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Review on Cluster Head Election Algorithms Based on Distance and Energy

Shweta Gupta
University Institute of Engineering & Technology
Kurukshetra University,Kurukshetra, Haryana, India
Nikhil Marriwala
University Institute of Engineering & Technology
Kurukshetra University,Kurukshetra
Haryana, India

ABSTRACT-

In past years, the applications of wireless sensor networks (WSNs) have developed extremely. In WSNs there is one procedure used for the increment of the lifetime of network and deliver additional efficient operative procedures known as clustering. Clustering is a method for dividing the recognizing arena of sensor network into a number of clusters. Every node selects its leader named cluster head. Therefore cluster head election is an important process for maximizing the network lifetime by using the distance and energy in an effective way. In this paper, we present a review of dissimilar clustering processes on the basis of distance and energy in WSNs underlining their purposes, characteristics etc.

Keywords: Wireless Sensor Networks, WSN, Clustering, LEACH, Cluster head election.

I.INTRODUCTION

New development in sensor technology and wireless communication creates the sensor nodes reasonable [1]. Several beneficial and different applications of WSNs contain applications demanding data collecting in tough, unfriendly atmospheres, climate, and temperature observing, recognition of natural or organic agent fears, and healthcare observing [2]. A WSN contains some small sensor nodes for monitoring of parameters [3].These sensor nodes gather the data and then forward it to the sink or base station (BS) directly, or through multi-hop communication [1]. The architecture of a wireless sensor network is shown in figure 1. These sensor nodes have a partial quantity of remembrance, handling capacity, communication range and above all restricted quantity of energy because sensor nodes are battery powered [1]. The consumption of energy can be minimized by agreeing only specific nodes interconnect with the sink. These nodes named cluster heads (CHs). CH gathers the data directed to every node and then transferring the collected data to the sink [2].

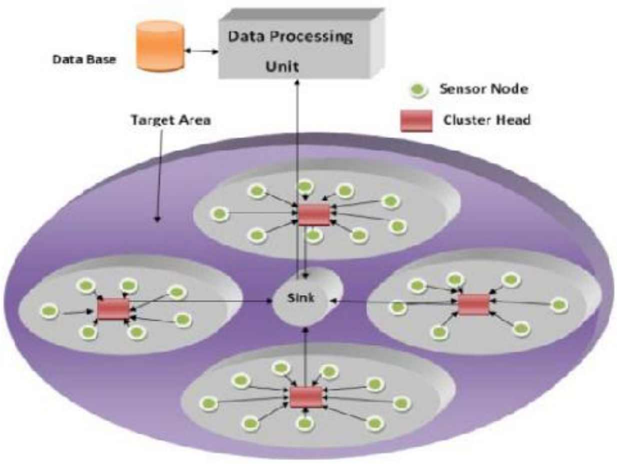

Figure 1: Architecture of the Wireless Sensor Network [3].

II. CLUSTERING

Clustering is the process in which sensor nodes in a network establish themselves into classified configurations [3]. Distributing the sensor networks into small adaptable units is called as clustering and procedure known as clustering process [4]. By doing clustering sensor nodes can use the system properties like radio resource, battery power more proficiently [3]. Clustering helps in minimizing the swapped communications in WSN resulting in the little consumption of battery power of individual sensor nodes. This elongates the lifetime period of the wireless sensor network [4].

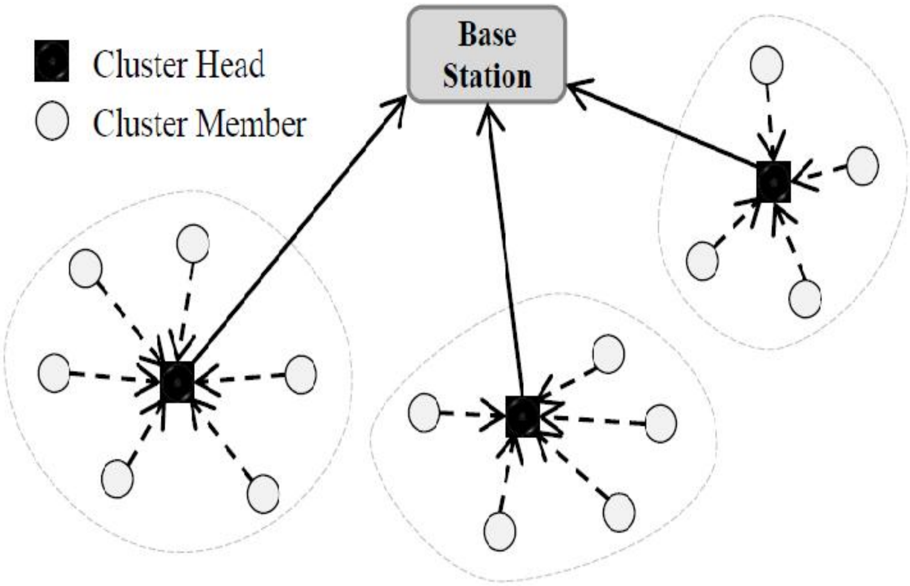

Figure 2: Cluster Based model [5].

Figure 2 shows an overall vision of WSNs, consisting of a base station, cluster heads and sensor nodes organized in an environmental area [5].

III. LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY (LEACH) PROTOCOL

Low energy adaptive clustering hierarchy (LEACH) is well known as distributed cluster head ordered routing protocol that incorporates the idea of clustering, media access, and data collection so that it give a brilliant outcome in terms of network lifetime [6]. The important characteristics of LEACH are:

- Limited synchronization and mechanism for cluster arrangement and procedure.
- The randomized revolution of the cluster "base stations" or "cluster heads" and the corresponding clusters.

LEACH is able to achieve local computation in each cluster to decrease the amount of data that must be transferred to the base station [5].

The LEACH process is commonly distributed in two phases:

1. Setup phase
2. Steady state phase

1. SETUP PHASE

In this phase, the nodes are distributed into some clusters dynamically and a CH is elected randomly among the cluster nodes for every cluster. While making clusters, an integer in the series 0 to 1 is elected randomly and the same is equated with a threshold, $t(s)$ [7]. The node is made as a CH for the present round, if chosen value$< t(s)$; else the node continues to stay as a child node. The threshold $t(s)$ is calculated by using equation (1).

$$t(s) = \begin{cases} \frac{p}{(1-p*[r \quad (\frac{1}{p})])} & i \; n \in G \\ 0 & i \; n \notin G \end{cases} \quad (1)$$

Where p = amount of the CH nodes among all the nodes, r = number of the round and G = the group of the nodes that have not yet been CH nodes throughout the first $1/p$ rounds.

Once different cluster heads (CHs) are elected, advertisement messages are broadcast by the CHs. These messages are received by many of the neighboring nodes and determine the presence of one or more CHs [6]. A node can select one of the CHs, in case additional CH occur, established on the received signal strength indication (RSSI). After the setup phase, each CH knows its associates [7].

2. STEADY STATE PHASE

After cluster establishment, a CH assigns its time division multiple access (TDMA) schedule to the nodes maintained by it. On the basis of TDMA schedule, a node sends its recognized and stored data to its CH [6]. Once a CH gathers all the statistics from its member nodes, it calculates the cumulative of data of other nodes and its individual data and sends the collective value to the sink. Usually, the time period of steady state phase is longer than that of the setup phase. After every round, new cluster heads are selected. Figure 3 shows the timeline process containing steady state and setup phase of the LEACH protocol [7].

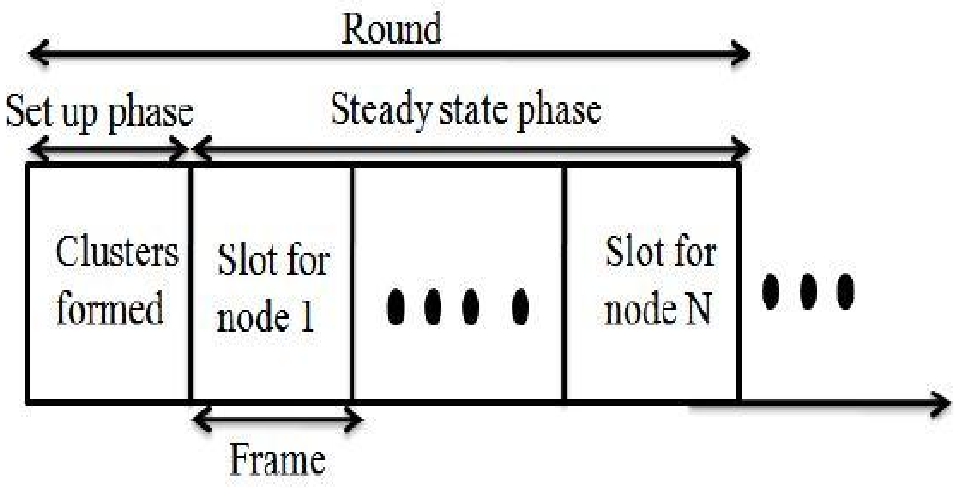

Figure 3: LEACH protocol time line process [7].

IV. FIRST ORDER RADIO MODEL

The first order radio model is shown in figure 4 is broadly used in WSNs. This model dissipates E_e = 50 nJ/bit to route the circuitry of transmitter or receiver andϵ_a = 100 pJ/bit/m^2 for the transmit amplifier (see Table 1). In this type of model, a node communicates k bits of data from another node at a distance of d meter. The consumption of energy can be measured as follows:

$$E_T \; (k,d) = \begin{cases} k * E_e \quad + k * \epsilon_f \; * d^2, d < d_0 \\ k * E_e \quad + k * \epsilon_m \; * d^4, d \geq d_0 \end{cases} \quad (2)$$

$$E_R \; (k,d) = k * E_e \quad (3)$$

Where E_T is the transmitter electronics energy, E_R is the receiver electronics energy, ϵ_f and ϵ_m are transmit amplifiers, d_0 is defined as $\sqrt{\frac{\epsilon_f}{\epsilon_m}}$. If the distance is not as much of the threshold d_0, then the free space propagation model are used; else the multipath fading channel model is taken [8].

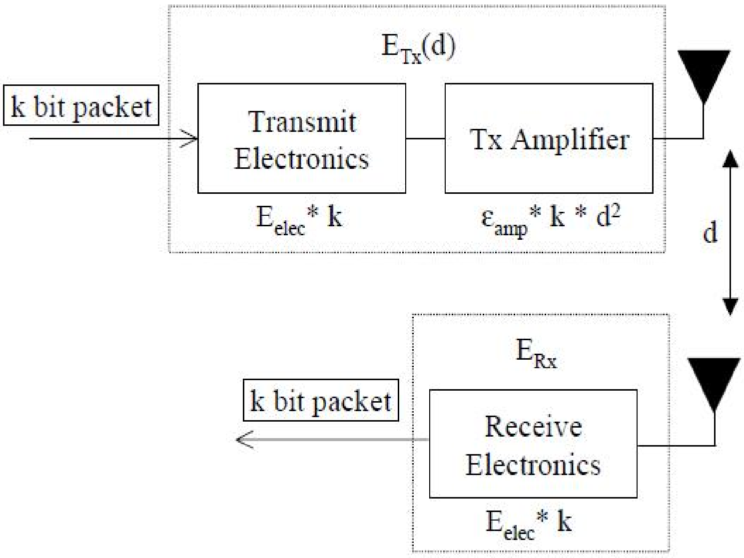

Figure 4: First Order Radio Model [8].

Table 1: Radio Characteristics.

Operation	Energy Dissipated
Transmitter Electronics ($E_{T\ -e}$) Receiver Electronics ($E_{R\ -e}$) ($E_{T\ -e}$ $= E_{R\ -e}$ $= E_e$)	50 nJ/bit
Transmit amplifiers (ϵ_a)	100 pJ/bit/m^2

V. LITERATURE SURVEY

In this segment, we temporarily define various procedures related to clustering process. Different algorithms established on the distance and energy has been anticipated in this segment. The objective is to elongate the lifetime period of nodes and to reduce the consumption of energy, resulting in heightened network lifetime and performance.

Chen Guijun et. al. [9] proposed an algorithm in which a different threshold function is introduced. On the basis of remaining energy, this algorithm defines the possibility of cluster head, so as to ensure the nodes with advanced remaining energy have a greater probability of becoming a cluster head than that with the low residual energy. If r is the orientation energy compared with remaining energy of node then,

$$p_i = p_o \quad \frac{E_i(r)}{\bar{E}(r)} \quad (4)$$

Where, p_o = the optimal proportion of cluster heads, $\bar{E}(r)$is the normal energy at round r in the network and threshold for every node is in every round is given as:

$$T_{(S_i)} = \begin{cases} \frac{p_i}{1-p_i\left(r \quad \left(\frac{1}{p_i}\right)\right)} & i\ S_i \in G \\ 0 & o\ he\ \ e \end{cases} \quad (5)$$

p_o is replaced by p_i.

Jiang Hongtao et. al. [10] proposed an enhanced clustering routing procedure established on density, energy and position information of sink. The node density factor and the energy factor are presented in the threshold formula $T(n)$:

$$T(n) = \begin{cases} \frac{p}{1-p*(r \quad (\frac{1}{p}))} * [E(i) + \mu \quad (i)] \ i \ n \in D \\ 0 \quad\quad o \ he \end{cases} \quad (6)$$

Where μ is a node density factor, 0< μ ≤ 1.

The density factor $D(i)$ and residual energy $E(i)$ is well-defined as follows:

$$D(i) = \frac{(N_n \quad hb \quad (i)-1)}{N_a} \quad (7)$$

Where $N_n \quad hb$ is the existing neighbor node number and N_a is the number of nodes of the whole network.

$$E(i) = \frac{E_r}{E_s} \quad (8)$$

Where E_r is the node's remaining energy and E_s is the starting energy.

This algorithm helps in decreasing the consumption of the node energy and to prolong the lifetime period of the whole network.

Weizheng Ren et. al. [11] proposed a new clustering algorithm EDL (Energy and Distance LEACH). EDL solves the issue of limited energy and energy balance of WSN. The enhanced threshold function is given as:

$$T(n) = \begin{cases} \frac{p}{1-p*[r \quad (\frac{1}{p})]} \frac{E_i(t)}{E_t \quad (t)}, \quad i \ n \in G \\ 0 \quad\quad o \ he \end{cases} \quad (9)$$

Where $E_i(t)$ is the present residual energy of a node, $E_t \quad (t)$ is the entire energy of all the nodes in the network.

The distance threshold is given as:

$$D_d = \frac{\sqrt{S}}{\sqrt{N*p}} \quad (10)$$

Where S is area of a limited region, N is number of network nodes and p is proportion of cluster head in all the nodes.

EDL performance is better than the LEACH. The results presented that the EDL prolongs survival period of the network effectively.

Nihar Ranjan Roy et. al. [12] proposed an energy effective communication routing protocol which considers the remaining energy of nodes and the distance from the sink for cluster head election. The distance from every node to the sink node is given by equation:

$$d = \sqrt{\begin{pmatrix} S(i).x_d - \\ S(n+1).x_d \end{pmatrix}^2 + \begin{pmatrix} S(i).y_d - \\ S(n+1).y_d \end{pmatrix}^2} \quad (11)$$

The different threshold equation is given as:

$$te = \frac{p}{1-p\left(r*m \quad \left(\frac{1}{p}\right)\right)}\frac{S(i).E_r}{S(i).E_0} + p\left(1-\frac{S(i).E_r}{S(i).E_0}\right) \quad (12)$$

Where $S(i).E_r$ is the remaining energy of nodes and $S(i).E_0$ is the original energy of nodes. This algorithm gives 25 to 30 % better results as compared to LEACH protocol.

Zhang Jian-Jun et. al. [13] proposed an algorithm which considers the ideal number of cluster heads. This algorithm resolves the difficult for the nodes having the lesser energy of becoming the cluster head. The probability of nodes having the higher remaining energy to become the cluster head is increases and hence the survival time increases effectively. The threshold is described as:

$$T(n) = \begin{cases} \frac{p}{1-p\left(r \quad \left(\frac{1}{p}\right)\right)}\frac{E_c}{E_{i}} & i \; n \in G \\ 0 & o \; he \end{cases} \quad (13)$$

Where E_c is the node's existing energy and E_{i} is the original energy.

WANG Ningbo et. al. [14] proposed a based on both the distance from the sink and remaining energy, transmitting node is chosen from cluster heads to become transmit node between the sink and other cluster heads.

The threshold value is defined as:

$$T_r(n) = \begin{cases} \frac{p}{1-p\left(r \quad \left(\frac{1}{p}\right)\right)}\left[\delta + (1-\delta)\frac{E_r}{E_0}\right] & i \; n \in G \\ 0 & o \; he \end{cases} \quad (14)$$

Where δ symbolizes the number of successive rounds through which the node has not been a cluster head. Once the cluster head is chosen, on the basis of remaining energy R node is selected and distance of cluster head from sink nodes is given as:

$$\lambda = \frac{E_r}{d_{t \;\; B}} \quad (15)$$

Where $d_{t \;\; B}$ is the distance between current cluster head and the base station. This protocol saves around 20 % energy of sensor network in comparison to LEACH protocol.

Jing Yang et. al. [15] proposed an enhanced routing procedure based on LEACH known as ILEACH. This algorithm introduces a new threshold. It takes distance and remaining energy into consideration. Data accumulation tree is built for transmitting data to sink from cluster head. The threshold is given as:

$$T_{(n)_n} = \begin{cases} \frac{p*k_x}{1-p(r \quad d\left(\frac{1}{p}\right))} & i \; n \in G \\ 0 & o \; he \end{cases} \quad (16)$$

Here $k_x = \frac{E_i}{\bar{E}(r)}$ (17)

Where E_i is the remaining energy of node i and $\bar{E}(r)$ is average remaining energy of all nodes at the current round.

ILEACH has a longer network lifetime and less consumption of energy than LEACH.

Dr. Sumit Srivastava et. al. [16] proposed an algorithm named Distance Based Cluster Head (DBCH). The node which is nearer to the sink or base station will be elected as a cluster head. It starts a different threshold equation as:

$$T(n) = \frac{p}{1-p\left(r \quad \left(\frac{i}{p}\right)\right)} + (1-p)\frac{D_m \quad -D_{i\ t\ \ B}}{D_m \quad -D_m}\left(\frac{E_R}{E_0}\right) \qquad (18)$$

Where E_R is the remaining energy of a node for the current round and E_0 is the original energy. D_m and D_m represent the maximum and minimum distance from a node to base station.

Table 2: Comparative analysis

Authors	Year	Threshold function used
Rui Hou, Weizheng Ren and Yaodong Zhang [11]	2009	$T(n) = \begin{cases} \frac{p}{1-p\left[r \quad \left(\frac{1}{p}\right)\right]} \frac{E_i(t)}{E_{t} \quad (t)} & i\ n \in G \\ 0 & o\ he \end{cases}$
Long-Long and Zhang Jian-Jun [13]	2010	$T(n) = \begin{cases} \frac{p}{1-p\left(r \quad \left(\frac{1}{p}\right)\right)} \frac{E_c}{E_i} & i\ n \in G \\ 0 & o\ he \end{cases}$
Chen Guijun, Zhang Xueying and Wang Maofeng [9]	2012	$T_{(S_i)} = \begin{cases} \frac{p_i}{1-p_i\left(r \quad \left(\frac{1}{p_i}\right)\right)} & i\ S_i \in G \\ 0 & o\ he \end{cases}$
WANG Ningbo and ZHU Hao [14]	2012	$T_r(n) = \begin{cases} \frac{p}{1-p\left(r \quad \left(\frac{1}{p}\right)\right)}\left[\delta \quad + (1-\delta\ )\frac{E_r}{E_0}\right] & i\ n \in G \\ 0 & o\ he \end{cases}$
A. Pratap Singh, N. Sharma and N. Ranjan Roy [12]	2013	$te \quad = \frac{p}{1-p\left(r * m \quad \left(\frac{1}{p}\right)\right)} \frac{S(i).E_r}{S(i).E_0} + p * \left(1 - \frac{S(i).E_r}{S(i).E_0}\right)$
Li Hui, Jiang Hongtao and Li Hua [10]	2013	$T(n) = \begin{cases} \frac{p}{1-p*(r \quad \left(\frac{1}{p}\right))} * [E(i) + \mu \quad (i)] & i\ n \in D \\ 0 & o\ he \end{cases}$
Jing Yang, Zetao Li and Yi Lin [15]	2013	$T_{(n)_n} \quad = \begin{cases} \frac{p * k_x}{1-p(r \quad \left(\frac{1}{p}\right))} & i\ n \in G \\ 0 & o\ he \end{cases}$
R. Sharma , N. Mishra and Dr. Sumit Srivastava [16]	2015	$T(n) = \frac{p}{1-p\left(r \quad \left(\frac{i}{p}\right)\right)} + (1-p)\frac{D_m \quad - D_{i\ t\ \ B}}{D_m \quad - D_m}\left(\frac{E_R}{E_0}\right)$

VI. CONCLUSION

Clustering is a procedure used to decrease the consumption of energy and to provide the stability in wireless sensor networks. In this study, we have reviewed the different clustering procedures in the field of WSN based on distance and energy. Most of the new energy efficient clustering protocols designed for the sensor networks based on remaining energy, average energy etc. We summarize many schemes, showing their different threshold functions. Table 2 shows the comparison between various threshold functions used in different clustering procedures. Finally based on this survey work, we conclude that to attain optimal cluster head, CH should be elected on the basis of the distance and remaining energy. Therefore, the lifetime of the network is extended and energy proficiency is maximized.

REFERENCES

[1] A. Thakkar and K. Kotecha, "*Cluster Head Election for Energy and Delay Constraint Applications of Wireless Sensor Network*", pp. 1-8, IEEE 2013.

[2] I. Gupta, D. Riordan and S. Sampalli, "*Cluster-head Election using Fuzzy Logic for Wireless Sensor Networks*", in Proceedings of the 3rd Annual Communication Networks and Services Research Conference, IEEE 2005.

[3] Mr. P. G. Vispute, Sapana P. Sonar, Dr. S. Dorle and Dr. R. S. Kawitkar, "*Design, Implementation and Performance Evaluation of Efficient Energy Management Clustering Algorithm in Wireless Sensor Networks*", in International Conference on Electrical, Electronics and Optimization Techniques (ICEEOT) - 2016, pp. 1873-1878, IEEE 2016.

[4] B. Kumar and V. K. Sharma, "*Distance based Cluster Head Selection Algorithm for Wireless Sensor Network*", in International Journal of Computer Applications, vol. 57, issue 9, pp. 41-45, Nov. 2012.

[5] T. G. Nguyen, Chakchai So-In and N. G. Nguyen, "*Two Energy-Efficient Cluster Head Selection Techniques Based on Distance for Wireless Sensor Networks*", in 2014 International Computer Science and Engineering Conference (ICSEC), pp. 33-38, IEEE 2014.

[6] W. R. Heinzelman, A. Chandrakasan and H. Balakrishan, "*Energy-Efficient Communication Protocol for Wireless Microsensor Networks*", in Systems sciences, 2000. Proceedings of the 33rd annual Hawaii international conference on, vol. 2, pp. 1-10, IEEE 2000.

[7] R. K. Kodali, A. V. Sai Kiran, S. Bhandari and L. Boppana, "*Energy Efficient m- level LEACH protocol*", in 2015 International Conference on Advances in Computing, Communications and Informatics (ICACCI), pp. 973-979, IEEE 2015.

[8] M. Y. Tsai and Y. C. Chen, "*A Virtual Cluster Head Election Scheme for Energy-Efficient Routing in Wireless Sensor Networks*", in 2015 3rd International Conference on Future Internet of Things and Cloud, pp. 341-348, IEEE 2015.

[9] G. Chen, X. Zhang, Jun Yu and M. Wang, "*An improved LEACH algorithm based on heterogeneous energy of nodes in wireless sensor networks*", in 2012 International Conference on Computing, Measurement, Control and Sensor Network, pp. 101-104, IEEE 2012.

[10] L. Hui, J. Hongtao and L. Hua, "*The Improvement algorithm of cluster head election based on LEACH*", in 2013 6th International Conference on Intelligent Networks and Intelligent Systems, pp. 95-98, IEEE 2013.

[11] R. Hou, R. Weizheng and Y. Zhang, "*A wireless sensor network clustering algorithm based on energy and distance*", in 2009 Second International Workshop on Computer Science and Engineering, pp. 439-442, IEEE 2009.

[12] A. P. Singh, N. Sharma and N. R. Roy, "*Residual Energy and Distance based Energy-Efficient Communication Protocol for Wireless Sensor Network*", in International Journal of Computer Applications, vol. 74, issue 12, pp. 11-16, July 2013.

[13] X. L. Long and Z. J. Jun, "*Improved LEACH Cluster Head Multi-hops Algorithm in Wireless Sensor Networks*", in 2010 Ninth International Symposium on Distributed Computing and Applications to Business, Engineering and Science, pp. 263-267, IEEE 2010.

[14] N. WANG and H. ZHU, "*An Energy Efficient Algorithm Based on LEACH Protocol*", in 2012 International Conference on Computer Science and Electronics Engineering, pp. 339-342, IEEE 2012.

[15] Y. Jing, L. Zetao and Lin Yi, "*An Improved Routing Algorithm Based on LEACH for Wireless Sensor Networks*", in 2013 25th Chinese Control and Decision Conference (CCDC), pp. 3716-3720, IEEE 2013.

[16] R. Sharma, N. Mishra and Dr. S. Srivastava, "*A proposed energy efficient distance based cluster head (DBCH) Algorithm: An Improvement over LEACH*", in 3rd International Conference on Recent Trends in Computing 2015 (ICRTC-2015), vol. 57, pp. 807-814, 2015.