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RESEARCH ARTICLE

Energy Efficient Clustering Using Fuzzy Logic

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Abstract*—Wireless Sensor Networks (WSNs) are an important emerging wireless technology with the advantages of ease of distribution and low cost. They consist of a large number of nodes that sense real-time events and transfer them to a base station for processing. However, WSNs have a few constraints such as energy consumption due to the node CPU and battery which directly affects the network life time. In this paper, we propose a method that focuses on reduction of energy consumption and increasing the network life time using a fuzzy logic approach. The technique is based on two parameters, namely, energy level and centrality, and uses a controller that prevents unwanted concentration of cluster heads in a particular region. The simulation results clearly show a significant amount of increase in energy preservation and longer network life time compared to other proposed approaches.

***Keywords*— Wireless Sensor Networks; Fuzzy Logic; LEACH Protocol; Energy Consumption**

I. INTRODUCTION

Wireless Sensor Networks (WSN) is an emerging network technology that will take the convenience of using networks one step further. In such networks, tiny battery operated wireless sensors are deployed in harsh environment to collect continuous data, such as temperature, moisture, light intensity, pressure, vibration, etc. All the wireless sensor nodes send the collected data to a base station node either directly or via other sensor nodes. The base station node then sends the data to a remote location via the Internet or a WiMAX network for further processing. Despite their attractiveness, WSNs have a number of limitations. One of the main limitations of WSNs is directly related to the node hardware performance level, such as its CPU and battery, which results in higher energy consumption and reduction of network life time. The challenge is in choosing the right protocol that does not drain too much of energy from each node. There are a number of protocols and algorithms for transferring data packets from a node to the base station. One of the best methods used in WSNs to gather and send data is clustering. This method gives the advantages of overall system scalability, longer network lifetime, reduction in amount of redundant data to be transferred and energy consumption [1]. After the process of cluster-head selection, the incoming data from the cluster members is aggregated and moved to the base station directly or by using intelligent algorithm such as ant colony optimization [2]-[3], genetic algorithm [4], etc. The process of clustering gets challenging when it comes to choosing the number of nodes in its range and the selection of a suitable protocol. Choosing the right number of cluster-heads results in the least amount of energy consumption and hence increases the network life-time. This paper proposes a new technique for clustering that uses a fuzzy logic approach. The proposed method uses two parameters in order to select the cluster heads followed by a controller to excess concentration of cluster heads in a specific region. The rest of the paper is organized as follows. Section II surveys the pertinent literature. Section III describes the proposed method. Section IV discusses the simulation results and Section V concludes the paper.

II. LITERATURE SURVEY

There have been substantial amount of researches on clustering protocols for WSNs. One of the classical methods is LEACH [5]. It consists of two stages: first is the cluster construction and the second is the data communication and schedule creation where each node generates a random number between 0 and 1. The nodes with the values below the threshold level T(N), given in Equation 1, get promoted to cluster heads .

$$T(N) = \frac{p}{1 - p * (r \bmod 1/p)} \quad if \quad n \rightarrow G \qquad (1)$$

In Equation 1 p, r, G are the eligible percentages of the cluster head, number of rounds and set of nodes that have not been assigned as cluster heads in past 1/p rounds, respectively [6]. The LEACH protocol is effective in the case of static nodes and gives the highest performance when the nodes have an equal energy level. The drawback of LEACH is in the usage of local information to select the cluster heads. Furthermore, the base station has no hand in making this decision. Since the construction of LEACH is based on probability, there is always a probability that an area will result in one or more cluster heads and another area is left with none.

Fuzzy logic has been used in clustering approaches recently. One approach uses the sink to select the cluster heads; selection of cluster heads is done by calculating and comparing the three factors of battery level, node density and distance of sink to node by means of fuzzy logic [7]. This results in an output of very weak (0), weak (1), little weak (2), lower medium (3), medium (4), higher medium (5), little strong (6), strong (7) and very strong (8). Another approach was done with a similar methodology with the difference where the base station chooses the nodes using a genetic algorithm and the location of the nodes in order to create the optimum network [4].

III. PROPOSED METHOD

In this method we use two parameters that are sent to the fuzzy module, namely, the energy level and centrality rather than the normal approach of having the parameters of energy level, density and the distance in order to calculate the probability of each node's becoming a cluster head. The area is divided into two regions namely Zone 1 and Zone 2 as shown in Fig 1 such that the nodes located in Zone 1 have a probability to be assigned as cluster heads with respect to their energy level and centrality. In order to avoid the problem of excess concentration of cluster heads in a particular region, a controller is used to maintain a uniform distribution of cluster heads across the region of Zone 1.

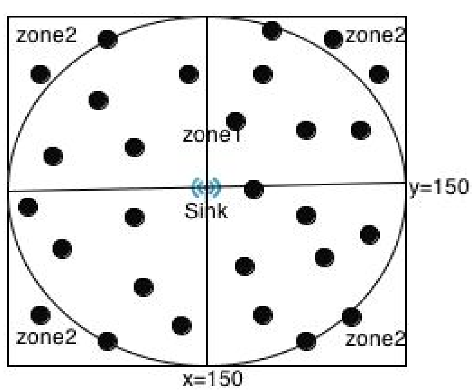

Fig 1: Allocation of Zones

Once the fuzzy module obtains the probabilities of the nodes becoming cluster heads, it transfers this information to the controller module. The controller module goes through a process of interrelated conditions in order to assign the rightful nodes to cluster heads.

This results in a uniform distribution of cluster heads across the region of interest. In our proposal, the number of cluster heads is directly related to the number of nodes alive, where a decrease in the number of nodes alive results in a decrease in the number of cluster heads. Fig 2 shows the flowchart of the proposed method.

Characteristics of the proposed method:

- The location of the base station is fixed at the centre of the area.
- The coordinates of the nodes in each round are changeable (dynamic).
- All nodes have an equal amount of energy at the start.
- Nodes are randomly distributed considering a restricted range of movement.

Nodes are randomly distributed across the area. The base station compares the node-sink distance with the threshold value TR as shown in Equation 2; nodes with a distance value above the threshold are ignored and the accepted ones are ready to get processed based on the two elements of centrality and energy level.

$$TR = \left(2 - \left(c^2 = a^2 + b^2\right)\right) \tag{2}$$

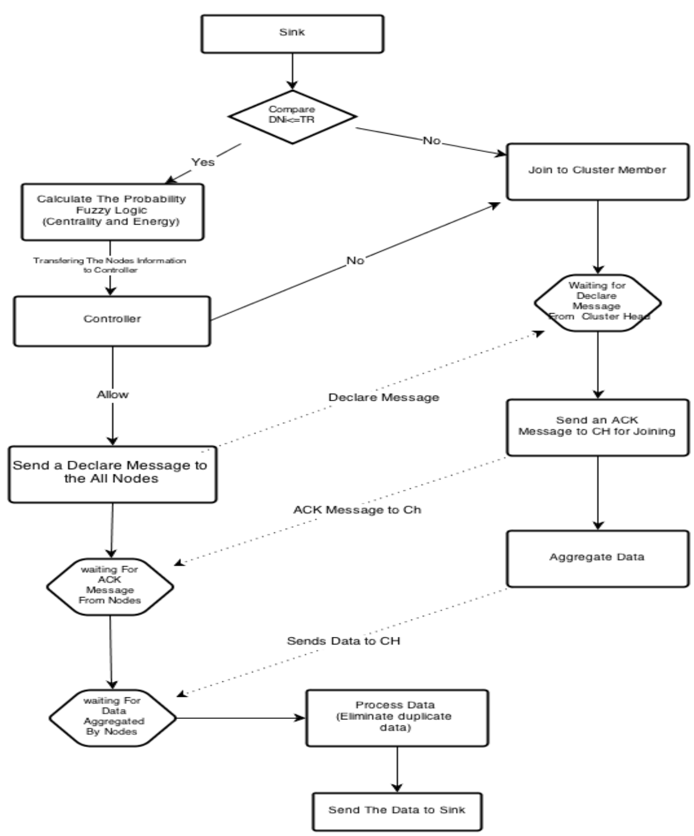

Fig 2. Flowchart of the proposed method

A. Fuzzification Module

The first step of fuzzy logic is the input of crisp values as shown in Table 1.

Table 1 The Fuzzy rules

EL	CN	Probability
Very Low	Bad	VLittle
Very Low	Medium	VLittle
Very Low	Good	Med
Low	Bad	VLittle
Low	Medium	Little
Low	Good	Med
Medium	Bad	Little
Medium	Medium	Med
Medium	Good	Med
High	Bad	Med
High	Medium	High
High	Good	Vhigh
Very High	Bad	Med
Very High	Medium	High
Very High	Good	Vhigh

B. Energy Level (EL)

The energy level (EL) is divided into five sub levels as shown in Table 2 and Fig 3.

Table 2 Energy levels

Level	Percentage
Very low	If 0% < EL <= 20%
Low	If 20%< EL <= 40%
Medium	If 40%< EL <= 60%
High	If 60%< EL <= 80%
Very High	If 80%< EL <= 100%

C. Centrality (CN)

CN is divided into three levels that are shown in Table 3 and Fig 4.

Table 3 Centrality levels

Level	Percentage
Bad	If 0% < CN <= 30%
Med	If 30% < CN <= 70%
Good	If 70% < CN <= 100%

D. Probability

The probability of a node's being chosen as a cluster head depends on the inputs and the classification. As a result there are five probabilities of Very little, Little, Medium, High and Very high as shown in Table 4 and Fig 5. At times, there exists an intersection of levels with one another.

Table 4 The probabilities of a node becoming a cluster-head

Probability	percent
VLittle	0-20
Little	21-40
Medium	41-60
High	61-80
Vhigh	81-100

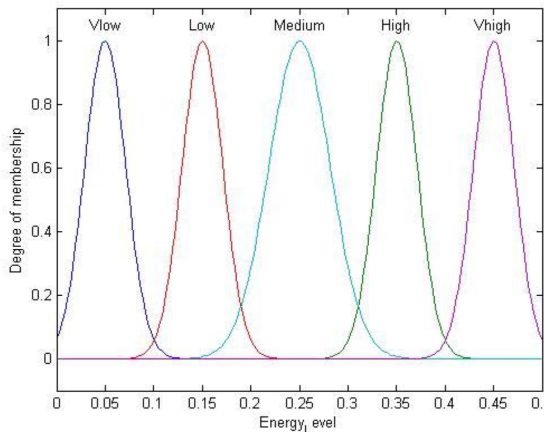

Fig 3. Fuzzy set for energy variable

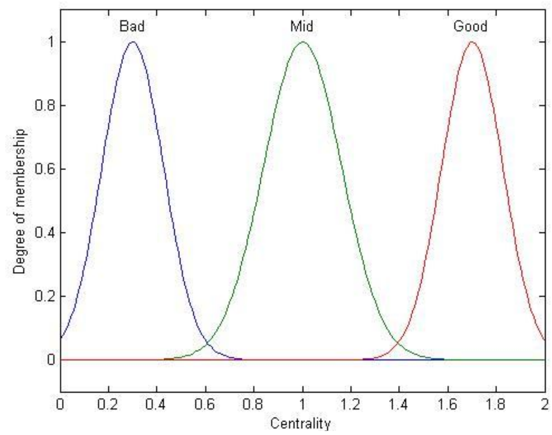

Fig 4. Fuzzy set for centrality variable

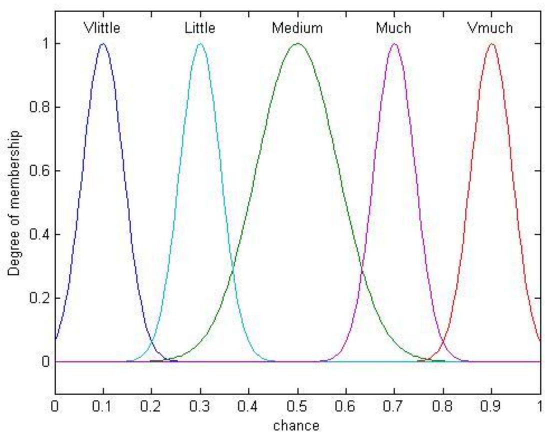

Fig 5. Fuzzy set for probability variable

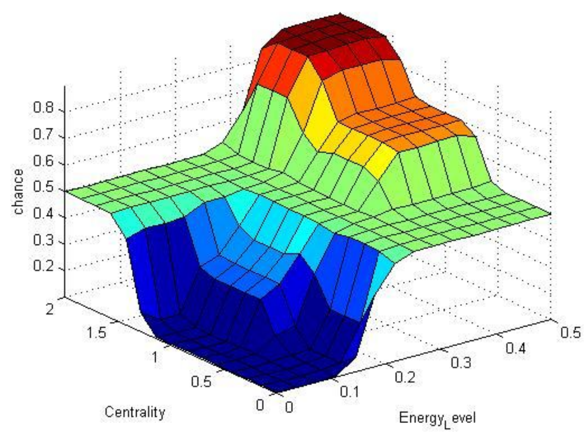

Fig 6. Surface Output

Fig 6 represents the 3 dimensional view of the fuzzy module with centrality, energy level and chance as the coordinates. It can be seen that when the centrality is good and energy level is high the chance for becoming a node to cluster head is high and vice versa.

E. Defuzzification

Defuzzification is the process of taking in crisp input values and giving out crisp output values. The fuzzy control system provides its fuzzy logic results based on a set of rules described in Table 3. There are a number of methods used to calculate the crisp value. In the proposed method, central of area (COA) [7], which is a popular method, is used to determine this value. COA is given by Equation 3.

$$C_{COA} = \left(\int c.u(c)dc / \int cdc\right) \quad (3)$$

F. Energy Consumption Model

The proposed method uses the LEACH energy consumption model between the senders and receivers such as nodes (cluster members) and their cluster-head or cluster-head and the sink as per as Equation 4:

$$E_s = \begin{cases} KE_{elect} + K_{efp}d^2 & d \le d0 \\ KE_{elect} + K_{emp}d^4 & d > d0 \end{cases} \quad (4)$$

Where k and d are the bit data and distance between transmitter and receiver respectively and d0 is the threshold setting the amplification model used in leach model, which is described by Equation 5:

$$d_0 = square\left(\frac{e_{fs}}{e_{mp}}\right) \quad (5)$$

The receiver consumes a certain amount of energy by receiving k_bit data, which is described in Equation 6:

$$E_{remained} = kE_{elec} \quad (6)$$

IV. SIMULATION

The Simulation was performed in a MATLAB environment. The three simulated methods performed are; LEACH, Ran and Zhang's protocol [7] and the proposed method. The focus has been on energy consumption with respect to nodes alive and energy preservation in the entire network. The parameters are as described in Table 5.

Table 5. Parameters

Parameter	**Value**
Initial Energy	0.5 j
Number of nodes	100
Location of sink	Center
Location of nodes	Dynamic
Packet Size	4000 bit
Transmit Amplifier Type Area Coordinate	Efs & Emp 150×150
ETX &ERX	50*0.000000001 j
Movement Range	Maximum (2m)
Rounds	Max 2000

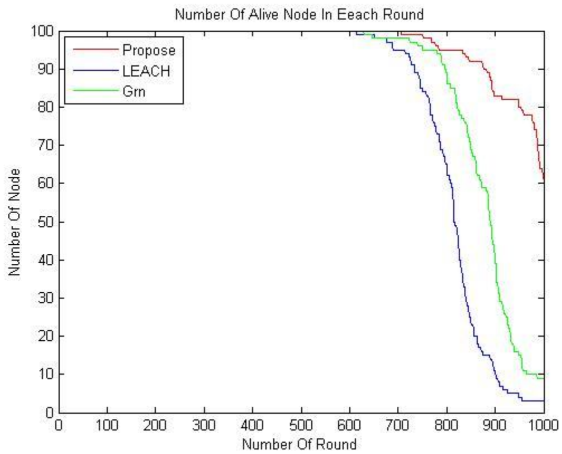

Fig 7. Number of Nodes alive in each round

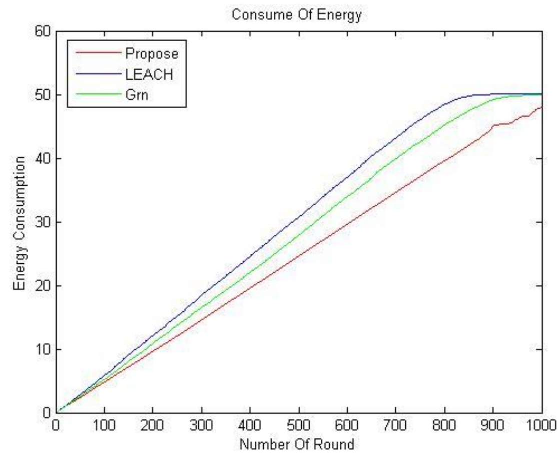

Fig 8. Energy preservation in each round

Fig 7 describes the number of nodes left alive with respect to the number of rounds. An increase in the number of rounds results in the reduction of the number of nodes left alive. By the 1000^{th} round the LEACH and Ran and Zhang's methods are left with very low or no nodes alive, where as the proposed method is left with quite a significant number of nodes alive. This results in a much longer network lifetime which is shown in Fig 8.

V. CONCLUSION

Energy consumption level is a major challenge in WSNs. The focus of many researches has been to lower the energy consumption level and consequently increase the network life time. The proposed method uses a fuzzy logic approach for clustering using the two parameters of energy level and centrality, supported by a controller in order to avoid unwanted concentration of cluster heads in a particular region. As a result, energy is saved in the process of assigning nodes to cluster-heads, hence, significant increase in network life time.

References

[1]. Y.Zhang, L.T. Yang, J.Chen, *RFID and Sensor Networks: Architectures, Protocols, Security, and Integrations*, International Standard Book CRC Press, 2010.

[2]. K.S.Ali and K.Sindhanaiselvan, "Ant colony Optimization Based Routing in Wireless Sensor Network", *Int. J. Advanced Networking and Applications*, pp. 1686-1689, 2013.

[3]. S.Okdem and D.Karaboga, "Routing in wireless Sensor Network Using an Ant Colony Ptimization(ACO)Router chip", *Sensors*, pp. 909-921, 2009.

[4]. E.Saeedian and M.Jalali, "CFGA: Clustering Wireless Sensor Network Using Fuzzy Logic And genetic Algorithm", *Intrernational conference on sensor networks*, pp. 1-4, 2011.

[5]. W.Heinzelman, A.Chandrakasan and H.Balakrishnan,"Energy-efficient communication protocol for wireless microsensor networks," *Proc. of the 33rd Annual Hawaii International Conference on System Sciences (HICSS*), pp. 3005– 3014, 2000.

[6]. Siew. Z.W, " Energy efficient clustering algorithm in wireless sensor networks using fuzzy logic control, " *IEEE internatinal Conference on Networking*, pp. 392-397, 2011.

[7]. G.Ran and H.Zhang, "Improving on LEACH Protocol of Wireless Sensor Networks Using Fuzzy Logic", *Journal of Informaton & Computational Science*, pp.767-775, 2013.

[8]. S.Mao and Z.Zho method, "An Improved Fuzzy Unequal Clustering Algorithm for Wireless Sensor Network", *Springer Science & Business Media*, pp. 206-214, 2013.

