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A Fuzzy Based Approach for Clustering in WSNs

Ramakant[1], Dr. Kamal Sharma[2], Sourabh Budhiraja[3]

[1]Student, M. Tech, ESEAR, Ambala
[2]Professor, Dept. of ECE, E-Max group of Institutions, Ambala
[3]Assistant Professor, Dept. of CSE, E-Max group of Institutions, Ambala

***Abstract*— A Clustering algorithms have gained popularity in this field, because of their approach in cluster head selection and data aggregation. LEACH (distributed) is the first clustering routing protocol which is proven to be better compared to other such algorithms. In this paper, we propose a Fuzzy based approach for energy efficient clustering. The proposed scheme merges the idea of Residual Energy and distance between nodes with that of the central control algorithm providing uniform distribution of cluster heads throughout the network. This scheme reduces energy consumption and prolongs network life time significantly as compared to LEACH.**

***Keywords*— wireless sensor networks; clustering; routing; cluster construction; data transmission.**

I. INTRODUCTION

A WSN consists of spatially distributed autonomous sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants. Sensor networks are being deployed for a wide variety of applications [2], including by military applications such as battlefield surveillance and is now used in many industrial and civilian application areas, environment and habitat monitoring, healthcare applications, home automation, and traffic control.

With the advancement in micro-fabrication technology, Wireless Sensor Networks (WSNs) have started to play a vital role in our daily lives. It is because of the decrease in cost of the sensor nodes, leading to increasing distribution of WSNs to a larger extent. Possible applications for wireless sensor networks exist in a variation of fields, including industrial process watching and control, environment and environment monitoring, machine health monitoring, home automation, health care applications, nuclear reactor control, fire detection, object chasing and traffic control. Efficient design and operation of wireless sensor networks have become a hot area of research in recent years, due to the huge capacity of sensor networks to enable applications connecting the physical world with the simulated world. It is likely to obtain data about physical or eco-friendly phenomena by networking large number of tiny sensor nodes that was hard or impossible to obtain in more conventional ways.

In [3] we have given a review of clustering protocols comes under WSNs.

II. LEACH PROTOCOL FOR CLUSTERING

A. LEACH

The main objectives of LEACH [1], was to find a way to low intake of energy in the cluster and to advance the life time of WSN. LEACH implements a hierarchical and adaptive approach to shape the network into a set of clusters, managed by selected CHs. The CH carries out many tasks, such as periodic gathering of data from the associate members of the cluster, combination of data to remove redundancy among correlated values, transmission of the aggregated data directly to the base station through a single hop method. In the schedule created by the CH, each node of the cluster is allotted a time slot that can be used by non-CH nodes for transmission. The CHs show the schedule to their corresponding cluster members. For reducing the possibility of collisions among sensor nodes, LEACH nodes use a code division multiple access (CDMA) based scheme for communication. The network model used by LEACH is depicted in Figure 1.

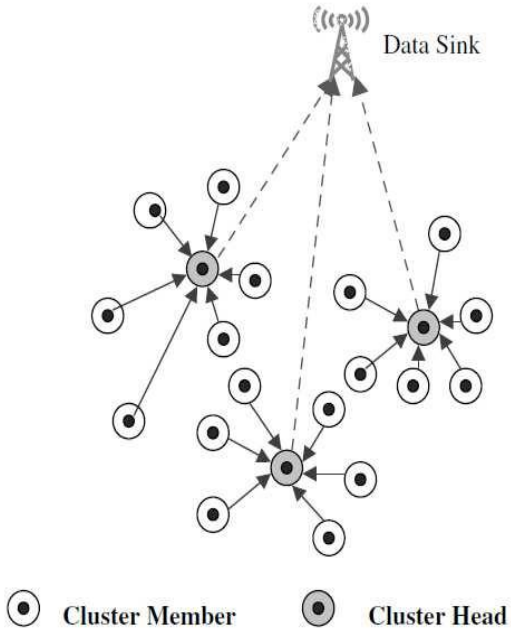

Figure 1: Model of LEACH

The basic operation of LEACH consists of many rounds, each round being divided into two phases.

The first phase called the setup phase consists of three steps,

(i) Cluster-head advertisement,
(ii) Cluster set-up and
(iii) Transmission schedule creation.

The second phase, the steady-state phase, focuses on,

(i) Data transmission to cluster heads,

(ii) Signal processing
(iii) Delivery to the base station.
To minimize the protocol overhead, the duration of the setup phase is expected to be comparatively shorter than the steady-state phase.
At the start of the setup phase, cluster-head selection takes place. The role of CH rotates among sensor nodes, thereby dispensing energy consumption evenly across the network nodes. To determine if it is its turn to become a CH, a node n, produces a random number x (between 0 and 1), and equate it with the CH selection threshold T(n).

$$T(n) = \begin{cases} \frac{P}{1-P*\left(r \bmod \frac{1}{P}\right)} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

Where,
P is the desired percentage of cluster heads, r is the current round and G represents the set of nodes that have not been selected as CHs in last 1/P rounds.
The node becomes a CH if its produced value, x, is less than T(n). The CH selection threshold, T(n) is aimed to guarantee with high likelihood that a determined fraction of nodes, P, should be elected as CHs at each round. Further, the threshold ensures that the nodes, those have been CHs in last 1/P rounds, will not again be nominated in the current round. At the completion of the CH selection process, every node that is certain as a CH, publicizes its new role to the rest of the network. Upon receiving the advertise-ments, each remaining node selects a cluster to join based on the received signal strength. The nodes inform their matching CHs of their desire to become a member of the cluster. Once the cluster is formed, each CH creates and distributes a TDMA schedule that specifies the time slots allocated to each member of the cluster for transmission.
The completion of the setup phase signals the start of the steady-state phase. In this phase, nodes collect the essential data and use their assigned slots to transmit those to the CH. Data collection is performed occasionally. Then, the CH nodes receive all the data; aggregate them before sending to the base-station. The network goes back into the setup phase after a certain time, which is determined a priori.

III. PRESENT WORK

A. PROBLEM DEFINITION

Sometimes the Clustering is not done in a well manner as some of the nodes did not get best cluster head. So this problem should not be there in the network. The Cluster head and corresponding nodes with this head should be chosen effectively.

B. OBJECTIVE

In this research we study few of clustering Routing techniques in WSN. The summarized of goal of work for the dissertation as follows:

- The objective of our work is to find an Energy Efficient based clustering method in WSN.
- As the SNs are limited in energy so we will try to use cluster head (CH) to save all the outlier detection reading found in the cluster.

We will use MATLAB for simulating our work. MATLAB is widely used in all areas of applied mathematics, in education and research at universities, and in the industry. MATLAB stands for MATrix LABoratory and the software is built up around vectors and matrices.

C. CLUSTER-BASED APPROACH FOR ENERGY-EFFICIENCY IN THE WSNs

To make the model energy efficient we make use of the concept of clustering. was developed for application where there are SNs periodically collecting scalar data and send them to BS for further analysis. The physical scalar sensor measurements are processed by means of existing models or methods, with the aim of predicting the occurrence of events, such as flooding, fire or intruders. The model considers a network with the following characteristics:
The SNs fixed, are energy-constrained and they have the same capability; The BS has not subject to energy restrictions and is located inside the sensing field; there is no batteries recharge after node deployment; this general scenario may be used for various applications ranging from civilian and military areas.

1. CH election

As mentioned earlier, in hierarchical architectures, the nodes are divided into clusters and a set of nodes is periodically elected as a CH. CHs are used for more complex tasks, such as: the management of each cluster, collecting data from non-CHs, data aggregation, and sending the collected data to the BS. In this context, it is important to use multiple metrics for CH election to provide an energy-efficient and load balance model. Furthermore, the cluster formation process can lead to poor energy use, if the CHs that are elected are only based on a single metric. In this context, CLENER proposes an equation, which is used by nodes to enable them to become a CH.
During the initialization of the network, BS broadcasts a startup message, which enables the node to compute the distance to BS. Following this, the nodes are able to adjust the transmission power according to distance, which reduces the energy consumption since higher transmission power consumes more energy.
After adjusting the transmission power, each node generates a random number (μ), which ranges from 0 to 1. Then, the node decides to become a CH by comparing μ with the T(n), which is computed by means of Equation 2. If μ is less than T(n), the node becomes a CH for the current round.

$$T(n) = \eta \frac{p}{1-p\left(r \bmod \frac{1}{p}\right)} + \alpha\left(1 - e^{\frac{-RE^2}{2\sigma^2_{RE}}}\right) \ldots (1)$$

Where η and α are weights to give importance, the sum is exactly 1. The Residual Energy is denoted as RE, and σ_{re} means the energy variance, which is used to produce better CH candidates.
Equation 1 uses a gauss function, due to the fact that has better result in terms of energy efficiency and representation in the context of an imprecise environment.
Now, the node that becomes CH broadcasts a ch message, which contains the value of its remaining energy. Then, CH waits for a join message from the non-CH nodes. However, if the CHs do not receive a join message, this CH should not

become CH. Algorithm 1 describes the steps for CH election and cluster formation.

2. Cluster Formation

During this sub-phase, 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 using Takagi-Sugeno Fuzzy System (TS). The non-CH chooses the CH with a higher probability value and sends a join message to CH.

Fuzzy logic provides a rigorous algebra for dealing with inaccurate information. The linguistic input variables of the system are the remaining energy, expressed in percentages and the distance between non-CH and CH (expressed in meters). The specifications related for the input and output functions of the system and their respective Linguistic Values (LV) are as follows:

- Residual energy: u=[0,100]: LV = low, average, high;
- Distance: u=[0,100]: LV = small, average, big;
- Probability: u=(0,1]: LV = very high, high, moderately high, fairly high, average, fairly low, moderately low, low, very low.

For the representation of the linguistic states (low, high, small and large) of the input variables, the degrees of membership to these sets must remain constant for certain values of the universe of discourse.

The membership functions designed for the system are shown in figure 2. The rules are expressed as logical implications in the form of IF-THEN statements in a mapping from fuzzy input sets to output functions.

The rules are determined on the basis of an analysis of the whole network behavior through extensive simulations over time. They result in a class of higher probability, ensure an excellent chance these nodes will be elected, and differentiate depending on their distance from each CH.

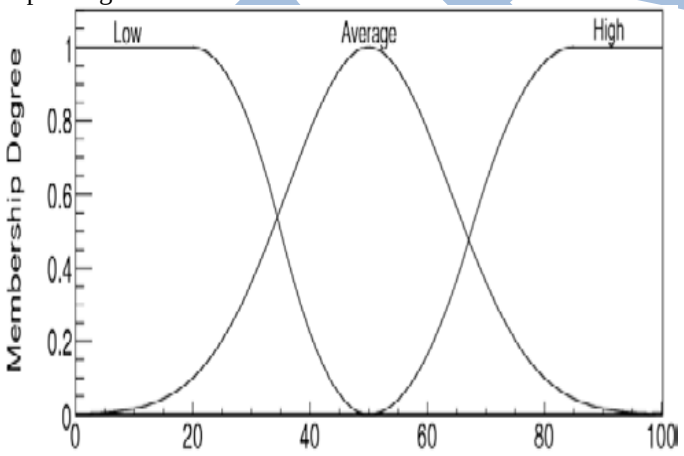

Figure 2: Membership Functions

The use of fuzzy logic is appropriate, whenever it is not possible to employ a mathematical model for the system. Additionally, fuzzy can reduce the complexity of the model, computational effort and memory TS receive context information from nodes as input and converts into fuzzy linguistic variable input.

The Pseudo code of Proposed Model is:

Step1: Start

Step 2: Create a Network

Step 3: Create Clusters from network using:

a) A CH is selected from the SNs.
b) Based on last step, Non-CHs select the best CH by considering a multiple metrics i.e. residual energy and a distance from non-CH to CH using the concept of Fuzzy logic and Cluster is created.

Step 4: Stop

IV. Performance Evaluation

The basic parameters used for simulations are listed in table 1.

Table 1: Parameters employed in Simulation

Parameter	Value
Field Size	50m X 50m
Location of Base Station	25m X 25m
No. of Nodes	100
Probability of cluster	0.1
Initial Energy of sensor node	20 J
The Data packet Size	4000 bits
DeltaT	10
η	0.4
α	0.6
E_{fs}	10 J/bit/m^2
E_{mp}	0.0013 J/bit/m^4

Based on these parameters author will carry out the simulations. These parameters are taken after studying different research papers used in Wireless sensor network.

Figure 3 shows the energy consumed by Traditional LEACH protocol in the given 4 rounds.

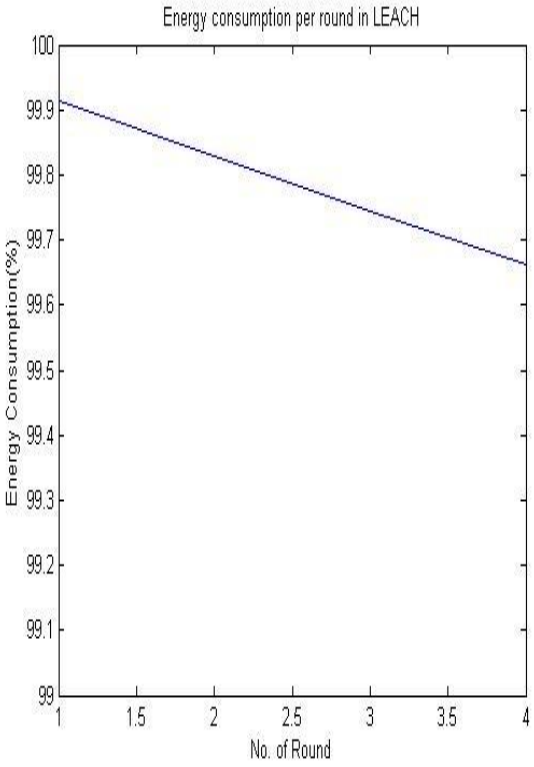

Figure 3: Energy Consumption in LEACH

Figure 4 shows the energy consumed by new scheme in the given 4 rounds.

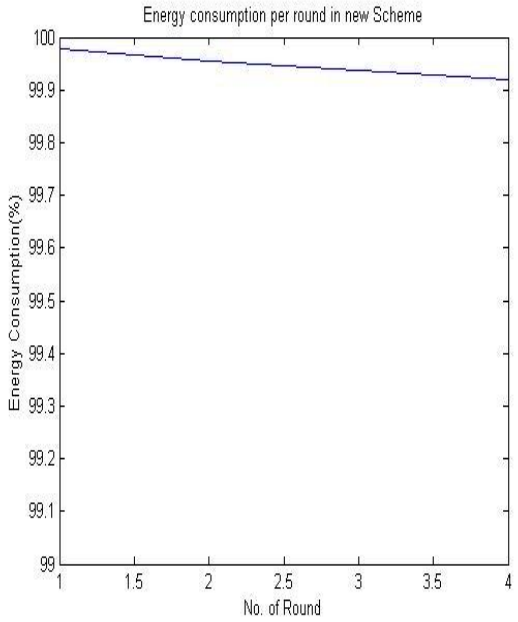

Figure 4: Energy Consumption in New Scheme

Figure 5 shows the comparison of energy consumed by both LEACH and new scheme. It shows that the new scheme is more energy efficient than the traditional LEACH protocol.

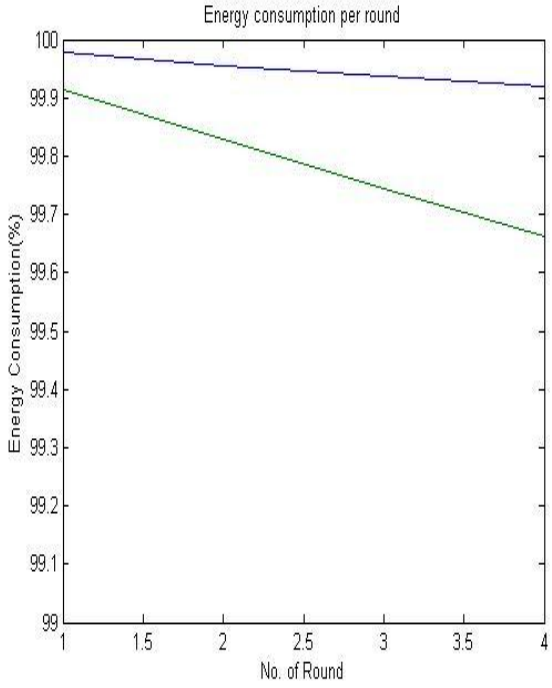

Figure 5: Comparison of Energy Consumption

V. Conclusion

In this paper, we have presented an efficient technique for clustering of sensor node in the 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.

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