assigning a number to each node. If the produced arbitrary number is smaller than the probability value (TH) of the nodes then it becomes the preliminary cluster's head. The algorithm describes the calculation of the threshold value for each round.

$$TH = P / (1 - P * (r \bmod 1/ P) \quad (2)$$

If r is the current round number, P is the desired percentage of the cluster head (e.g. P = 0.05). The fuzzy logic technique, like EAUCF, is utilized to calculate the competition radius of each cluster head node. EAUCF was applied to compute two basic factors to estimate the competition radius: the distance between the base station and the current energy level of the node. However, in this study,

they identified three basic variables, two of which were EAUCF and the third of which was the attempt cluster head node degree.

ALGORITHM FOR CALCULATING THRESHOLD VALUE

TH = probability to become a tentative cluster head
Tentative_Cluster_head = False
For each node do
R = rand (0, 1)
Node State = member
If R\TH then
Tentative_Cluster_head = True
Comp_Radius = Fuzzy_Logic1 (distance, residual energy, node degree)
End if
End for
Send CHMsg (ID, Comp_Radius, RE) to its neighbors
Each node M on receiving the CHMsg from node N
If N (residual energy)[M(residual energy) then
Tentative Cluster head = False
End if

For the computation of the competition radius in EAUCF, they focused only on the node's energy. When the battery power is low and the cluster head's service area is too large, it's critical to minimize the cluster head's service area [15]. Table 1 describes the rules of competition radius rules of residual energy, node degree.

Table 1. Competition Radius rules

Base Station	Residual Energy	Node Degree	Competition Radius
Close	Low	High	Very Small
Close	Low	Medium	Small
Close	Low	Low	Rather Small
Close	Medium	High	Rather Small
Medium	Low	High	Medium Small
Medium	Low	Medium	Medium
Medium	Low	Low	Medium Large
Far	Low	High	Medium Large
Far	Low	Medium	Rather Large
Far	Low	Low	Large

Table 2. Cluster Head Selection in Fuzzy

Distance	Cluster Head_Node_Degree	Cluster Head_selection
Close	Low	Very Large
Close	Medium	Large
Medium	Low	Medium Large
Medium	High	Medium Small
Far	Low	Rather Small
Far	Medium	Small

The main advantage of applying this feature is for improving the node degree and reducing the competition radius. The radius from the BS, the residual energy of the attempt cluster head, and the node degree of the attempt cluster head are the three fuzzy variables considered in this article. The fuzzy input variables and information attributes are utilized to generate the competition radius which is listed below.

Distance BS - (close, medium, far)
Residual energy - (low, medium, high)
Node degree - (low, medium, high)

The competitive radius of the proposed cluster head is a fuzzy performance variable. The final cluster head is chosen within the maximum competition radius of high residual energy inside the maximum competition radius. The non-cluster header nodes should be linked to the cluster head for the data transfer once the final cluster head has been determined [16]. The sensor nodes are connected to the cluster head closest to them. In uneven clustering, however, if more nodes are near to the cluster head, which has a small competition radius, the cluster head should appear.

The cluster head can deplete its energy more rapidly since it has low energy and is very close to the base station. Non-CH members can join the cluster head not only based on the distance to the cluster head, but also on the CH-degree, which is the ratio of the number of nodes within the competition radius to the total number of nodes, in work. The fuzzy logic is utilized to overcome conflict once again. The main advantage is that it increases the number of cluster head nodes in direct range to the base station. The following are the fuzzy input factors and their language variables used to determine cluster head:

Distance - (close, medium, far)
CH_Node_Degree - (low, medium, high).

V. SIMULATIONS RESULTS

In this section, analysis of simulations is carried out by MATLAB and the node movement patterns are used to maintain a count of the transmission. These communication sessions are started at various nodes and delivered to a variety of destinations. Results are compared in terms of both characteristics and performance.

Table 3. Simulations results for Network Lifetime

Number of Nodes	CCS	LEACH	EAUCF
50	9.506	9.654	9.791
75	9.558	9.681	9.812
100	9.572	9.694	9.822
115	9.667	9.754	9.861

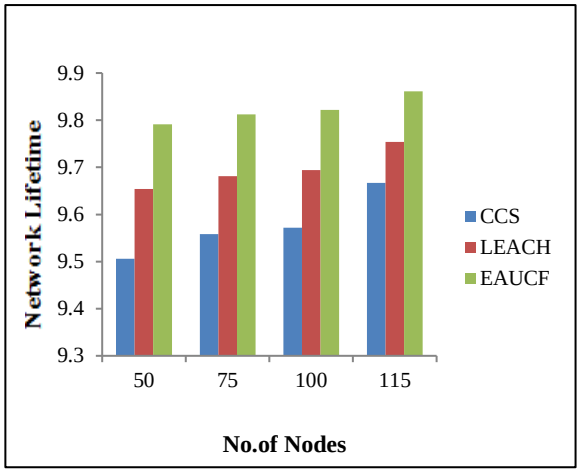

Fig. 2. Simulations Results For Delivery Delay

Table 4. Simulations Results For Delivery Delay

Number of Nodes	CCS	LEACH	EAUCF
50	9.675	9.811	9.945
75	9.687	9.821	9.956
100	9.694	9.833	9.958
115	9.713	9.846	9.965

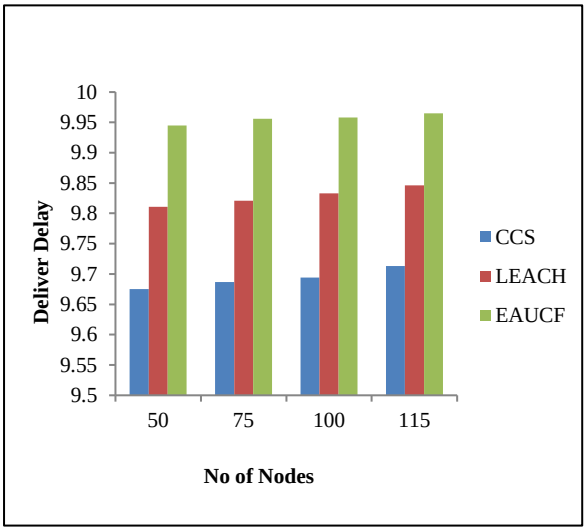

Fig. 3. Comparison of Delivery Delay

VI. CONCLUSION

In WSN architecture, energy efficiency is a major concern. The proposed fuzzy logic based on an uneven clustering technique is used to find the final cluster which is chosen based on the energy level of the tentative cluster head inside the cluster radius and calculated using residual energy and the node degree of the cluster heads. Nodes are admitted to the cluster head depending on distance and cluster head to make efficient use of resources and extend the network's life. The proposed algorithm is tested by simulations using MATLAB.

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