Enhancing the lifetime of LEACH Protocol using NNA for Wireless Sensor Network

Anjali Bharti[#1], Kanika Sharma[#2]
M.E Student, Assistant Professor
Department of ECE Engineering
National Institute of Technical Teachers Training and Research (NITTTR)
Chandigarh, India

ABSTRACT-The use of wireless sensor networks is increasing day by day and at the same time, it faces the problem of energy constraints in terms of limited battery lifetime. In this paper, we propose an energy efficient algorithm in which network is divided into five sectors with an equal angle for maintaining uniformity of cluster heads. This algorithm is improved EE-LEACH-MIMO algorithm in which data from the sensor nodes is transmitted through shortest path by nearest neighbor algorithm in multi-hop fashion and results in reduction of energy consumption in the network. The residual energy and the location of each node from sink are considered for the selection of cluster head and co-operative node for MIMO system. The simulation results show that the proposed algorithm enhances the energy efficiency and the lifetime of the network.

Keywords-Wireless sensor networks, LEACH, cooperative MIMO, EE-LEACH.

I. INTRODUCTION

A wireless sensor network consists of large number of sensor nodes which has the ability of sensing, computing and transmitting data from the harsh environment. These sensor nodes have limited battery resource which deplete at a faster rate due to communication and computation operations. Energy efficiency and enhancing the lifetime network are the most important objective of wireless sensor networks. The Interference and channel fading are the big problems for the design of energy efficient routing protocol for wireless sensor network especially in military applications [1].

MIMO is a technology which is used to increase the data rate and cooperative diversity which also reduces energy consumption during transmission in fading channels. However MIMO technology is impractical to be used with wireless sensor network directly due to physical limitation of a sensor node which can accommodate only one antenna [2]. So, cluster based approach formed the topology of the network which is similar to MIMO systems. MIMO system can be formed by the cluster head and the node chosen for cooperatively transmitting information in a cluster.

LEACH is a clustering based routing protocol which reduces energy consumption in wireless sensor networks [3]. However, the improvement against the non-uniform distribution of cluster head is not done and the residual energy of node is not considered for the selection of cluster head [4-7].In [8], the author proposed an algorithm which combines LEACH algorithm with MIMO technology. The EE LEACH (energy efficient LEACH) protocol considered residual energy and location of sensor node for the selection of cluster head and co-operative nodes. In base paper, the author combines LEACH algorithm with EE-LEACH protocol.

The EE-LEACH-MIMO protocol combines EE-LEACH with MIMO technology which enhance the network lifetime. But it considers direct communication between member nodes and cluster head or transmits the data in single-hop where more energy is consumed [9].

In this paper, we proposed an energy efficient algorithm in which sensor nodes send their data to the cluster head through shortest path using nearest neighbor algorithm in multi-hop approach. The residual energy and distance of sensor nodes from sink is considered for the selection of cluster head and co-operative node. Then both cluster head and cooperative node transmit data packets to the sink through cooperative MIMO.

The remainder of the paper is described in section II. The energy consumption model of the network is discussed in section III. Then the simulation and its result analysis are

followed in section IV. Finally, the conclusion is made in section V.

II. AN IMPROVED ENERGY EFFICIENT LEACH ALGORITHM

In this section, we proposed an algorithm which improved the performance of EE-LEACH –MIMO scheme in terms of network lifetime. The model of the improved algorithm is shown in Fig.1. N sensor nodes are randomly deployed over R X R network area. The network is partitioned into optimal number of clusters. In each cluster, there is one cluster head and several member nodes. One of the member nodes is choose as cooperative node to form cooperative MIMO system to transmit data to the sink. The sink is located far away from the monitoring area as shown in Fig.1.

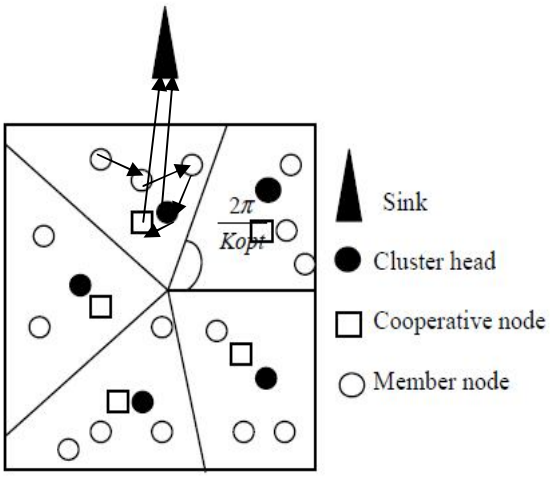

Fig.1The sketch map of network model

In this algorithm all the operations are organized into many rounds. In each round, there are three stages: cluster head selection, Calculation of shortest path using nearest neighbor, selection of cooperative node and data transmission.

A. Partition

The network is partitioned into optimal number of cluster as calculated in [3]. The centre of circle is taken as centre of deployment of the network area, the network area is divided into optimal number of clusters by an angle $2/k_{opt}$ for clustering [4].The optimal number of clusters in the network can save energy and also enhance the lifetime of network.

B. Calculation of shortest path using Nearest Neighbor Algorithm

The nearest neighbor algorithm is simple algorithm to compute shortest path. The member nodes in the cluster transmit their data to the cluster head through shortest path using nearest neighbor algorithm. The nearest neighbor algorithm calculates distance between each node in the cluster and finds the destination node which is cluster head in this approach. The nearest neighbor algorithm is explained as:

1) It chooses any random node as starting node for the path.

2) It finds the node which has minimum distance from the starting node and adds that node as second node for the path.

3) Now, it again finds the node which has minimum distance from second node and add it as third node for the path.

4) Continue this process until it reaches to the cluster head by covering all the nodes once.

5) Stop the algorithm.

The nearest neighbor algorithm has following advantages:

- It executes quickly.
- It is simple and easy to implement.

C. Cluster Head Election

In clustering based network, a cluster head consumes more energy than the member nodes because it handles various operations like collecting data from member nodes, aggregate the data and finally transmitting the aggregated data to the sink. After the partitioning of the network, each node sends data packet which consist the ID, residual energy and location of the node. The sink calculates the distance of each node from its location. The node is elected as cluster head in a given cluster by the sink based on two criteria: 1) a node has highest residual energy in a given cluster 2) a node has minimum distance from sink.

D. Cooperative Nodes Selection

The cooperative nodes are selected for the implementation of cooperative transmission. M_t-1 cooperative nodes are selected for M_t sensor cooperative transmission. The node is selected as cooperative node which has second highest residual energy in the cluster and minimum distance from sink.

E. Data Transmission

In this phase, the cluster head creates and broadcasts the TDMA schedule which consists of time slots for data transmission. Then member nodes send data to the cluster

head through shortest path using nearest neighbor algorithm in their assigned time slot alternatively. During the rest time, they fall asleep which saves energy. Then cluster head transmits data to cooperative node. Finally both cluster head and cooperative node send data to the sink with space time block codes (STBC).

III. ENERGY CONSUMPTION MODEL

The energy consumption model in our algorithm is same considered in [2]. The energy consumption for transmitting and receiving l-bit message in a distance d meters for traditional single transmission in a k–th power path loss are respectively:

$E_{SISO\_Tx}(l,d) = lE_{Tx-elec} + lE_{amp}d^k$

$E_{SISO\_Rx}(l) = lE_{Rx-elec}$

In case of cooperative transmission, they are:

$E_{MIMO\_Tx}(l,d) = M_t lE_{Tx-elec} + lE_{Mt}d^k$

$E_{MIMO\_Rx}(l) = M_t lE_{Rx-elec}$

Where E_{amp} accounts for the effect of amplifier, carrier frequency with a prescribed bit error rate and antenna. $E_{Tx-elec}$ and $E_{Rx-elec}$ denote the transmitter and receiver circuit energy consumption per bit, respectively: E_{Mt} accounts for the number of transmitting antenna based on E_{amp}.

IV. SIMULATION AND ANALYSIS

EE-LEACH-MIMO is taken as references for energy efficiency analysis. For evaluating network lifetime and energy efficiency, we consider the number of nodes still alive with the number of rounds. The simulation parameters are given in table. I. The value of E_{Mt} is similar for different M_t. In our system parameters, K_{opt}= 5.

Table I. Simulation Parameters

Parameter	**Value**
Area of network	100m X 100m
Packet size	2000 bit
Number of nodes	100
Position of sink	(50,175)
Initial energy	0.5J
$E_{Tx-elec}$	50nJ/bit
$E_{Rx-elec}$	50nJ/bit
E_{amp}	100pJ/bit/m2
M_t	2
Frequency	2.5 GHz
Energy for data fusing	5nJ/bit
d_{max}	10m

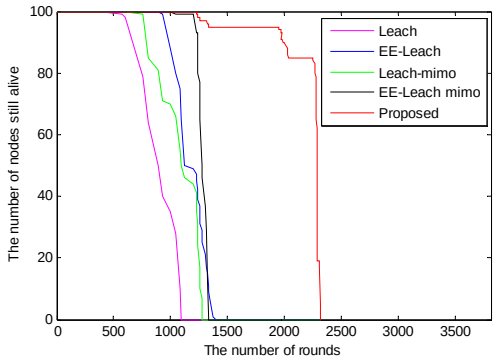

Fig. 2 The profile for network of protocols

Fig.2 shows the overall profiles about the network lifetime and energy efficiency for all the protocols and the proposed algorithm has the longest network lifetime among all the algorithms and it is more energy efficient than others.

V CONCLUSION

The proposed algorithm is simulated in MATLAB. In the paper, we integrate nearest neighbor algorithm into EE-LEACH-MIMO which reduces energy consumption in the cluster by providing shortest path for data transmission from member nodes to the cluster head. The profile of network lifetime of protocols shows that the proposed algorithm is energy efficient and its network lifetime is the longest among all the algorithms.

REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci “A Survey on sensor networks” IEEE Communication Magazine, pp. 393-422, 2002.

[2] S. Cui, A. J. Goldsmith, and A. Bahai, “Energy-efficiency of MIMOand Cooperative MIMO Techniques in Sensor Networks,” IEEE Journal on Selected Areas inCommunication, vol. 22, pp. 1089-1098, 2004.

[3] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, “Energy-Efficient Communication Protocol for Wireless Microsensor Networks,” Proc. Hawaii International Conference on System Sciences (HICSS), pp. 1-10, 2000.

[4] W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, "An Application-Specific Protocol Architecture for Wireless Microsensor Networks," IEEE Transactions on Wireless Communications, vol. 1, pp. 660-670, 2002.

[5] H. Gou and Y. Yoo, "An Energy Balancing LEACH Algorithm for Wireless Sensor Networks" Proc. International Conference. Information Technology, pp. 822-827, 2010.

[6] X. Li, N. Li, L. Chen, Y. Shen, Z. Wang, and Z. Zhu, "An Improved LEACH for Clustering Protocols in Wireless Sensor Networks," Proc. International Conference Measuring Technology and Mechatronics Automation (ICMTMA 10), pp. 496-499, 2010.

[7] F. M. Omer, D. A. Basit, and S. G. Asadullah, "Multi-hop Routing with Low Energy Adaptive Clustering Hierarchy," Proc. International Conference Sensor Technologies and Applications (SENSORCOMM 10), 2010, pp. 262-268, 2010.

[8] X. Li, M. Chen and W. Liu, "Application of STBC-Encoded Cooperative Transmissions in Wireless Sensor Networks," IEEE Signal Processing Letters, vol. 12, pp. 134-137, 2005.

[9] Yongming Qin, Qiuling Tang, Ye Liang, Xiuyu Yue, Xian Li, "An Energy-Efficient Cooperative MIMO Scheme for Wireless Sensor Networks Based on Clustering" *14th IEEE Conference on Computational Science and Engineering (CSE)* pp. 471-474, 2011.