International Journal of Advance Research in Science and Engineering
Vol. No.4, Special Issue (01), Sepetember 2015
www.ijarse.com
IJARSE
ISSN 2319 - 8354

ENHANCEMENT OF NETWORK LIFETIME USING MULTIHOP CLUSTERING ROUTING IN WSNS

Divya Prabha[1] and Vishal Kumar Arora[2]

[1,2]*Department of Computer Science & Engineering*

Shaheed Bhagat Singh State Technical Campus,Ferozepur, Punjab, (India)

ABSTRACT

A WSN is a network which consists of many sensor nodes distributed randomly that collect and processes their data in an efficient manner. One of the major challenges in WSNs is efficient utilization of energy during various operations which requires special attention. A large amount of sensor node's energy is consumed due to the inner-network communications. This paper presents an integrated multihop hierarchical clustering distributed routing protocol i.e. MHCD-LEACH that select cluster heads by considering three parameters: Higher residual energy, more number of neighbours and less distance to BS. Multihop path decides with minimum distance from each CH node to the base station. Far CHs firstly send their data to the CH which is near to the BS and then near CHs finally send collected data to the destination or BS. To minimize the load, this protocol also considers direct communication by normal nodes near to the BS. If the distance between nodes to cluster head is less as compared to base station, then the nodes join the cluster with nearest cluster head otherwise it sends data directly to the base station. To conserve energy, this protocol uses high amplification energy for Inter-cluster communication and low amplification energy for Intra-cluster communication. Our proposed protocol demonstrates the results from analysis by simulating these protocols in MATLAB simulator. Simulation results indicate that the novel routing protocol significantly reduces the energy consumption and increases the total lifetime of the WSN compared to the LEACH or Multihop-Leach protocol. Simulation results bring out that our protocol outperforms the original Leach protocol in term of energy consumption and network lifetime.

Keywords: LEACH, Multihop-LEACH, Network Lifetime, Residual energy based cluster head selection, Power consumption, Clustered WSNs.

I. INTRODUCTION

With the recent advancement of technology and culture, the way of accessing information by people has increased conveniently. Wireless communication technology is one of the medium of accessing and transmitting information. WSN (wireless sensor network) [3], [18] consists of more than hundreds or thousands of small sensor nodes having limited energy, memory, and computational capabilities. Sensor nodes consists a very small battery having limited energy and it is impossible to change or replace the battery of node once it is deployed. So, low energy consumption by each node in performing operations is one the challenge in WSNs [2]. Also energy consumption directly affects the lifetime of the network. A variety of energy efficient routing protocols has emerged. LEACH (Low Energy Adaptive Clustering Hierarchy) is one of the most popular routing protocols

that use clustering approach in order to minimize the energy consumption [13], [20]. Although LEACH protocol is energy efficient routing protocol but it assumes only single hop to transmit data to the sink. Therefore, it is not only suitable for large area network. Based on the LEACH, M-LEACH (Multihop leach) differs from LEACH in that it uses multihop approach in order to transfer data to the sink or destination [14], [16].

In this paper we propose an Integrated Multihop Hierarchical Clustering Distributed Routing Protocol MHCD-LEACH which is both energy efficient and uses multihop approach that further enhances the energy consumption and network lifetime [8], [10], [11]. Proposed protocol is characterized by: 1) Nodes having maximum residual energy, more number of neighbors & less distance to BS is selected as CH 2) Multihop path decides with minimum distance from each CH node to the base station. 3) Direct communication by normal nodes near to the BS 4) high amplification energy for Inter-cluster communication and low amplification energy for Intra-cluster communication. The use of intermediate nodes with maximum residual energy, more number of neighbors, less distance to BS and direct communication to BS by near nodes enhance the network's lifetime.

II. RELATED WORK

2.1 Leach Protocol

LEACH i.e. Low Energy Adaptive Clustering Hierarchy [3] proposed by Wendi R Heinzelman et al. is the first clustering hierarchical -based routing protocol for wireless sensor network which splits the whole network into clusters, in each cluster one node elect as a Cluster Head (CH) is responsible for generating and operating a TDMA (Time division multiple access) schedule and aggregates data gathered from nodes before sending to the BS. Because data collected by cluster member nodes from their respective cluster is highly correlated and duplicate. Remaining nodes are cluster members as shown in figure 1.

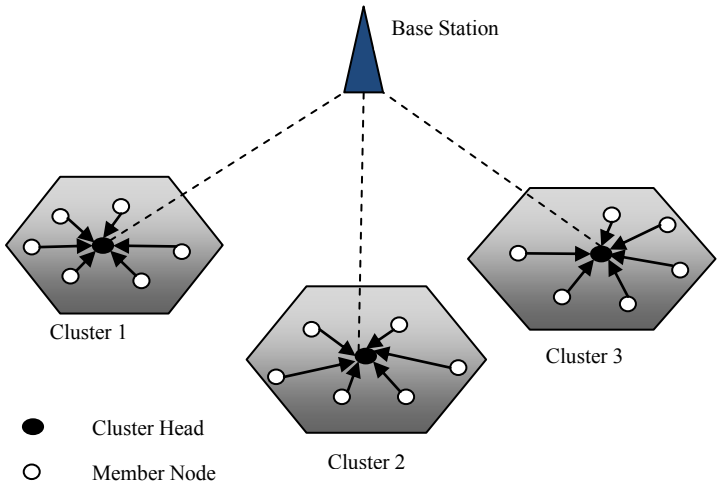

Fig. 1 Singlehop Communication for Small Network in LEACH

This protocol distinguishes the whole operation into two portions;

2.1.1 Setup Phase

After processing the deployment of sensors in network, each node decides independently of other nodes if it will elect as a CH or not. This judgment takes into account the node that hasn't been a CH for long time is more likely to choose itself as a CH than nodes that have been a CH recently. In the advertisement phase, the CHs inform their member nodes with an announcement message that they become CHs [4]. Normal nodes join the

cluster by picking the announcement message on the basis of strongest received signal strength. Then CH creates a TDMA schedule table and broadcasts it to their member nodes. Therefore, all the cluster members get their idle slots for data transmission, and then go to the next phase [20], [22].

2.1.2 Steady State phase

After election of CHs, in this phase transmission of data to BS begins. Member nodes send their data during allocated TDMA slot by the CH. This transmission uses a minimal quantity of energy. Energy dissipation by member nodes can be minimized by turning off the radio electronics of member nodes until the nodes allocated TDMA slot [23]. When data is received by all member nodes, CH aggregates the redundant data and sends it to the BS. Thus LEACH performs local aggregation of data in each cluster in order to lower the amount of data that transmitted to the BS [5].

2.2 Multihop Leach Protocol

In [6], [11], Multihop Leach is an extension of original leach protocol that saves the energy consumption of each node in WSN. This protocol is different from Leach in manner it takes multihop path to send data to the sink [7], [9]. Leach is not suitable for large are network because it uses only single hop communication between CH and BS; therefore, for more distance it will consume more energy. Multihop leach [6] proposed by F. Xiangning et al., overcomes this problem by adopting multihop communication between CHs and BS.

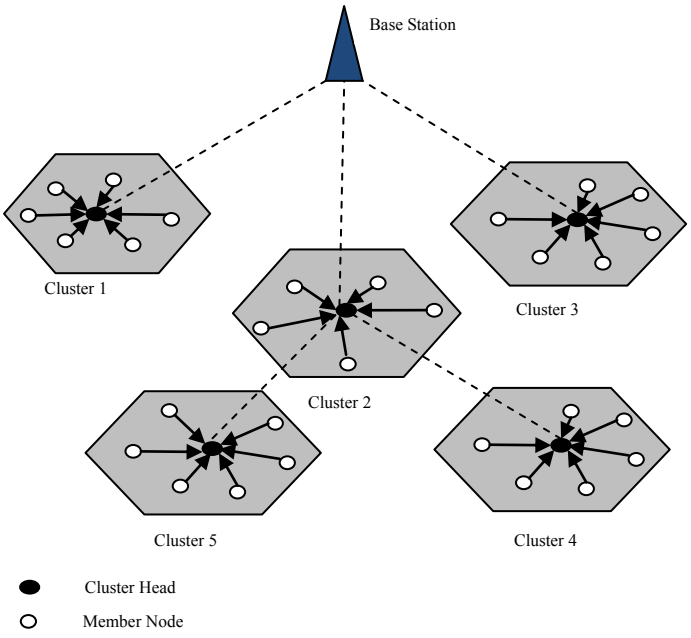

Fig. 2 Multihop Communication for Larger Network in M-LEACH

Multihop-Leach chooses a path with any of the following characteristics:

1. Minimum distance between CH & BS.
2. Minimum hop count between CH & BS.
3. Minimum energy consumption.

If communication distance between CH and BS is very large then it first sends data to the CH which is near to BS and then this CH finally send data to the BS. With this approach, it decreases the energy consumption and increases the period of network's life [15], [19].

III. NETWORK MODEL

3.1 Assumptions

This wireless sensor networks consists of immobile sensor nodes randomly deployed in a 100m x 100m square region. We consider the following characteristics of network:

1) The network is designed by N sensors nodes randomly deployed in square field and has cluster hierarchical topology.
2) Sensor nodes are homogeneous, immobile and energy constrained.
3) The Base Station is fixed and its location is pre-determined which is at the centre of the network.
4) In cluster, the cluster member nodes are cognizant of their cluster heads and can communicate directly with them.
5) Energy consumed for sensing and processing the data is not considered.
6) The cluster-head nodes communicate with their next-hop cluster-head, and finally far cluster-head node is communicated with BS.

3.2 Energy Model

This study also considers simple radio model for computing the energy dissipated in communication. The transmitter consumes energy to run the radio electronics and power amplifier whereas the receiver consumes energy to run the radio electronics. We consider both free space model (d2 power loss) and multi- path fading model (d4 power loss) depending on the distance between transmitter and receiver.

$$E_{TX}(k,d) = \begin{cases} (E_{elec} \times k) + (\varepsilon_{mp} \times k \times d^4), & d \geq d_0 \\ (E_{elec} \times k) + (\varepsilon_{fs} \times k \times d^2), & d < d_0 \end{cases}$$

Where the threshold distance d_0 is

$$d_o = \sqrt{\varepsilon_{fs}/\varepsilon_{mp}}$$

Where E_{elec} the energy is needed to run the radio electronics, ε_{mp} and ε_{fs} is the energy required running the transmitter amplifier depending on the distance d. To receive a k-bit message, energy consumed is

$$E_{Rx}(k) = E_{elec} \times k$$

Data gathered from member nodes and neighbor nodes are highly redundant and correlated. Hence cluster heads done data aggregation. Energy dissipated for aggregating m messages of k bits each is

$$E_{DA}(k) = E_{agg} \times k \times m$$

IV. PROPOSED WORK

In this approach, MHCD-LEACH: a modified version of M-LEACH has been proposed.

MHCD-LEACH characterized by:

1) CH selection on the basis of three parameters

a) maximum residual energy

b) more number of neighbors &

c) less distance to BS

2) Multihop path decides with minimum distance from each CH node to the base station.

3) Direct communication by normal nodes near to the BS

4) High amplification energy for Inter-cluster communication and low amplification energy for Intra-cluster communication.

This uses energy of each node more efficiently and then prolongs network's life. After completing the process of CHs selection, this protocol communicates with BS via multihop. Far CHs send their data to that CH which is near to BS and then only the near CHs are responsible for further transmission with BS. Once the relay nodes have been selected, the next operation is the formation of clusters. All the normal node decides itself whether it wants to join the cluster or directly communicates with BS.

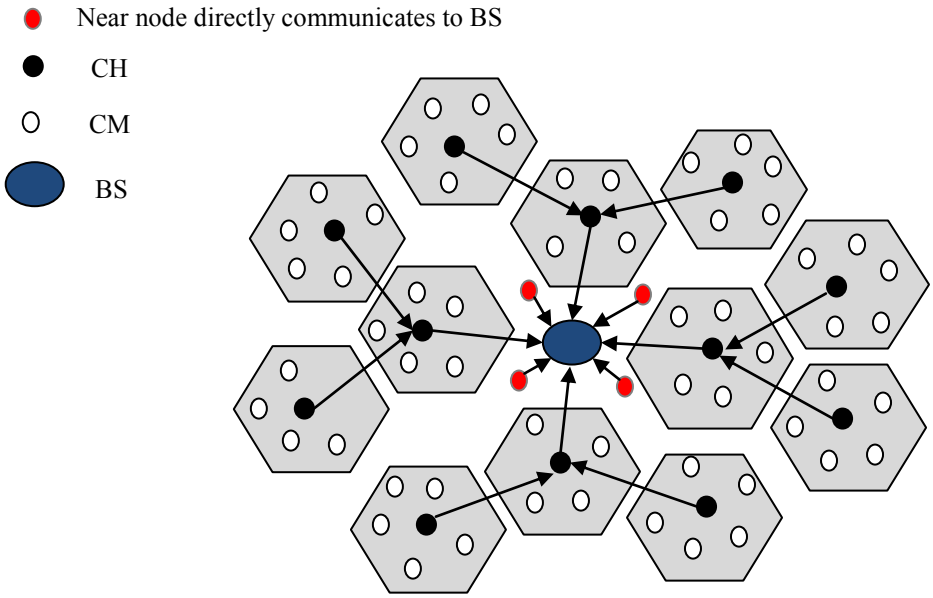

Fig. 3 MHCD-LEACH with direct Communication to the BS by Near Nodes

The operation of this protocol is broken into rounds and each round consists of three phases: (1) Cluster Head selection (2) multihop path selection and cluster formation (3) data transmission phase

1) Cluster Head selection

When set-up phase begins, all nodes go into the CH selection phase. The node having higher residual energy, more number of neighbors and less distance to BS become CH and advertise itself as a CH for the current round.

2) Multihop Path selection and cluster formation

Once CHs are selected, all CHs compute their distance to each other CH and also compute distance from BS to itself. If the distance between two CHs is less as compared to the distance between CH and BS, then in this situation CH will choose the intermediate CH as their next hop which is near to BS. Once CHs selects their intermediate or next hop CH, cluster formation starts. If the direct communication distance between normal nodes to BS is less as compared to via CH, then the nodes sends data directly to the BS. Otherwise it joins the

cluster with nearest CH. When all nodes decide the cluster to which it belongs, CH creates TDMA schedule and broadcast to their all cluster member nodes. Hence clusters are organized in this manner.

Besides minimizing energy consumption in cluster formation, this integrated MHCD-LEACH also introduce two different levels of amplification energy to amplify signals according to types of transmission. Basically, in clustered wireless sensor networks there can be two modes of transmission.

1) Intra Cluster Transmission
2) Inter Cluster Transmission

Intra Cluster Transmission is defined by a communication within a cluster i.e. cluster member nodes sense data and convey sensed data to their respective cluster head. Whereas Inter Cluster Transmission is defined by communication between two CHs. In original LEACH, amplification power is set same for all types of transmissions. Using high amplification energy for Inter-cluster communication & Low amplification energy for Intra-cluster communication saves much amount of energy.

3) Data Transmission phase

Data transmission occurs in steady-state phase of original leach protocol. Each member nodes send their data to their respective cluster heads in the allocated time slots. After receiving all the data from member nodes, data aggregation is performed by CHs and sent this aggregated data finally to the BS via multihop. Nodes near to the BS continuously send data to BS.

V. SIMULATION & RESULTS

In order to evaluation of proposed algorithm, the algorithms with the similar basic idea are selected. The LEACH & M-LEACH algorithm as the basis of cluster-based routing algorithm and multihop transmission respectively is selected in order to compare with the proposed novel protocol. This simulation is implemented by considering the simulation parameters shown in following table 1.

Table I: Simulation Parameters

Parameters	Values
Network Size	100m * 100m
Number of Nodes	200
Sink Location	(50,50)
Initial Energy	0.1 J
Eelec	50 nJ/bit
Efs	10 pJ/bit /m2
Emp	0.0013 pJ/bit/m4
Eagg	5 nJ/bit /message
CH's probability	5 %
Data Packet Size	512 bytes
Nodes Distribution	Uniform random distribution

Once CHs are selected, all CHs compute their distance to each other CH and also compute distance from BS to itself To evaluate and compare the performance of proposed protocol, four performance metrics are used:

1. Network Lifetime: Number of nodes alive in each round.
2. Remaining Energy: Total remaining energy of all the nodes in each round.
3. Total No. of Cluster heads: Total number of elected in each round.
4. Scalability: In terms of when total number of nodes increase.

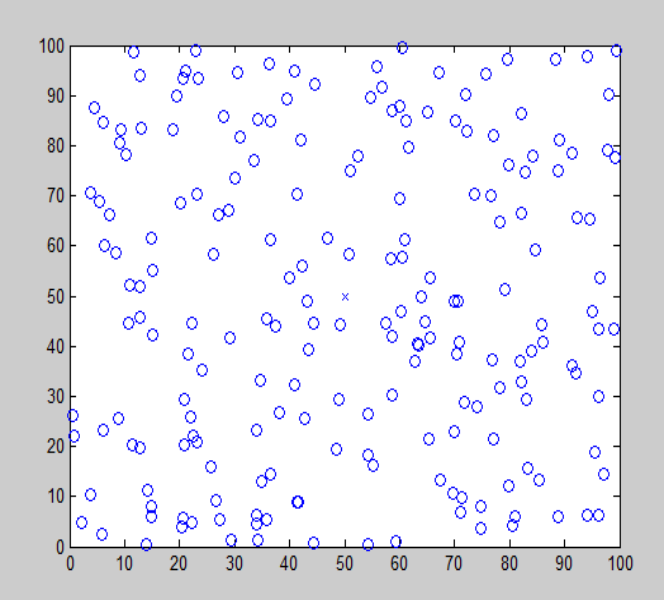

Fig. 4 Total no. of Nodes (200) Randomly Distributed Over an Area of 100m x 100m

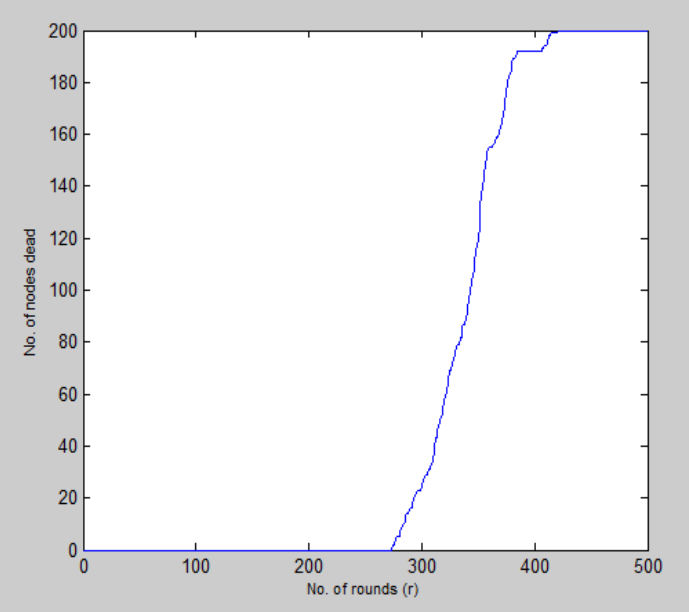

Fig. 5 Dead Nodes

From TABLE II, Fig. 5 and Fig. 6, it is clear that the proposed MHCD-LEACH protocol has better lifetime than existing protocols. If the lifespan of the network is until the death of first node, then MHCD-LEACH has prolonged lifetime than LEACH and M-LEACH.

Table II. Comparison of Network Lifetime of Leach, m-Leach & Mhcd-Leach

Network	Protocol	First node dead round	Half node dead round
100m X 100m	LEACH	145	199
	M-LEACH	146	194
	MHCD-LEACH	275	347

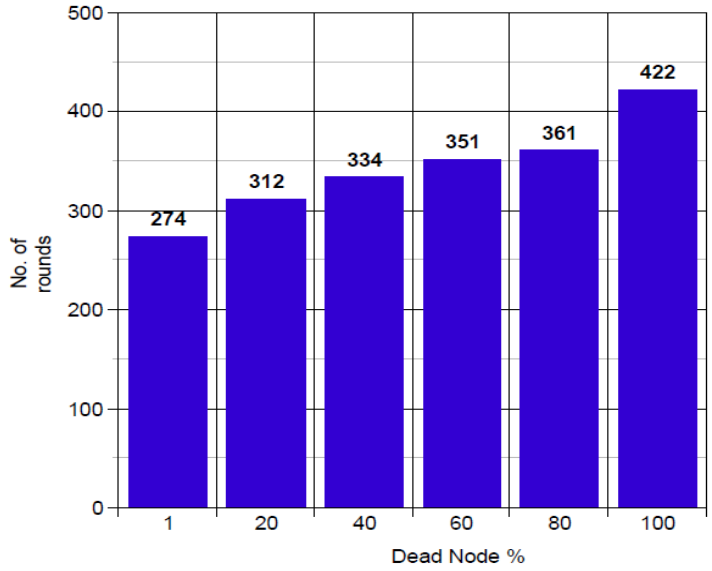

Fig. 6 Percentage of Node Dead in Rounds

In Fig. 6, the proposed MHCD-LEACH has more energy consumption than LEACH and M-LEACH because of choosing both multihop and direct transmission by near nodes.

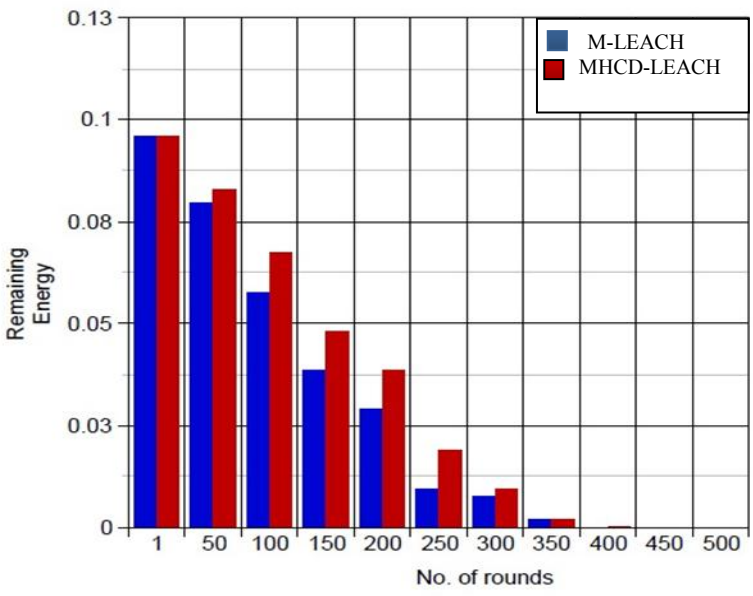

Fig. 7 Remaining Energy for 100m×100m Area Network

Fig. 8 shows total number of cluster heads selected per rounds. Desired percentage of CHs is 5%. Therefore, in proposed protocol initially 9 to 8 CHs are selected and further it decreases gradually. Nodes having high

remaining energy, more no. of neighbors and less distance to BS selected has cluster head prolongs the network lifetime.

TABLE III. shows different simulation scenario by increasing total number of nodes from 100 to 200 and initial energy from 0.1 joule to 0.5 joule. For 0.1 joule initial energy, MHCD-LEACH enhances network lifetime for both 100 and 200 nodes. While for 0.5 joule initial energy our proposed protocol enhances network lifespan if we consider the lifetime of the network is until the half node's death or last node's death.

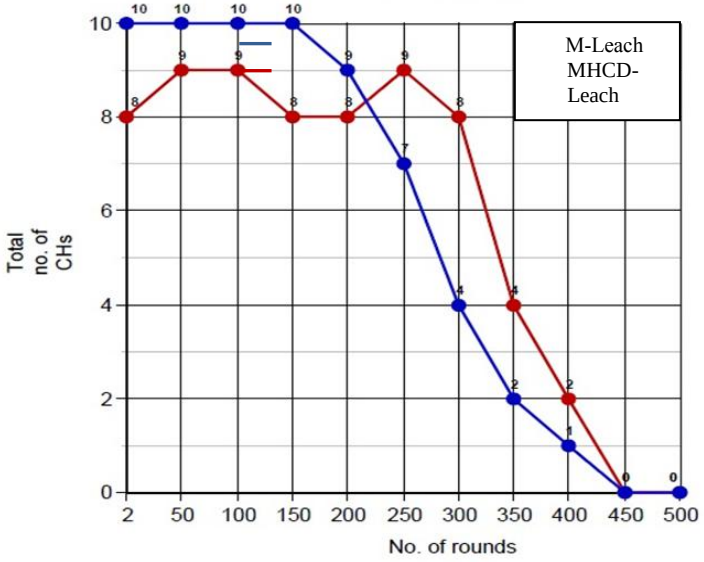

Fig. 8 Total no. of CHs in rounds

TABLE III: Scalability in Terms of Network Lifetime

Network Area	E_0 (Joule)	No. of Nodes	MHCD-LEACH		
			FND	HND	LND
100m×100m	0.1 J	100	271	332	402
100m×100m	0.1 J	200	275	347	422
100m×100m	0.5 J	100	1334	1612	2018
100m×100m	0.5 J	200	1357	1632	1961

VI. CONCLUSION

Designing an efficient routing protocol in WSNs faces a lot of challenges; one of the most important issues is energy conservation which has significant effect on network lifetime. Hierarchical Clustering is one way to reduce energy consumption in WSNs. In this paper, we introduced the Multihop Hierarchical Clustering Distributed (MHCD) approach which reduces the energy consumption and enhance the network lifetime. MHCD is a cluster based multihop routing protocol which changes the CH selection scheme. Since cluster heads are selected on the basis of higher residual energy, more number of neighbors & less distance to BS of nodes, the network lifetime can be enhanced. Also energy is consumed by using dual transmitting power levels. From

the simulation results, it is clear that the proposed protocol gives a better lifetime & minimized energy consumption by efficient cluster head selection approach after very first round and dual transmitting power levels for intra-cluster and inter-cluster communication.

VII. ACKNOWLEDGEMENT

I would like to express my gratitude from the core of my heart to **Mr. Vishal Kumar Arora**, Assistant Professor in Department of Computer Science & Engineering, SBSSTC for his precious time, support and guidance. He has been a constant source of motivation and encouragement throughout the research work. I would also like to thank all the authors for their valuable research paper, seminars and other source of information.

REFERENCES

[1] J. Elson, K.Rmer: "A New Regime for Time Synchronization". ACM Computer Communication Review (CCR) 33(1), 149-154 (2003).

[2] N. Sepideh, N. Aras, A. Fairouz "SLTP: Scalable Lightweight Time Synchronization Protocol for Wireless Sensor Network", Springer-Verlag Berlin Heidelberg 2007.

[3] W. Heinzelman, A. Chandrakasan and H. Balakrishnan, "An applicationspecific protocol architecture for wireless micro sensor networks", IEEE Transaction on Wireless Communications, vol. 1, pp. 660-670, 2002.

[4] M. Aslam, M. B. Rasheed, T. Shah, A. Rahim, Z. A. Khan, U. Qasim, M. W. Qasim, A. Hassan, A. Khan, N. Javaid , "Energy optimization and Performance Analysis of Cluster Based Routing Protocols Extended from LEACH for WSNs".

[5] Meenakshi Sharma, Anil Kumar Shaw, "Transmission Time and Throughput analysis of EEE LEACH, LEACH and Direct Transmission Protocol: A Simulation Based Approach", Advanced Computing: An International Journal (ACIJ), Vol.3, No.5, September 2012.

[6] F. Xiangning and S. Yulin, "Improvement on LEACH protocol of wireless sensor network", 2007 IEEE International Conference on Sensor Technologies and Applications.

[7] Muhamnmad Omer Farooq, Abdul Basit Dogar and Ghalib Asadullah Shah, "MR-LEACH: Multi-hop Routing with Low Energy Adaptive Clustering Hierarchy", 2010 IEEE Computer Society, SENSORCOMM.

[8] W. Liu and J.Yu, "Energy efficient clustering and rout ing scheme for wireless sensor networks", IEEE 2009.

[9] Mayank Chandra, Prashant Saini, Manju Khari, C. S. Vinitha, "Clustering In Wireless Sensor Networks: Performance Comparison Of Leach And Multi-Hop Leach Protocols", Proceedings of 24th IRF International Conference, 3rd May 2015, Chennai, India.

[10] Ashlyn Antoo, Rameez Mohammed A, "EEM-LEACH: Energy Efficient Multi-hop LEACH Routing Protocol for Clustered WSNs", 2014 IEEE, International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT).

[11] Imen Souid, Haithem Ben Chikha, Malika El Monser, Sondes Gasmi and Rabah Attia, "Multi-Hop Dynamic Clustering LEACH Protocol for Large Scale Networks", 2014 IEEE.

[12] Saman Siavoshi, Yousef S. Kavian, Mehdi Tarhani, "An Energy-balanced Distributed Clustering Protocol for Wireless Sensor Networks", 2014 IEEE.

[13] M. Patil and Rajashekhar C. Biradar, "A Survey on Routing Protocols in Wireless Sensor Networks", 18th IEEE International Conference on Networks (ICON), 2012.

[14] Tang qiang, Wang bingwen, Dai zhicheng, "MS-Leach: A Routing Protocol Combining Multi-hop Transmissions and Single-hop Transmissions", IEEE 2009 Pacific-Asia Conference on Circuits, Communications and System.

[15] Kemal Akkaya & Mohamed Younis: "A survey on routing protocols for wireless sensor networks", 2003 Elsevier.

[16] Sudhanshu Tyagi , Neeraj Kumar, "A systematic review on clustering and routing techniques based upon LEACH protocol for wireless sensor networks", 2012 Elsevier.

[17] M. Aslam, N. Javaid, A. Rahim, U. Nazir, A. Bibi, Z. A. Khan: "Survey of Extended LEACH-Based Clustering Routing Protocols for Wireless Sensor Networks", 14th International Conference on High Performance Computing and Communications, 2012 IEEE.

[18] Harneet Arora, Gurbhej Singh "Review on Data Dissemination and Gathering in Wireless Sensor Networks". 2013th International Journal of Emerging Research in Management & Technology.

[19] Slaheddine Chelbi, Majed Abdouli, Rafik Bouaziz and Claude Duvallet: "Multi-Hop Energy Efficient Routing Protocol Based on Data Controlling for Wireless Sensor Networks". 2013, IEEE.

[20] S. Bansal and V.K. Arora, "Distributed and Centralized Clustering Approaches: Leach vs. C-Leach", HCTL Open International Journal of Technology Innovations and Research (IJTIR) 2015.

[21] G. Singh, H. Arora, "Design and Architectural Issues in Wireless Sensor Networks", 2013th International Journal of Advanced Research in Computer Science and Software Engineering.

[22] M. J. Handy, M. Haase and D. Timmermann "Low Energy Adaptive Clustering Hierarchy with Deterministic Cluster-Head Selection".

[23] Rajesh Patel, Sunil Pariyani and Vijay Ukani, "Energy and Throughput Analysis of Hierarchical Routing Protocol (LEACH) for Wireless Sensor Network", International Journal of Computer Applications, April-2011.