

## COMPREHENSIVE REVIEW ON CLUSTERING TECHNIQUES IN WIRELESS SENSOR NETWORKS

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*Abstract--In a wireless sensor network, the sensor nodes play an important role. This network is known as an independent system where a number of sensor nodes are used. Two significant elements of a wireless sensor network are Base station and sensor nodes. The main task of the sensor nodes is to receive the data and transfer this data to the Base station. In a heterogeneous sensor network, there are two kinds of sensor nodes are used. Here, some sensor nodes have lower energy and some have greater range of energy. It is observed that the sensor density tends to enhance with the overloading of gateway in a single-tier network. As a result of this kind of overload, interruption in communication takes place. Also, a single tier architecture is not feasible in nature as a number of sensor nodes are used and sometimes, these nodes are not capable of long distance communication. For efficient usage of the nodes energy, clustering algorithms are used so that the network life can be enhanced. This paper highlights the Fuzzy logic based clustering for wireless sensor networks.*

**Keywords - Wireless, Network, clustering, Sensor, Node**

### 1. INTRODUCTION

In a wireless sensor network, the communication between a number of sensor nodes is done with the help of a wireless channel. A number of tasks such as monitoring of environment, security and tracking of target etc are performed by wireless sensor networks. These days, the usage of these kinds of networks is also done for measuring the parameters of the environment and the sensor readings are transferred to the remote server. Here, the more chances are the detection of the common process by the nearby sensors; hence, duplicity in the raw data tends to emerge. Consequently, all the raw data can't be transferred to the remote server in an efficient way.

To eliminate this limitation, clustering is used in wireless sensor networks. Here, the main task of using the clustering is to enhance the level of scalability and improve the efficiency of the energy. In the clustering structure, the sensor

nodes are arranged into clusters and for each cluster, a random node is selected which is known as a cluster head and all other nodes act as member nodes.

In cases where there is need of huge number of nodes, Hierarchical clustering is used. This type of clustering is helpful in load balancing and proper utilization of the resources. A cluster is the collection of the nodes in a network where these nodes are arranged in hierarchical structure. In each cluster, there are two elements i.e. cluster head and member nodes. The job of the member nodes is to collect the data and transfer this data to their respective cluster heads. All the data is collected at the end of cluster head and lastly, this huge amount of data is transferred to the Base station. Here, it is observed that the cluster heads consume more energy as compared to the member nodes.

In the process of data collection based on cluster, cluster members collect the data and transfer it to the cluster heads. In the process, the cluster heads transfer the data to the data sink with the help of direct communication or intermediate cluster heads. It is also observed that the clustering not only achieves efficiency in energy but also, it maintains low packet latency in the aggregation of data.

To overcome the delay in transmission, packets are collected at cluster heads in order to minimize the overhead of transmission of packet headers and control packets. This clustering also helpful in simplifying the path from the source node to the sink node. For this purpose, shorter routing path is used so that the data traffic can be lowered down in an effective way.

Ajay Jangra et al. [1] highlighted a new mechanism of security based on S-LEACH. Here, S-LEACH is the extended version of LEACH routing protocol. This protocol is used for the detection of the Sybil attack. The configuration of this mechanism is done in order to provide the initiation to the Sybil attack where the task of detection is relayed on the strength of the signal when the number of cluster heads exceeds the threshold in the wireless sensor networks. This security mechanism covers

the safety of the consumption of the energy with the help of number of experiments.

Deng Zhejiang et al. [2] presented a model to overcome the power limitation and size of memory for wireless sensor networks. In this model, data related to the routing is maintained by the routing protocol which consequently helps in lowering down the consumption of power. In this research, he analyzed the PEGASIS and LEACH protocol. He proposed a routing protocol with three-tier architecture for wireless sensor networks based on LEACH in order to reduce the dissipation of power.

Fan Xiangning et al. [3] proposed two types of LEACH protocol i.e. energy-LEACH protocol and multihop-LEACH protocols. Here, the former protocol is used to improve the selection method of the cluster head whereas the multihop-LEACH protocols are used to improve the mode of communication between sink and cluster head. On comparison, it is found that the performance of the Energy-LEACH and Multihop-LEACH Protocols is much better than that of the LEACH Protocols.

Fuzhe Zhao, You Xu, Ru Li, Wei Zhang et al. [4] presented a novel way of selecting the cluster heads. This method is helpful in minimizing the unwanted energy and power consumption for each and every node. In this process; at the time of the selection of the cluster heads, the introduction of the dynamic change of energy of the sensor nodes is performed in order to distribute the energy evenly across the given network.

Fuzhe Zhao et al. [5] highlighted the method where the cluster heads are selected which tends to minimize the energy consumption used on the computation of each and every node in the network. It is observed that the traditional method for the selection of the nodes make the life span of the cluster heads very short and consequently, it leads to the consumption of more and more energy.

Haosong Gou et al. [6] presented partition-based LEACH. This kind of LEACH is used to make the partition of the network into a number of sectors. After that, the node with the highest level of energy is selected which is termed as the head of each sector with the help of the centralized computations. With the help of p-LEACH, the cluster of the sensor nodes is formed relying on the strength of the signal where cluster heads are used to provide the path for the data to move to the base station and the respective clusters.

Heewook Shin et al. [7] described a novel method of clustering with efficient energy. He

described that a wide range of unnecessary energy and time are spent in order to reform the clusters at the initial stage of every round. This limitation leads to the increase in the number of clusters. To overcome this limitation, he proposed a clustering scheme where the motive is to eliminate the process of the recreation of the clusters needed at every stage after the initial phase which is referred as COTS (Clustering with One Time Setup). This setup permits the role of cluster head is handed over between the members in a cluster.

Hu Jumping et al. [8] presented a novel type of wireless sensor network. This network is made up of a number of sensors with small energy which are widely organized in a large area.

Jun YUE, Weiming ZHANG, Weidong XIAO, Daquan TANG, Jiuyang TANG et al. [9] proposed a new protocol for the aggregation of the data based on the uneven clusters. Here, the network is partitioned into a number of grids having uneven sizes and the task of the implementation of the rotation of the cluster head is performed for each grid.

Y. Yang et al. [10] presented a protocol i.e. LEACH-B (LEACH- Balanced). In this protocol, the selection of the cluster head is performed according to the LEACH protocol.

## 2. METHODOLOGY

We are using MATLAB for implementing our clustering algorithm. MATLAB (matrix laboratory) is a fourth-generation high-level programming language and interactive environment for numerical computation, visualization and programming. MATLAB is developed by Math Works. It allows matrix manipulations; plotting of functions and data; implementation of algorithms; creation of user interfaces; interfacing with programs written in other languages, including C, C++, Java, and Fortran; analyze data; develop algorithms; and create models and applications. It has numerous built-in commands and math functions that help you in mathematical calculations, generating plots and performing numerical methods.

In this article, we are proposing Fuzzy Logic based clustering. This type of clustering is the advanced version of the clustering based on weight in wireless sensor networks. The drawback of the clustering based on weight is that it tends to select the unwanted cluster heads. In this way, nodes having higher range of residual energy are not provided with enough opportunities to form the cluster heads.

To overcome this limitation of the weight based clustering, we propose Fuzzy Logic based clustering in wireless sensor networks. In this method, all the nodes having equal amount of energy are provided with same number of chances in forming the cluster head.

This type of clustering also provides those nodes having higher range of residual energy, the opportunities to be chosen as cluster head which tend to lie in the boundary range of another cluster head.

Fuzzy Logic based clustering is also helpful in enhancing the overall lifetime of the specified network. Here, the main thing which is observed for the selection of the cluster head is the residual energy of each node. This type of clustering also helps in the computation of the residual energy as the monitoring of the energy consumed and communication is performed efficiently.

Cluster heads are found with the help of Fuzzy Logic which tends to select optimal number of cluster heads. It is very feasible to use the Fuzzy logic in the cases where it is difficult to implement a mathematical model for the network. Also, this Fuzzy logic tends to minimize the level of complexity of the model and takes the data related to the memory as input and transforms this input into fuzzy variable input.

Here, the radio analysis is performed with the help of first order radio energy which has the following form:

$$I_{init} = 0.5 \text{ in Joules}, I_{elec} = 50 * 0.000000001$$

$$I_{MP} = 0.0013 * 0.000000000001,$$

$$I_{da} = 5 * 0.000000001$$

Where,

$I_{init}$  is initial energy

$I_{elec}$  is electrical energy,

$I_{MP}$  is amplification energy,

$I_{da}$  is data aggregation energy.

Pseudo code of Proposed Model

Step1: Start

Step 2: Create a Network

Step 3: Create Clusters from network with the help of:

- a. multiple metrics are used to select a cluster head from a number of sensor nodes. Here, Fuzzy logic clustering is used with the parameters of residual energy and distance between cluster head and non-cluster head.
- b. Based on the step 3(a), non-cluster heads are used to choose the appropriate cluster head based on the metrics of distance in order to be its member.

Step 4: Stop

Comparison between weight based clustering in WSN (existing method) and Fuzzy Logic based clustering in Wireless Sensor Network (Proposed method)

Weight based clustering in Wireless Sensor Network (existing method)	Fuzzy Logic based clustering in Wireless Sensor Network (Proposed method)
1. Weight based clustering tends to select the unwanted cluster heads. In this way, nodes having higher range of residual energy are not provided with enough opportunities to form the cluster heads.	1. In Fuzzy Logic based clustering, all the nodes having equal amount of energy are provided with same number of chances in forming the cluster head.  This type of clustering also provides those nodes having higher range of residual energy, the opportunities to be chosen as cluster head which tend to lie in the boundary range of another cluster head.
2. Weight based clustering in WSN also enhances the lifetime of the network but not that much as observed in case of Fuzzy Logic clustering.	2. Fuzzy Logic based clustering is also helpful in enhancing the overall lifetime of the specified network.
3. Here, the complexity of the model is observed more as compared to Fuzzy logic clustering.	3. Fuzzy logic tends to minimize the level of complexity of the model and takes the data related to the memory as input and transforms this input into fuzzy variable input.
4. In Weight based clustering, the first dead node is found after 500 rounds	4. In Fuzzy logic clustering, the first dead node is found after 700 rounds

### 3. RESULTS

In the initial phase, a network is presented where the nodes are randomly distributed as shown in figure 1.

In Figure 2, a novel scheme is proposed where the task of selecting the cluster head is performed with the help of provided logic of presented model. Here, the star shape in blue color is used for the cluster heads whereas the dead nodes are represented as red stars.

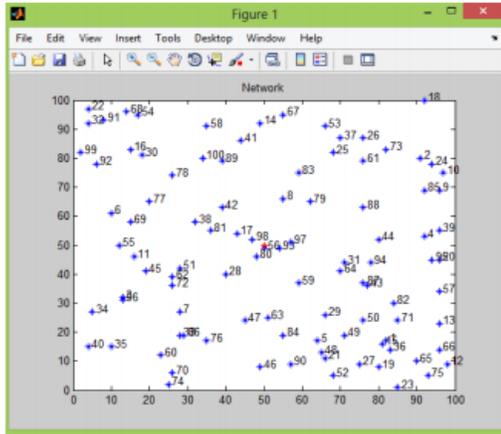


Fig.1. Network creation using 100 Nodes

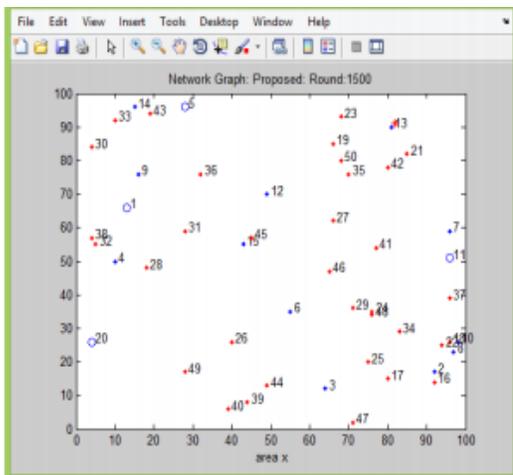


Fig. 2. Formation of Cluster

Here, the Probability functions are used to elect the cluster heads for each normal node which is evaluated with the help of the Fuzzy Logic system. It uses two input variables in the form of residual energy and the distance which exists between the cluster head and the node.

Figure 3 and 4 present inputs and their respective representation in the fuzzy system.

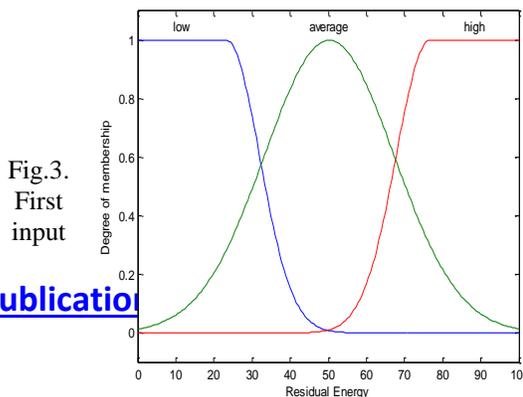


Fig.3. First input

in the form of Residual Energy for the Fuzzy system

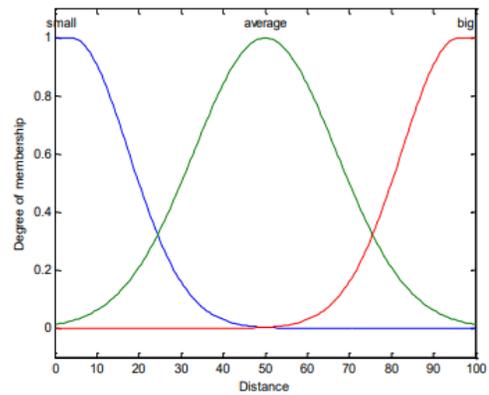


Fig.4. Second input in the form of distance between the cluster head and the node for the Fuzzy system

Figure 5 shows the correlation between Residual energy and Distance for Fuzzy system.

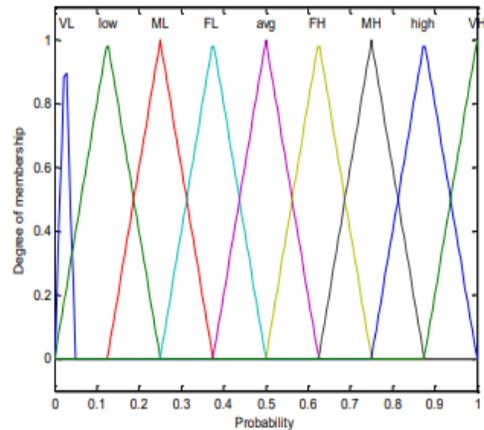


Fig. 5. shows the surface graph for probability for the formation of cluster

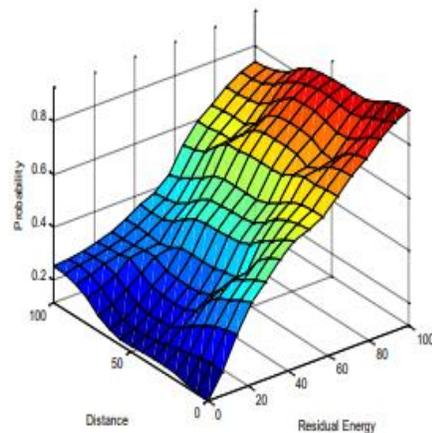


Fig.6. Surface graph for probability for the formation of cluster

With the help of Fuzzy logic based on probability, the probability for each cluster head

can be computed for each and every cluster head. In a round, the node with more probability in correspondence with any cluster head is termed as the member of that cluster for corresponding cluster head. In this way, the task of the formation of the clusters is performed.

**Performance Evaluation**

Figure 7 shows that in Fuzzy logic clustering, the first dead node is found after 700 rounds whereas the same tends to occur after 500 rounds in case of weight based clustering algorithm. It concludes that our proposed clustering based on Fuzzy Logic is quite more energy efficient as compared to weight based clustering.

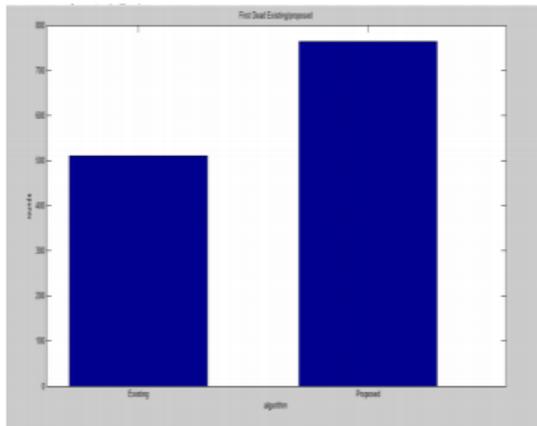


Fig.7.Comparison of weight based clustering algorithm and Fuzzy Logic based clustering algorithm with respect to first dead.

Figure 8 shows the performance of the weight based clustering algorithm and Fuzzy Logic based clustering algorithm in terms of number of dead nodes. Here, blue line is used to highlight the weight based clustering whereas green line is used to represent Fuzzy Logic based clustering. The result shows that the remarkable improvement in the performance of Fuzzy Logic based clustering as compared to the weight based clustering in terms of 1000 rounds.

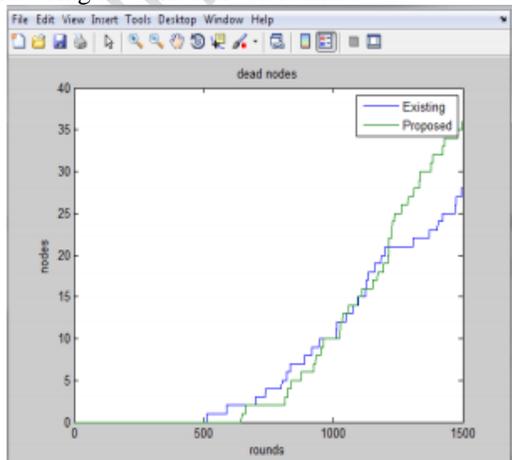


Fig.8.Performance evaluation of weight based clustering and Fuzzy Logic based clustering in terms of no. of dead nodes& no. of rounds.

Figure 9 shows the performance of the weight based clustering algorithm and Fuzzy Logic based clustering algorithm in terms of number of dead residual energy with clustering rounds. Here, blue line is used to highlight the weight based clustering whereas green line is used to represent Fuzzy Logic based clustering. The result shows that the Fuzzy Logic based clustering has same residual energy upto initial 500 rounds as in the case of weight based clustering.

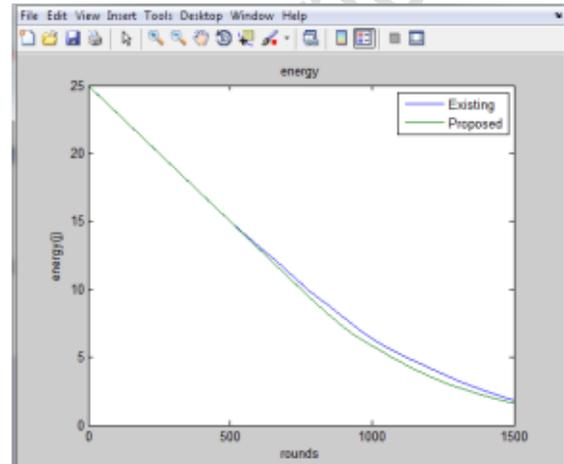


Fig. 9.Comparison of performance of the weight based clustering algorithm and Fuzzy Logic based clustering algorithm in terms of number of dead residual energy with clustering rounds.

**4. CONCLUSION**

We have presented an efficient technique for clustering of sensor node in the homogenous WSNs. In the existing LEACH protocol the clusters are formed using the distance calculation from the node to cluster head. But for a network to be good designed there should be a better cluster formation. For a better cluster formation the concept of fuzzy logic is used in which non-CHs select the best CH by considering a multiple metrics, i.e. residual energy and a distance from non-CH to CH. Then, non-CHs compute a probability value to each CH candidate. The non-CH chooses the CH with a higher probability value and sends a join message to CH.

The use of fuzzy logic is suitable, whenever it is not possible to use a mathematical model for the system. Additionally, fuzzy can reduce the complexity of the model, computational effort and memory. Energy consumption is affected by message communication between nodes, so our

technique is efficient than traditional LEACH protocol.

## 5. REFERENCES

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