



An Improved Cluster Based Energy Efficient Algorithm to Enhance Network Lifetime in Wireless Network

Neeraj Dhiman, Vikas Gupta
ECE, JMIT, Radaur, Haryana,
India

Abstract— Rapid growth in wireless sensor network (WSN) has been observed because of advancement in micro electro mechanical systems (MEMS). A wireless sensor network is a group of tiny sensor nodes which are randomly deployed over a particular area in order to sense the environment for over a long period of time. So energy preservation is always a challenging issue. In the present work, a new scheme is proposed that uses fuzzy logic for energy efficient cluster head election. Simulation results show that proposed scheme improves network lifetime as compared to the LEACH and CLENER methods.

Keywords - Wireless sensor network, Cluster head, Base Station, Fuzzy logic.

I. INTRODUCTION

A wireless sensor network consists of a large number of very small sensor nodes that senses the data from the area where practical approach is not possible. Nodes collect this sensed data and perform information processing [1]. Sensor nodes cannot be accessed after their deployment so are useless after their energy is over. So energy consumption issue is one of the most challenging issues. In recent years, a number of researches have been done in this field [2]. Clustering in wireless sensor networks is an effective technique to enhance the scalability and network lifetime. Main purpose of clustering is to divide the network into a number of nodes with a leader, commonly known as cluster head. Clustering enables nodes to transmit their data through the shortest path which will make it more energy efficient [3]. In designing a WSN, there are many key issues to be considered such as limited energy capacity, sensor locations, node deployment, scalability, data aggregation. These are the advantages of using clustering algorithm. Due to so many advantages, WSNs have wide area of applications. These can be used in military application, environmental application like flood detection, temperature measurement, health and home applications and many more [4]. Each individual node consists of one or more sensing devices, a processor, a communication unit, and a power supply [5] [6]. All sensors communicate with each other to generate good quality information about the physical environment. Each sensor has knowledge of its computing capability, communication system, and energy resources to be consider. These deployed sensors after collecting data could send it to other sensors or to an external base station (BS). BS connects the sensor networks to the end user and can access the reported data. [7]. If only particular nodes communicate with BS, the energy consumption could be reduced. These particular nodes called as cluster heads (CHs) aggregate the collected data from nodes, and send it to larger distance thereby reducing the energy usage [8]. So appropriate CH selection must be done. In this paper, fuzzy logic approach have been used for CH election based on three factors residual energy, distance between node and CH, and distance between CH to BS. We compare our approach with two techniques LEACH and CLENER. Simulation results show that new scheme consumes less energy as compared to other techniques. In the next section, overview of related work is given. In section 3, we discussed our system model. Fuzzy logic based simulation results are compared with LEACH and CLENER in section 4. Finally, section 5 concludes the paper.

II. RELATED WORK

The basic architecture of a WSN is as shown in Figure 2.1. Here nodes send the data to their corresponding cluster heads. Cluster heads then aggregate and send the data to base station. While studying clustering, some assumptions have been made which are:

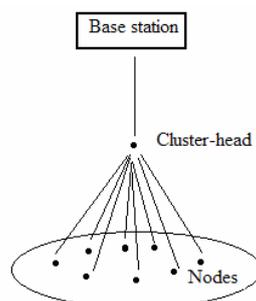


Figure2.1 WSN Architecture

- The base station is fixed and located far from the sensor nodes.
- All nodes have same initial energy.
- Nodes can have knowledge of their residual energy.
- Nodes can have knowledge of its geographical position.
- Wireless communication between nodes is symmetrical.
- First order radio model is used for communication.

Many proposals have been made to select cluster heads.

LEACH [9] protocol is the oldest clustering algorithms in WSN which is a hierarchical method. Its main goal is to maximize network lifetime and even energy distribution across all network nodes. Nodes sends the received information to cluster heads and cluster heads transmit that data to the base station. All data processing tasks like data aggregation/fusion are performed by cluster head. In LEACH the operation is divided into two phases.

1. Set up phase
2. Stead state phase

In the setup phase, each node introduces a random number between 0 and 1, that is, the probability of being selected as the cluster heads. If the probability P which is the desired percentage of CH nodes in the sensor population of node n is less than threshold $T(n)$, the node n will become a cluster head for that particular round r . Threshold value can be calculated as:

$T(n)$ is calculated as follow:

$$T(n) = \frac{P}{1 - P(\text{rmod}(\frac{1}{P}))} \quad \text{if } n \in G \quad (1)$$
$$T(n) = 0 \quad \text{otherwise}$$

Here G is the set of sensor nodes that have not become cluster head since last $1/P$ rounds.

The amount of energy consumption during the network lifetime is effective and the algorithm is not efficient in terms of energy consumption. In this process, energy consumption is much effective .since the CH election is totally based on probabilistic functions so at a time; a node with almost no energy can become a CH which will make protocol less efficient. So this algorithm is not efficient in terms of energy and in turn network lifetime. EEHC [10] Protocol is a randomly distributed clustering algorithm which is an extension over LEACH to solve the problem of CH election. In EEHC, algorithm can be run at the time hen energy level of CHs fall below a certain threshold value. Genetic algorithm as introduced in [11] which subject fitness function depending on distance between BS and CH nodes. Main goal of this algorithm is to elect the best CH out of all based on the factor of left over energy.

CLENER [12], a cluster based approach as being introduced that provides energy efficient protocol than that of LEACH and EEHC. This protocol uses a revised probabilistic function to elect a CH and fuzzy logic to form a cluster based on two factors which are: residual energy and distance from a node to CH. In this, concept of residual energy, two weighted functions η and α are introduced to get more specific and efficient CH election. CLENER has a better performance over LEACH and other protocol due to the reason that CLENER proposes the residual energy as the main variable in the CH election. So it can manage resources and energy distribution effectively. The Problem associated with CLENER in this context is much required that implies the need for load balancing and efficient resource utilization [13].In clustering there is always scope for protocol that make the network more efficient and distribute energy evenly throughout the network which can be done by electing best CH. so the main goal of this paper is to obtain energy efficient based clustering method in WSN.

III. PROPOSED METHOD

In this paper, the cluster head election and cluster formation is done by using proposed scheme that uses fuzzy logic for the same. When sensor periodically collects data and sends it to BS for further processing, concept of clustering is being used. The proposed model considers some of the facts, which are that all sensor nodes are fixed and have same initial energy. Secondly, the BS is located inside the sensing field. Thirdly, no battery recharge can be done after node deployment. A simple static clustering model is used for a network to be energy efficient which will improve the concept of LEACH.

The proposed scenario can be used in application of civilian and military areas. Information about various environmental factors such as humidity, wind speed and temperature etc. can be monitored in rainforest areas that can be used to analyze event occurrence. Our proposed algorithm is composed of two phases namely cluster head election and cluster formation.

A. Ch election

As it is already discussed that in clustering, some clusters with a head i.e. CH are formed. Where in CH performs all complex tasks like aggregation of data, transmitting it comparatively at large distance to BS, so appropriate CH election is must. In new proposed scheme, The BS initializes b sending a startup message to all the nodes. By getting this message, all nodes fist compute its distance from BS by received Signal Strength Indicator (RSSI) so that they can adjust their transmission poi in ode to consume less power for transmission. After that all nodes generate a random number μ , which then compare with a threshold value $T(n)$. If the value of μ is less than the threshold value, the node ill become the CH. The $T(n)$ can be deduced from,

$$T(n) = \eta \frac{P}{1 - P \left(r \bmod \left(\frac{E}{P} \right) \right)} + \alpha \left(1 - e^{-\frac{RE}{2\sigma^2}} \right) \quad \text{if } n \in G \quad (2)$$

Description of the parameters used is:

P: probability of number of CH in a particular round.

r: Current round.

E: residual energy of nodes.

σ : Energy variance.

η, α : Weight function. Their sum is exactly 1.

The CH then sends a ch message to all nodes that contains knowledge of its residual energy and waits for a join message. Algorithm 1 explains process of CH formation and election.

B. Cluster formation

In this phase, member nodes select the best CH with the help of some metrics, i.e. residual energy, distance from non-CH to CH and distance from CH to BS. Then, member nodes compute a probability value for each CH using Mamdani fuzzy system. A node will elect CH with higher probability value and sends a join message to CH.

The importance of Fuzzy logic is that it could effectively deal with conflicting situations and imprecision in data without complex mathematical model. The linguistic input variables of the system are the residual energy, the distance between non-CH and CH (expressed in meters) and distance between CH and BS (expressed in meters). The specifications related to 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 from Non-CH to CH: $u=[0,100]$: LV = low, average, high;
- Distance from CH to BS: $u=[0,100]$: LV=low, average, high;
- Probability: $u= [0, 1]$: LV = very high, high, moderately high, fairly high, average, fairly low, moderately low, low, very low.

These linguistic variables can be represented in terms of their degree of membership. 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 3.1. IF-THEN statements is used in mapping rules as logical implication from fuzzy input sets to output functions.

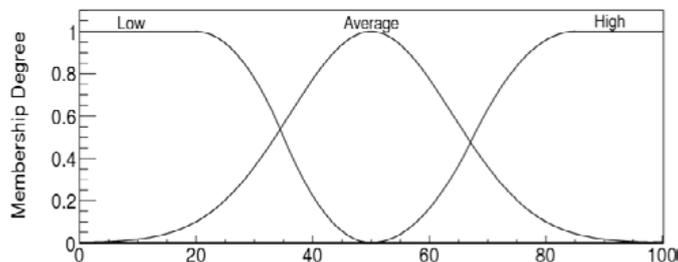


Figure 3.1: Membership Functions

With these parameters, rules are determined based on analysis of whole network it hide simulation over time. This results in obtaining a large probability candidate and provides the best CH to coordinate with. It varies in accordance with multiple metrics. Table I shows the fuzzy inference rules used in the system.

With the help of Fuzzy logic control linguistic variables can be manipulated in mathematical form. Fuzzy logic simplifies the algorithm, executes the real time decision and performs fast. Also study of extra parameters in CH election can produce an optimized solution.

TABLE I FUZZY INFERENCE RULES

S. No.	Residual Energy	Distance from Non-CH to CH	Distance from CH to BS	Probability
1.	High	Small	Small	Very high
2.	High	Average	Small	Very high
3.	High	High	Small	Moderate high
4.	High	Small	Average	Very high
5.	High	Average	Average	Moderate high
6.	High	High	Average	High
7.	High	Small	High	Moderate high
8.	High	Average	High	High
9.	High	High	High	High
10.	Low	Small	Small	Very low
11.	Low	Average	Small	Very low

12.	Low	High	Small	Moderate low
13.	Low	Small	Average	Very low
14.	Low	Average	Average	Moderate low
15.	low	High	Average	Low
16.	Low	Small	High	Moderate low
17.	Low	Average	High	Low
18.	Low	High	High	Low
19.	Average	Small	Small	Fairly high
20.	Average	Average	Small	Fairly high
21.	Average	High	Small	Average
22.	Average	Small	Average	Fairly high
23.	Average	Average	Average	Average
24.	Average	High	Average	Fairly low
25.	Average	Small	High	Average
26.	Average	Average	High	Fairly low
27.	average	High	High	Fairly low

C. Algorithm description

- Step1: node n calculate the probability of selection as CH according to its residual energy, the distance to the base station as well as CH b using fuzzy logic control,
- Step2: calculate the threshold T (n) according to equation 1.
- Step3: node generates a random number between 0 and 1, expressed as μ .
- Step4: if $\mu < T (n)$, node n will be selected as the CH, and broadcast message to other nodes, executing step5 else jumping to step6;
- Step5: node n receives a join message from normal nodes and assigns TDMA slot to the members of the cluster.
- Step6: node n is waiting until receiving a broadcast message and uses fuzzy logic for selecting which CH should it join, and reply to joining a cluster request to the cluster head.

IV. RESULTS

For testing and analysing the proposed algorithm, some experimental studies were performed. The algorithm is simulated using MATLAB software.

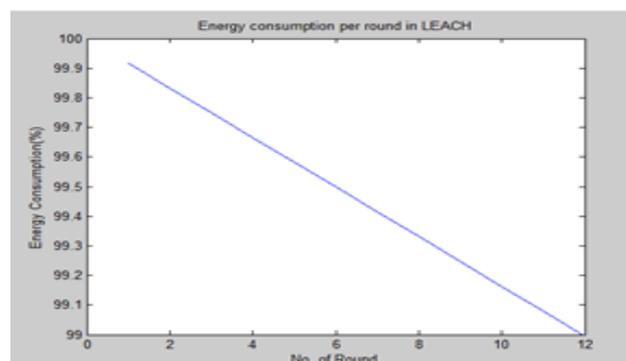
A. Performance evaluation

Basic parameters to be used for simulation are given in table II.

TABLE II PARAMETERS EMPLOYED IN SIMULATION

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

Based on these parameters, simulation has been done. Figure 4.2 shows energy consumption by LEACH in given 12 rounds.



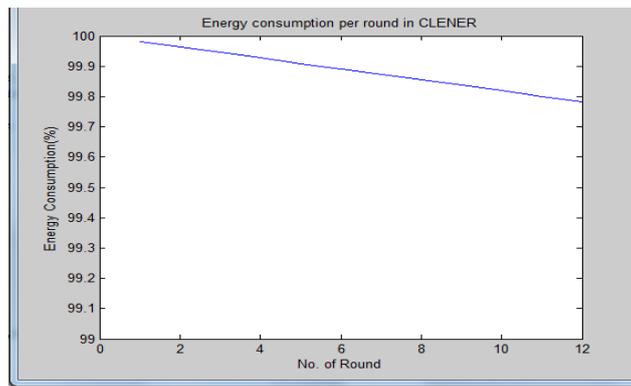


Figure 4.3: Energy consumption per round by CLENER

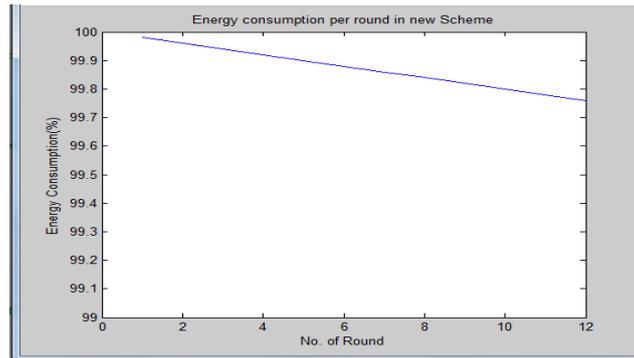


Figure 4.4 Energy consumption by new scheme

Figure 4.3 and 4.4 shows energy consumption per round by CLENER and new proposed scheme respectively and Figure 4.5 shows overall comparison between traditional LEACH, CLENER and new scheme, which clearly shows the betterment of new scheme in terms of energy efficiency over LEACH and CLENER.

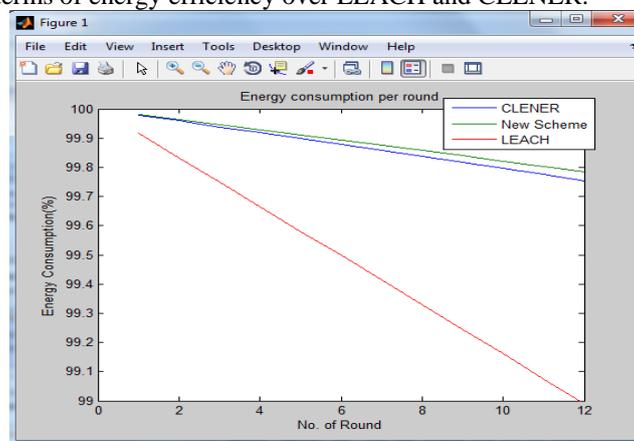


Figure 4.5: comparison of proposed scheme

V. CONCLUSION

In this paper, a new approach for WSN clustering using Fuzzy logic is studied. The parameters which are used in the algorithm are residual energy, distance from the base station and distance from CH. The goal of this paper was to study a new logic to select the best cluster heads that combine different criteria modifying the energy efficiency of cluster heads. Also, using the proposed algorithm, the energy consumption per round is evaluated and compared with some previous methods which have proved better performance and improves energy consumption. The scheme can be effective to use in large scale networks. There is always a scope of methods for more energy efficient networking in WSN clustering.

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