Cumhuriyet Üniversitesi Fen Fakültesi
Fen Bilimleri Dergisi (CFD), Cilt:36, No: 6 Özel Sayı (2015)
ISSN: 1300-1949

Cumhuriyet University Faculty of Science
Science Journal (CSJ), Vol. 36, No: 6 Special Issue (2015)
ISSN: 1300-1949

A new fuzzy method for clustering heterogeneous nodes in Wireless Sensor Networks (WSNs)

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Received: 20.04.2015; Accepted: 09.07.2015

Abstract. A Wireless Sensor network (WSN) contains a considerable number of sensor nodes and one base station where information is received through sensors and sent to base station. Sending information by each node to station reduces node energy and, accordingly, network lifespan due to distributed nodes and their various intervals. Thus, each node sends its data to neighboring cluster head in order to send the information to base station through that node and more energy is saved. Therefore, clustering and selecting appropriate cluster head is a topic which can be effective on network lifespan. Many different methods were introduced to cluster nodes in these networks with their own advantages and disadvantages. In this article, a new fuzzy logic-based clustering method in WSN increases the network lifespan.

Keywords: Fuzzy logic, Wireless Sensor Network, clustering, cluster head

1. INTRODUCTION

Technology improvement has caused that the wireless sensor networks lifetime used in various applications such as military, medical, environmental and etc in recent years. A network of hundreds or thousands nodes that follow a specific task. These nodes had limited power, limited memory and poor processors. As structure, these nodes were homogeneous and had equal energy or heterogeneous and had a different structure. The main problem of nodes was the limited power. [1] - [4]

There are several ways to send data that one of which was directly transmission that each node sent its data immediately to the base station or sink. In this way, a lot of node energy wasted due to a multiple transmissions. Another method is chosen cluster head that according to its cluster head, each node sent its data to adjacent cluster head and cluster head was responsible for sending them to the sink. In this way, the network lifetime increases, but the choice of a suitable cluster head can affect the longevity of the network. [5]

LEACH Protocol [6] was one of the most popular clustering methods that chose cluster head randomly and had no focus on nodes energy, selected cluster head that destroyed by this method quickly was not the best. EAUCF method [7] extrapolated the distance to the base station and nodes energy. Method [8] and [9] chose cluster head based on node centrality and remaining energy that centrality definitions of these two methods were different. All the mentioned methods presented clustering on homogeneous nodes with the same energy.

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Special Issue: International Conference on Non-Linear System & Optimization in Computer & Electrical Engineering

In this paper, a new method is provided based on fuzzy logic in order to choose the cluster head which node energy, the number of neighbors, distance to the sink and distance to pervious cluster head as matter entries handled chose of cluster head among heterogeneous nodes. This method was compared with LEACH and EAUCF protocol because LEACH was the most magnificent method of clustering in these networks and EAUCF method was one of the newest methods that handled clustering chose with fuzzy logic. Therefore, comparing the proposed method with two algorithms is more important.

2. FUZZY LOGIC

In general, Fuzzy logic defined according to human logic. In many applications, to speak of real numbers is difficult. Fuzzy logic went beyond of the values of "zero-one" classic software and opened new port towards software science and computers, because it applied vessel and limited space between numbers of zero and one in its logic and arguments. Fuzzy logic elicit and applied the space between the two values of "go" or " don't go", the new values of " might go out" or "we go" or if "might go" .

A fuzzy system covering three components: fuzzification, inference system and defuzzification. fuzzification was responsible of mapping the real numbers of fuzzy sets that this work done to help the membership function charts. fuzzification were pointed such as Gaussian, Singleton and triangle. Inference system included a series of if-then rules that fuzzy inference is performed on these rules Mamdani minimum, Mamdani multiply and Zadeh were such inference system. defuzzification have been made the task of mapping the fuzzy sets to real numbers that including inference engine that also noted the center of gravity, center of area and maximum.

3. RELATED WORKS

According to presented methods provided diversity relatively high in the area, therefore, in this part two of the most basic LEACH clustering in wireless sensor networks and protocols, two methods LEACH of that the most basic algorithms of clustering in wireless sensor networks and EAUCF that was new fuzzy protocols which administered clustering on homogeneous nodes with further details will be explained. It should be noted that both protocols were compared methods with the proposed method.

3-1 LEACH Method

This protocol is a clustering method to use random values for choosing cluster head and distribution of energy between nodes takes advantage. This protocol consists of two phases. In first phase, clusters forms and in second phase in cluster sent message to cluster head and they sent to the base station after collecting. The sensor nodes is calculated which corresponds to the number of node selection as cluster head node in the previous periods. Then, it selected a random number between zero and one.

If for a node this random number is calculated less than calculated diction, defines itself as a cluster head and messages are broadcast presentation. Other sensor nodes also make decisions based on received signal strength from the cluster head nodes to join the cluster. The calculated value of each node defined as T(n) that is in accordance with Formula 1. [1]

$$T(n) = \frac{p}{1 - p\left(r \bmod \frac{1}{p}\right)} \qquad \text{If } n \in G \qquad (1)$$

$T(n) = 0$ Otherwise

Where p was likely cluster head node, r was numerator of current round; G was the sets of nodes of nodes that did not to change to 1 / p cluster head. See the remaining energy of the node that was not criterion for selection of cluster head and the most important concern in wireless sensor networks maintain greater energy may be the loss of early nodes.

3-2 EAUCF Method

This clustering is one of the newest methods of clustering protocols. Cluster head selection uses the following assumptions. Random distribution of nodes, equilibrium after its initial distribution, determines the distance of nodes with received signal strength and equal energy of nodes were the assumptions of this method. This is done with fuzzy clustering. The node energy and the distance of base station were as fuzzy inputs on triangular fuzzification and inference results sent through Mamdani inference engine and related rules to center of area defuzzificaion and gave a number for each node in each stage that this number is that threshold T(n).

It is clear that this method had more lifetimes in comparison with LEACH protocol, but it can still make changes to the fuzzy parameters to get better results.

4. SYSTEM MODELING

4-1- Network Model

The number (N) of sensor nodes placed randomly in the environment. Each node sends its data to the cluster head node and node collected its data cluster head and data received in the cluster and sent to high level cluster head node that close to the base station. This process continued until the data reach to the base station.

It is intended that the assumptions were as follows:

1- The nodes were immobile and static after distribution.

2- Sent data through cluster head to the sink and from the sink to base station.

3- The distance to the sink was determined.

4 - The nodes were heterogeneous and had unequal energy.

4-2 Energy Model

Energy of data transmission and receipt of them is calculated of equation 2 and 3.

$$Etrans = \begin{cases} lElec + l\varepsilon fsd^2 & d \prec dth \\ lElec + l\varepsilon mpfd^4 & d \geq dth \end{cases} \quad (2)$$

$$Erec = lElec \quad (3)$$

l is data length as bit, $Eelec$ is digital electric energy, €mp and €f are amplifier energy and dth showed the distance threshold is calculated by equation 4.

$$dth = \sqrt{efs / emp} \tag{4}$$

cluster head node also spent energy, the equation 5 is calculated.

$$E(CHk) = Nk \times l \times Eelec + (Nk + 1) \times l \times EDA + l \times (Eelec + \varepsilon mpfd^4) \tag{5}$$

Nk was node cluster numbers and EDA was needed energy to collect data. Received energy of sensor nodes numbers (n) randomly placed in the environment.

5. THE PROPOSED METHOD

Clustering presented in this paper was a method based on fuzzy logic like EAUCF that its input had crucial role in improving their results. These inputs included remaining energy, the number of neighbors, the distance to the sink and the distance to the cluster head that each of them affects appropriate cluster head. The remaining energy had an important role in determining the cluster head as the main input. The second entry was the number of node neighbors. According to the node had more neighbors, more likely to have a cluster head. The third entry was the distance to the sink that decreases this number caused more clustering head and the last input which distinguished towards present and similar methods was the distance to cluster head as nodes which had less distances to previous stage cluster head were more likely to cluster head to the next round.

Most of sources and fuzzy clustering methods utilized of various inputs for selecting cluster head that used the most important in inputs of presented method. But, the considerable note was previous cluster head.

If a node have a good relative value at the input and have a distance of less than around the rest of the nodes, you can choose without calculation, as the cluster head. Therefore, we can increase the speed of calculation.

The method was that each node calculated its distance to the sink and also the numbers of neighbors in the beginning. Since, there is no cluster head at the first stage to calculate the distance values, a fixed number of primary energy and two other inputs will send to fuzzificaion. In this paper, triangular fuzzificaion is used. Figures 1 to 4 showed the inputs membership functions.

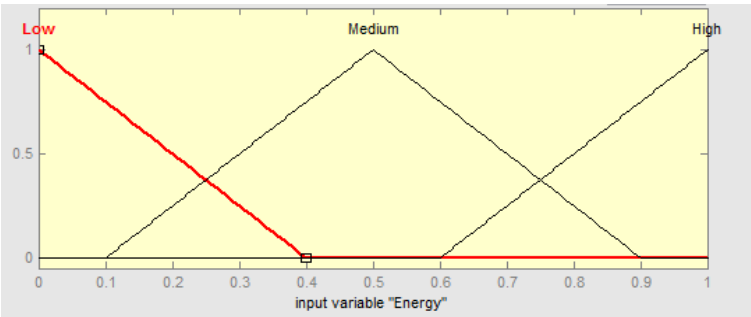

Figure 1. Input membership function, node energy.

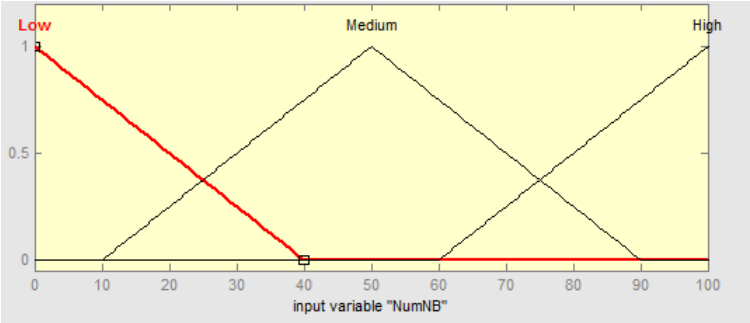

Figure 2. Input membership function, neighbor's number.

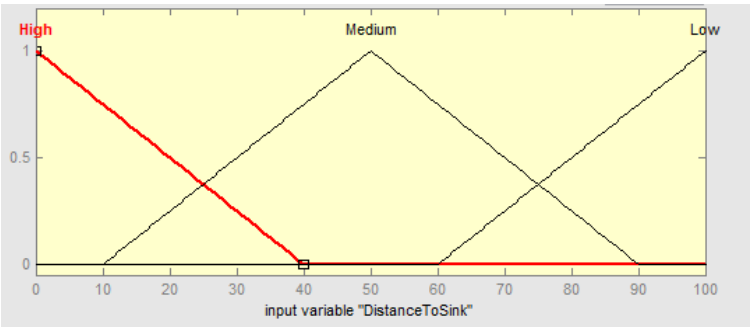

Figure 3. Input membership function, the distance to the plate.

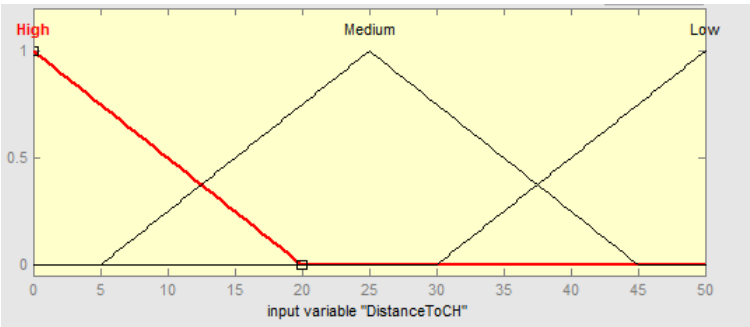

Figure 4. Input membership function, the distance to previous cluster head.

The output of fuzzy was at inference engine and this engine with cited rules concluded in Table 1. It should be noted that due to the high number of inference rules, a few of which are mentioned in the table. In this article, it used the Mamdani minimum inference engine. The output is provided to defuzzificaion which can be back the resulting number to the real world. Figure 5 shows the output membership function.

This paper utilized the center of gravity for defuzzificaion. Finally, for each node calculated a number with threshold T(n) at the end of each round that this number of produced random number by each node between zero and one was more are selected as cluster head.

Each node calculated the distance of previous cluster head within remaining energy and sent with two other inputs to fuzzificaion Later, the distance to the cluster head node of the previous with the remaining energy to assigned passing previous stages which it can be cluster head or not?

Figure 5. The output membership function, the chance of the cluster head.

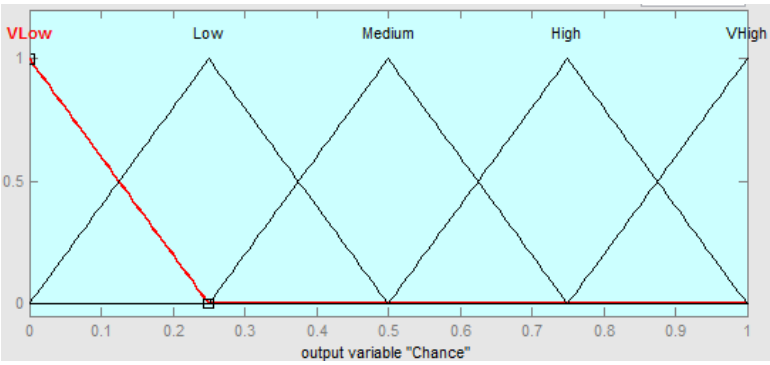

Table 1. Some fuzzy rules.

Remain energy	Neighbors numbers	Distance to plate	Distance to cluster	chance
low	high	high	medium	low
Low	Medium	Medium	High	Very low
Low	Low	Low	Low	Medium
Medium	High	High	High	Low
Medium	High	High	Low	Medium
Medium	Medium	Low	Low	High
High	Low	Medium	High	Medium
High	High	Medium	Low	High
High	Medium	Low	Low	Very High

6. THE RESULTS OF SIMULATION

For the simulation used MATLAB software. Parameter is shown in Table 2.

Table 2. Parameters problem.

Parameters	Numbers
100	Node
100 * 100	Network sizes
(50,50)	Sink place
500	Package sizes
50 nJ/bit	Eelec
10PJ/bit/m^2	εfs

0.0013PJ/bit/m^4	$\square mpf$
0.5J	Primary energy
random	Network topology

Figures 6 to 8, a view of the distribution of nodes in three LEACH, EAUCF and presented methods showed at the end of 1,300. Dead and removed nodes from the network are marked with red dots.

Figure 9 shows a graph of deaths of sensor nodes according to clustering method. As it known in the figure, the number of removed nodes of network was less than nodes were out in two presented methods. So, the longevity of the network increased in presented method.

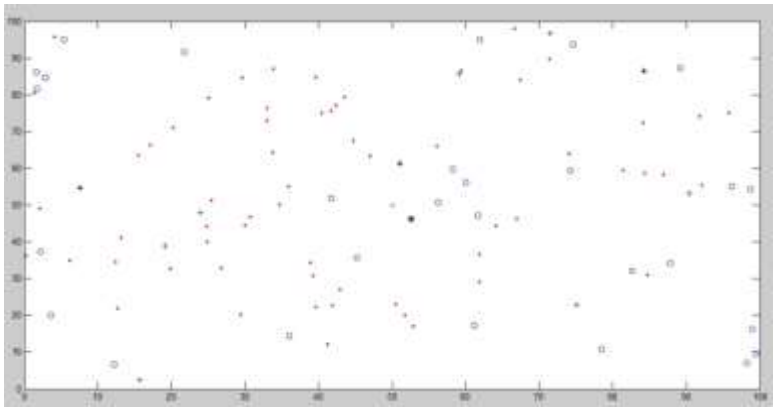

Figure 6. The situation of nodes in **LEACH** method at the end of 1300 round.

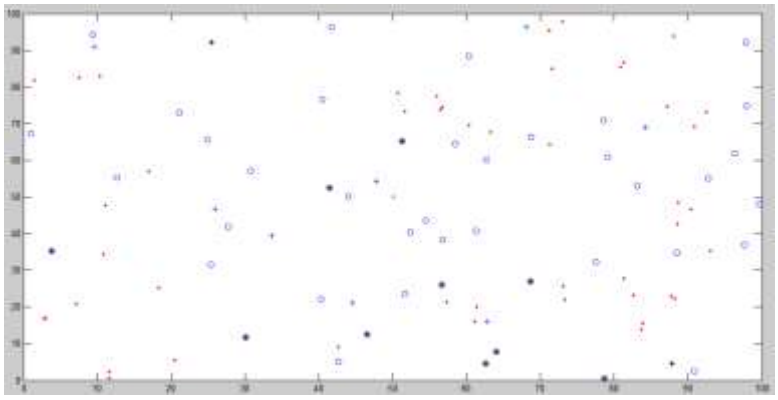

Figure 7. The situation of nodes in EAUCF method at the end of 1300 round.

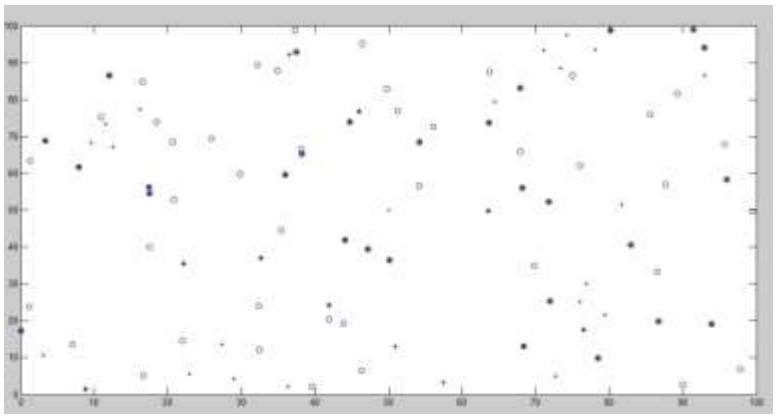

Figure 8. The situation of nodes in proposed method at the end of 1300 round.

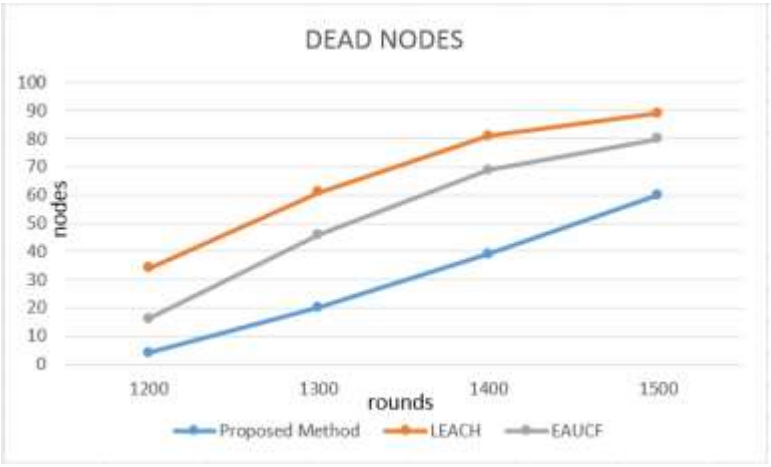

Figure 9. The difference of dead nodes number in three LEACH, EAUCF and proposed methods in number of various rounds.

7. CONCLUSION

In this paper, a new method is presented based on fuzzy logic in heterogeneous nodes clustering in wireless sensor networks. This method was compared with LEACH protocol that is the most popular clustering method and also EAUCF algorithm as new protocol based on fuzzy logic. The fuzzy input parameters of proposed method increases the speed of calculation utilizes of the distance to the cluster head and simulation results represent increases the longevity of the network and more storage of energy in nodes.

REFERENCES

[1] B. Warneke, M. Last, B. Liebowitz, Kristofer and S.J. Pister .2001. Smart Dust: communicating with a cubic-millimeter computer, Computer Magazine, Vol. 34, No. 1, pp. 44-51, Jan.

[2] J.M. Khan, R. H. Katz and K. S. J. Pister. 1999 .Next cen-tuary challenges: mobile networking for smart dust, In Proceedings of the 5th Annual ACM/IEEE Inter-national Conference on Mobile Computing and Net-working (MobiCom 99), Aug., pp. 271-278.

[3] V. Hsu, J. M. Kahn, and K. S. J. Pister. 1998. Wireless communications for smart dust, Electronics Re-search Laboratory Technical Memorandum M98/2,.

[4] G. J. Pottie and W. J. Kaiser. 2000**.**Wireless integrated networksensors Communications of the ACM", Vol. 43, No. 5, pp. 51-58.

[5] Akyildiz Ian F and Kasimoglu Ismail H.2004. Wireless sensor and actor networks: research challenge Ad hoc networks, vol. 2, p.^pp. 351-367.

[6] M.J. Handy, M. Haase and D. Timmermann. 2002. Low energy adaptive clustering hierarchy with deterministic cluster-head selection in *Proc. 4th International Workshop on Mobile and Wireless Communications Network*, pp. 368 - 372.

[7] Hakan Bagci, Adnan Yazici. 2013. An energy aware fuzzy approach to unequal clustering in wireless sensor networks Applied Soft Computing 13, pp.1741–1749

[8] Md. Abdul Alim, Yucheng Wu and Wei Wang. 2013. A Fuzzy Based Clustering Protocol for Energy-efficient Wireless Sensor Networks in *Paris.* 2nd International Conference on Computer Science and Electronics Engineering, , pp. 2874 - 2878.

[9] Ashutosh Kumar Singh, Sandeep Goutele, S.Verma and N. Purohit. *2012* .An Energy Efficient Approach for Clustering in WSN using Fuzzy Logic *International Journal of Computer Applications*, pp. 8 - 12.