International Journal of Trend in Research and Development, Volume 2(5), ISSN 2394-9333
www.ijtrd.com

Cluster Head Selection Routing Protocol Using Fuzzy Logic

S. Zindhu
Assistant Professor, Department of Computer Science, Periyar University
St. Joseph's College of Arts and Science for Women, Hosur, Tamil Nadu, India.

***Abstract*—**Wireless Sensor Network (WSN) is made up of small batteries, sensor nodes, powered devices with limited energy resources and computational power. So, for long time working we need to save energy and balancing the energy consumption. In WSN, data is measured by nodes and same is send to the Base Station at regular intervals. These nodes are used to monitor physical condition and to pass their data through the wireless network to the main location. The crucial issues in wireless sensor network are to create a more energy efficient system. The clustering is one kind of mechanism and to reduce the network energy consumption. The routing process involves the Clustering of nodes and the selection of Cluster Head nodes (CH). These cluster which sends all the information to the Cluster Head Leader (CHL). After that, the cluster head leaders send aggregate the data to the Base Station (BS). The selection of cluster heads and cluster head leaders is performed by using Fuzzy Logic and the data transmission process is performed by shortest energy path.

Keywords*—Fuzzy Logic; Wireless Sensor Network; Cluster Head; Shortest Energy Path.*

I. INTRODUCTION

A wireless sensor network is one kind of energy constrained network. These sensor networks are formed by a number of sensor nodes, which are mainly powered by batteries. Sensor nodes are used to monitoring the physical and environmental conditions. WSN The transmission of a finite amount of information can be supported by finite energy. WSN have been considered as one of the most important technology. The sensor nodes have Micro Electronic Mechanical System (MEMS) and wireless communication technologies have enabled the invention of tiny, low cost, low power and multi-functional smart sensor nodes used in wireless sensor network. Routing is also an important factor that affects wireless sensor network. One of the most restrictive factors on the lifetime of wireless sensor networks is the limited energy resources of the sensor nodes. It can be organized hierarchically by grouping them into clusters in order to achieve energy efficiency.

In wireless sensor networks is one of the Low Energy Adaptive Clustering Hierarchy (LEACH). It is a hierarchical protocol. It used single-hop routing that means every sensor node transmits information directly to the cluster head. Mainly, it is not recommended for large area network. Some of the protocols in sensor are GPSR, BCDCP are proposed to improve the energy efficiency of LEACH protocol using multi hop routing schema. Base Station Control, Dynamic Clustering Protocol (BCDCP) is a centralized routing protocol, which uses Minimal Spanning Tree (MST) to connect to cluster head which randomly choose a leader to send data to sink. BCDCP route data energy efficiency in small-scale network. A Cluster Based Energy Efficient Location Routing Protocol (CELRP) is a location based routing protocol. It applies the greedy algorithm to chain the cluster heads. Each node can transfer data to only its neighbour nodes. It uses a greedy algorithm to form a chain node. These protocols used only one cluster head leader to transmit data to the base station. The protocols are not appropriate for large area networks. GPSR is a position based routing protocol, which performed by using a geographical positioning system. In this routing protocol, only a first level clusters heads can directly transmit data to the base station. Threshold Sensitive Energy Efficient is a protocol which designed for sudden changes in the sensed environment. In threshold protocol, the sensor network architecture is designed hierarchically. When the numbers of layers increases, it does not operate properly.

Energy consumption and network lifetime are the parameters to measure the energy efficiency of a wireless sensor network. In a network, this uses only one cluster head leader to transmit aggregated data to the base station. The sensor nodes start to die in a short round and also the nodes which are close to the base station die first. It causes to decrease network lifetime and imbalance energy consumption, which affects the energy efficiency of the whole network. It would be interesting to evaluate, how we can minimize the total energy consumption and prolong network lifetime of wireless sensor networks.

II. NETWORK MODEL OF PROPOSED ROUTING PROTOCOL

The network model of this study is shown in figure 1. This routing protocol provides balance in the energy consumption and prolongs the network lifetime

The new routing protocol organizes clusters so that all the nodes can be included in these clusters. It chooses cluster heads for each cluster using Fuzzy Logic, which is based on highest energy resume and minimum distance from the base station. In this protocol, the Dijkstra algorithm is applied to find a shortest path of each node. After that, it chains the

cluster members and the cluster head according to shortest energy paths. Finally, cluster members send data packets to the cluster heads. In this protocol, multiple cluster head leaders are chosen by the base station using fuzzy logic based on highest energy resume and minimum distance from the base station of each cluster head. Each cluster head leader can transmit data directly depending on the shortest energy path.

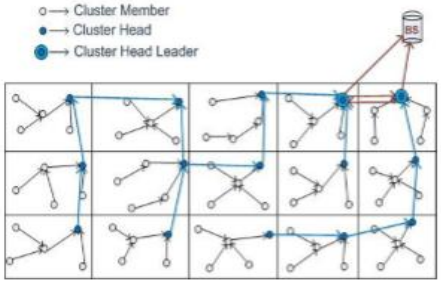


Figure: 1. Scenario of Proposed Network Model

This network to analyze network lifetime, average residual energy and energy dissipation of this study. The simulation results show that, this protocol is better in prolonging network lifetime and balancing energy consumption compared to the BCDCP, CELRP and ECHERP.

III. SIMULATION

Fuzzy Inference Engine to select cluster heads and cluster head leaders. We also apply the Dijkstra algorithm to chain the cluster members according to their shortest energy path.

A. Network Field Mapping

As shown in figure 2, we design a network field with 100 node, which are randomly scattered in this sensing field with dimension (100m x 80m) and base station located at position (130, 100).

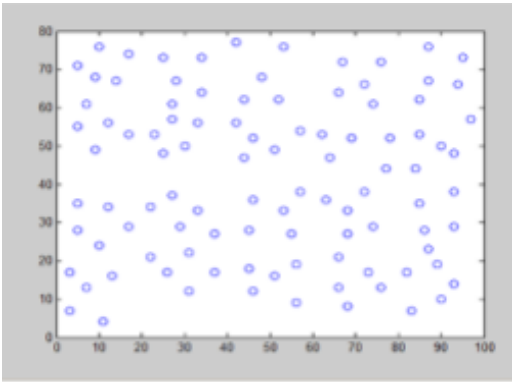


Figure 2: A Snapshot of random deployment of sensor nodes in the network field

To compare the performance of the study with other protocols, we ignore the effect caused by signal collision and interference in the wireless channel.

B. Clustering and Cluster Head Selection

In this protocol, clustering has been done with the fuzzy clustering method and cluster heads have been selected by fuzzy logic based on the energy resume and distance from the base station of a sensor node. Table. 1 summarizes the parameters used in our simulation.

Table. 1 Simulation Parameters

Parameter	Value
Network Field	(0,0) – (100,80)m
Base Station Location	(130,100)m
N (Number of nodes)	100
Initial Energy (E_{Init})	IJ
Eelec($E_{Description}$for E_{Tx}& E_{Rs})	50 nI/bit
ε_{fs} (free space)	10 pJ/bit/m^2
ε_{mp}(Multipath Fading)	0.0013 pI/bit/m^4
d_o(Threshold distance)	88m
E_{DA}(EnergyAggregationData)	5 nI/bit/signal
Data packet size(l)	4000 bits

We use equation which is given in [10] to determine energy spent for transmission of a 1-bit packet from the transmitter to the receiver at a distance (d) is defined as:

$$E_{Tx}(l,d) = l * E_{elec} + l * \varepsilon * d^{\infty}$$
$$= l * E_{elec} + l * \varepsilon_{fs} * d^2, \quad d < d_o$$
$$= l * E_{elec} + l * \varepsilon_{mp} * d^4, \quad d \geq d_o \qquad (1)$$

E_{Tx} is the energy dissipated in the transmitter of source node. The electronic energy E_{elec} is the per bit energy dissipation for running the transceiver circuitry.

The threshold distance do can be obtained from

$$d_0 = \sqrt{\frac{\epsilon_{fs}}{\epsilon_{mp}}} \qquad (2)$$

And E_{Rx} is the energy expanded to receive messages

$$E_{Rx}(l) = l * E_{elec} \qquad (3)$$

The distance (d) of node from one node to another node is calculated by the following equation.

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \qquad (4)$$

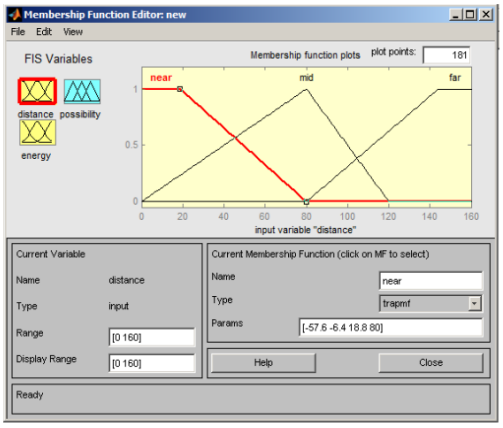
Energy cluster is the sum of energy in cluster heads.

$$E\ cluster = k_i * E_{Tx}(l,d) + E_{Rx}(l) + E_{DA} \qquad (5)$$

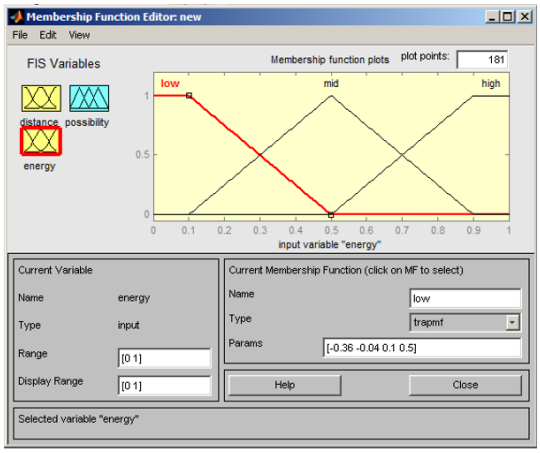
Where, ki indicates the number of member nodes in the cluster heads. $E_{Tx}(l,d)$ indicates energy transmission. $E_{Rx}(l)$ indicates energy receiver and E_{DA} indicates energy of data aggregation.

- Fuzzy Membership Functions Implementation

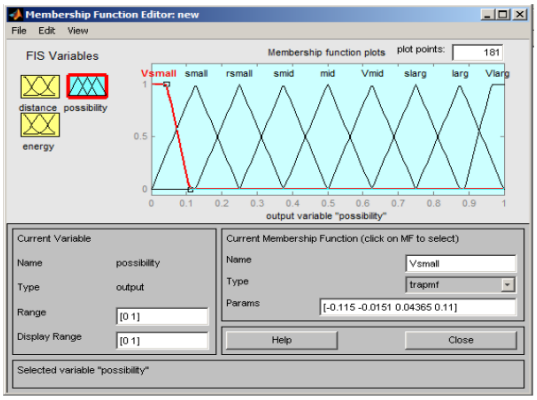
Membership functions [19, 20] of the fuzzy system parameters to determine the cluster heads are shown in the figures 3 (a), (b) and (c).



(a)



(b)



(c)

Figure 3 (a) Fuzzy Input Membership function (Distance)
(b) Fuzzy Input Membership function (Energy)
(c) Fuzzy Output Membership function (Possibility)

- Fuzzy Rules Generation

To find the possibility of a node to be a cluster head, it needs to assign fuzzy rules for all possible inputs. Table 2 shows these fuzzy rules.

Table. 2 Fuzzy Rules to Select Cluster Heads

Distance from the Base Station	Resume Energy	Possibility to be Cluster Head
Far	Low	Vsmall
Mid	Low	Small
Near	Low	Rsmall
Far	Mid	Smid
Mid	Mid	Mid
Near	Mid	Vmid
Far	High	Slarge
Mid	High	Large
Near	High	Vlarge

The Table 2 shows that a sensor node that has a greater distance from the base station and less residual energy has the lowest possibility to be a cluster head. On the other hand, a sensor node that has a lower distance from the base station and high residual energy has the highest possibility to be a cluster head.

C. Data Transmission Process

The cluster members are chained by finding a shortest energy path of each member. These shortest energy paths are selected by applying the Dijkstra algorithm to transmit data from each cluster member to cluster head and then all cluster head to the cluster head leaders in the network field. Finally, cluster head leaders send data to the base station according to their shortest energy paths.

D. Routing Protocols in WSN

Many clustering routing protocols are used in wireless sensor network. In routing protocol, main focus is on LEACH, EEUC and ZECR.

- *LEACH* (Low-Energy Adaptive Clustering Hierarchy)

It is hierarchical routing algorithm based on clustering. In each round every node has the probability to get selected as cluster head. It proposes the concept of round for the implementation of periodicity. It involves two phases in every round. Cluster set-up phase and steady data transmission phase. In sensor network algorithm is used to divide into clusters. So the communication loads are shared and the energy consumption of every part of the network is balanced. The network topology shaped by LEACH is shown in figure

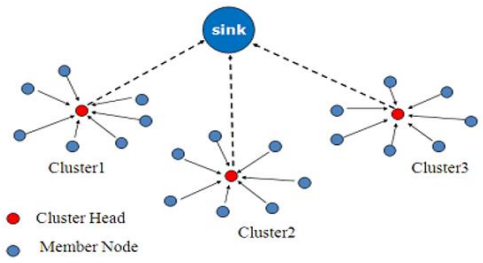


Fig. 4 Leach Protocol

- LEACH-FL (Low-Energy Adaptive Clustering Hierarchy using Fuzzy Logic)

In this method, it improves the LEACH protocol by using fuzzy logic on LEACH protocol. Selection of cluster head is based on the three variables are battery level of node, node density and distance from base station. We assume that all the nodes can get their coordinates in WSN. LEACH-FL has three parts- four fuzzification, functions, an inference engine and defuzzification modules.

- EECU Protocol (Energy Efficient Unequal Clustering)

The purpose of using EECU Protocol is to solve the hot spots problem that is caused due to their inter-cluster multi-hop routing. It can avoid the energy hole and balance the energy consumption of the whole network. The clustering strategy of EECU is – The cluster radius is set according to the distance between node and base station, so larger cluster are formed in the region far from base station. EECU network is as shown in the figure.

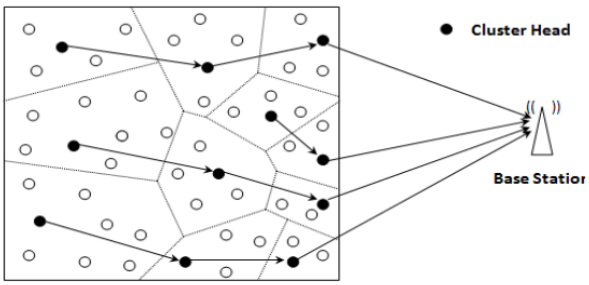


Figure 4: Overview of the Unequal clustering

D.4 ZECR (Zone-Divided and Energy Balanced Clustering Routing)

ZECR protocol is a very efficient protocol for WSN and adapts to the energy heterogeneous network. It can balance the energy consumption of the network and prolong the network life time obviously. ZECR protocol will be illustrated by the five parts in sequence- Zone division, size of cluster radius, cluster set-up phase, Inter-cluster multi-hop routing phase and data transmission phase.

- EEZECR (Energy Efficient Zone Divided and Energy Balanced Clustering Routing Protocol)

In this method, concept of two cluster heads is introduced that make ZECR protocol more energy efficient. In the network, different zones are divided by using zone divisional approach. Two cluster heads used are – Assistant Cluster Head (ACH) and Main Cluster Head (MCH). ACH will collect the data is send to MCH. Then MCH send that data to MCH of neighbor cluster that is nearer to base station. ACH is reduced the load from MCH and this will make multi-hop transmission more energy efficient.

CONCLUSION

In this paper, we present a set of observation with regard average energy dissipation, network lifetime and average residual energy of the proposed network. First, the network consumes less energy to transmit total aggregated data to the base station than other protocols. Its average energy dissipation is much lower than BCDCP, CELRP and ECHERP. Second, the network lifetime starts decreasing after more than 410 rounds, which is much higher than other protocols and means that this protocol is better than other protocols in terms of network lifetime. Finally, the average residual energy of the study is high which also means that it transmits more data than other protocols. It also concludes that, this protocol is an energy efficient protocol, which prolongs the network lifetime effectively.

The future work can be addressed as to consider the delay of the system. In addition, we also plan to design a heterogeneous network where it can have several base station that communicate together and use this protocol which selects multiple cluster heads using fuzzy logic and uses these cluster heads to transmit data to the base station.

Acknowledgment

I would like to thank almighty God for his support throughout my life. I also thank my friends and family members who provide the full support.

References

[1] Heinzelman, W. R., Chandrakasan, A., & Balakrishnan, & Balakrishnan, H. (2000, January). Energy-efficient communication protocol for wireless microsensor networks.

[2] Kodali R.K., Sarma N "Energy Efficient Routing Protocols for WSN's" international conference on computer communication and information, pp 1-4, 46 jan, 2013.

[3] Ben Alla S., Mohsen A. et al "Hierarchical adaptive balanced energy efficient routing protocol (HABRP) for heterogeneous wireless sensor networks" international conference on Multimedia Computing And Systems, pp 5-6, 7-9 april 2011.

[4] Chi-Tsun Cheng, Chi K. Tse et al "A Delay-Aware Data Collection Network Structure for Wireless Sensor Networks‖ Sensors Journal, IEEE, pp. 699 – 710, March 2011.

[5] Verma S., Sharma K. ―Energy Efficient Zone Divided and Energy Balanced Clustering Routing Protocol (EEZECR) in Wireless Sensor Network ” international journal of Circuits and System, jan2014

[6] M. Nikodem and B. Wojciechowski. ―Upper Bounds on Network Lifetime for Clustered Wireless Sensor Networks‖. NTMS, pages 1-6, 2011.

[7] L.A. Zadeh, "Fuzzy algorithms," Info. & Ctl., Vol. 12, 1968, pp. 94 – 102.