ISSN No. 0976-5697

Volume 3, No. 4, July- August 2012

International Journal of Advanced Research in Computer Science

REVIEW ARTICLE

Available Online at www.ijarcs.info

A LEACH Protocol for Design a Clustered Head Selection Approach in Wireless Sensor Networks

Sunita Parashar
Associate Professor
Department of Computer Sc. & Engineering
H.C.T.M, Kaithal, Haryana, India
Sunita.tu@gmail.com

Poonam Sharma*
M.Tech Student
Department of Computer Sc. & Engineering
H.C.T.M, Kaithal, Haryana, India
poonam.sharma87@rediffmail.com

Abstract: In recent years, there has been a growing interest in wireless sensor networks. One of the major issues in wireless sensor network is developing an energy-efficient routing protocol and enhancing nodes' lifetime from routing's aspect. LEACH includes the distributed cluster formation, local processing to reduce global communication, and randomized rotation of the cluster-heads. A wireless sensor network consists of hundreds or thousands of small energy-limited sensors that are densely deployed in a large geographical region. It has been demonstrated that Low-Energy Adaptive Clustering Hierarchy (LEACH) is an energy-efficient routing algorithm for Wireless Sensor Networks (WSN).
In this paper, we present a cluster head selection approach for LEACH. We state the principles of the LEACH and give the main flowchart and pseudo codes realizing LEACH. We improves the choice method of the cluster head, makes some nodes which have more residual energy as cluster heads in next round.

Keywords: Routing protocol; energy efficient; LEACH; wireless sensor network.

I. INTRODUCTION

A wireless sensor network is composed by hundreds or thousands of small compact devices, called sensor nodes, equipped with sensors (e.g. acoustic, seismic or image), that are densely deployed in the large geographical area. Sensor nodes collaborate to be able to cope with the environment; they operate completely wirelessly and are able to spontaneously create an ad hoc network, assemble the network themselves, dynamically adapt to device failure and degradation, manage movement of sensor nodes, and react to changes in task and network requirements. These sensors measure ambient conditions in the environment surrounding them and then transform these data into electric signals which can be processed to reveal some characteristics about phenomena located in the area around these sensors. Therefore we can get the information about the area and locations which are far away. The applications may be environment control such as office building, robot control and guidance in the automatic manufacturing environments, interactive toys, high security smart homes and the identification and personalization [1]. Wireless sensor networks (WSN) are the products which are integrated in the sensor techniques, embedded techniques and distributed information processing and communication techniques.

The appearance of the wireless sensor network is a revolution in information sensing and detection. Although there have been significant improvements in processor design and computing, advances in battery technology still lag behind, making energy resource considerations the fundamental challenge in the wireless sensor networks. Consequently, there have been the active research efforts on the performance limits of the wireless sensor networks. These performance limits includes the network capacity and network lifetime. Network capacity typically refers to the maximum amount of bit volume that can be successfully delivered to the base station ("sink node") by all the nodes in the network, while network lifetime refers to the maximum time limit that nodes in the network remain alive until one or more nodes drain up their energy.

Wireless sensor networks usually contain sensors, which are randomly and widely deployed. Sensors are powered by battery, which is impossible to get recharged after deployment. But sensor networks are designed to last. Thus, energy efficiency is an important issue in the sensor networks [1][2],[3],[4],[12]. Since routing consumes a lot of energy, an efficient routing scheme in sensor networks is also important.

A. Three Types of Node used in the WSN:

a. Micro-sensor nodes (MSNs):-The MSNs can be application–specific sensor nodes (e.g.; temperature sensor nodes (TSNs), pressure sensor nodes (PSNs), and video sensor nodes (VSNs) and they constitute the lower tier of the network. They are deployed in group s (or clusters) at strategic locations for surveillance or monitoring applications. The MSNs are small and low-cost. The objective of a MSNs is very simple .Once triggered by an event it starts to capture live information (e.g.; video), it sends directly to the local AFN. For each cluster of MSNs, there is one AFN, which is different from an MSN in terms of physical properties and functions.

b. Aggregation and forwarding nodes (AFN):- Data aggregation (or "fusion") for data flows from local cluster of MSNs, and forwarding (or relaying) the aggregated information to the next hop AFN (toward the base station) .For data fusion, an AFN analyzes

the content of each data stream (e.g.; video) it receives, from which it composes a complete scene by exploiting the correlation among each individual data stream from the MSNs. An AFN also serves as a relay node for other AFNs to carry traffic toward the base station. Although an AFN is expected to be provisioned with much more energy than MSNs, it also consumes energy than a MSNs, it also consumes energy at a substantially higher rate (due to wireless communication over the large distances). Consequently, an AFN has a limited lifetime. Upon depletion of energy at an AFN, we expect that the coverage for the particular area under surveillance is lost, despite the fact that some of the MSNs within the cluster may still have remaining energy.

c. Base-station (BS):-The sink node for data streams from all the AFN in the network. In this investigation, we assume that there is sufficient energy resource available at the base station and thus there is no energy constraint at the base station. In summary the main functions of the lower tier MSNs are data acquisition and compression while the upper –tier AFNs are used for data fusion and relaying information to the base-station [3], [4], [5], [13], [21].

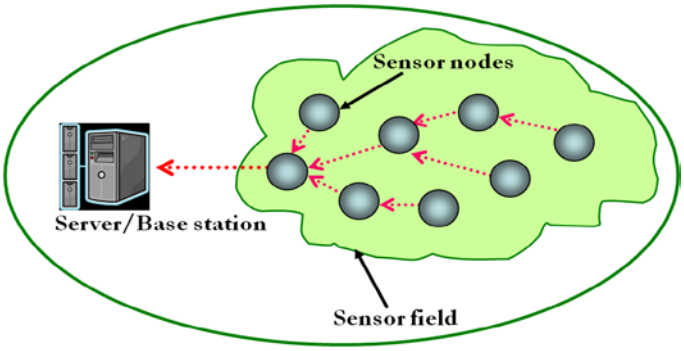

Figure1. Wireless sensor network

II. LEACH PROTOCOL

Low Energy Adaptive Clustering Hierarchy (LEACH) is a clustering-based protocol proposed by Wendi. In this paper, we propose an improved LEACH protocol for data gathering and aggregation. This protocol is a new protocol which bases on LEACH. Such innovation can extend the lifetime of the whole network due to much less energy dissipation for data transmission to basic station [5],[10].

LEACH utilizes randomized rotation of local cluster base stations (cluster-heads) to evenly distribute the energy load among the sensors in the network. LEACH uses the localized coordination to enable scalability and robustness for dynamic networks, and incorporates data fusion into the routing protocol to reduce the amount of information that must be transmitted to the base station [7], [10].

A. Related Work:

The operation of LEACH is broken up into rounds, where each round begins with a set-up phase, when the clusters are organized, followed by a steady state phase, when data transfers to the base station occur. In order to minimize overhead, the steady-state phase is long compared to the set-up phase.

In this paper, we described LEACH, a clustering-based routing protocol that minimizes global energy usage by distributing the load to all the nodes at different points in time. LEACH outperforms static clustering algorithms by requiring nodes to volunteer to be high-energy cluster-heads and adapting the corresponding clusters based on the nodes that choose to be cluster-heads at a given time. At different times, each node has the burden of acquiring data from the nodes in the cluster, fusing the data to obtain an aggregate signal, and transmitting this aggregate signal to the base station. LEACH is completely distributed, requiring no control information from the base station, and the nodes do not require knowledge of the global network in order for LEACH to operate.

Here are the key features of LEACH are:

a. Localized coordination and control for cluster setup and operation.
b. Randomized rotation of the cluster “base stations” or “cluster-heads” and also the corresponding clusters.
c. In LEACH, the operation is separated into fixed-length rounds, where each round starts with a setup phase followed by a steady-state phase. The duration of a round is determined priori.
d. Local compression to reduce global communication.

The use of clusters for transmitting data to the base station leverages the advantages of small transmit distances for most nodes, requiring only a few nodes to transmit far distances to the base station. However, LEACH outperforms classical clustering algorithms by using adaptive clusters and rotating cluster-heads, allowing the energy requirements of the system to be distributed among all the sensors [6],[7],[8],[13]. In addition, LEACH is able to perform local computation in each cluster to reduce the amount of data that must be transmitted to the base station. This achieves a large reduction in the energy dissipation, as the computation is much cheaper than the communication.

B. Description of LEACH protocol:

Main techniques of LEACH protocol include algorithms for distributing cluster forming, adaptive Cluster forming, and cluster header position changing. The technique of distributing cluster forming ensures self-organization of most target nodes. The adaptive cluster forming and cluster header position changing algorithms ensure to share the energy dissipation fairly among all nodes and prolong the lifetime of the whole system in the end.

LEACH protocol provides a conception of round. LEACH protocol runs with many rounds. Each round contains two states:

a. Cluster setup state: - In cluster setup state, it forms cluster in self-adaptive mode.
b. Steady state:-In steady state, it transfers data.

The time of second state is usually longer than the time of first state for saving the protocol payload [7],[9],[10],[12].

Figure 2 shows the process

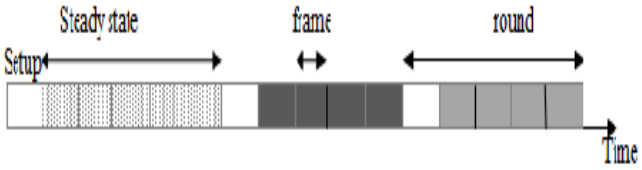

Figure 2.Operation time of LEACH

The flow chart of LEACH protocol is shown in figure3

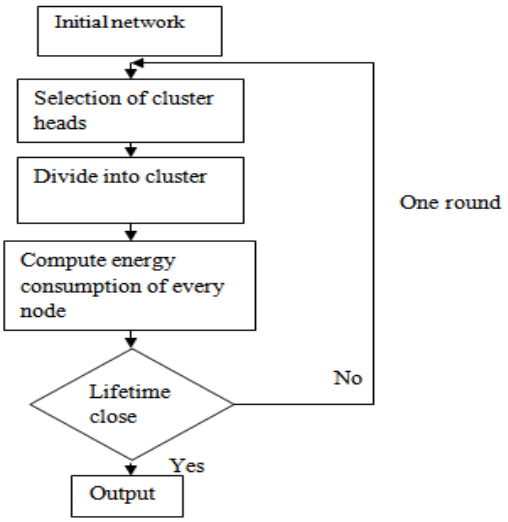

Figure 3. Flow chart of LEACH protocol

The flow chart of cluster selection is shown in figure 4.

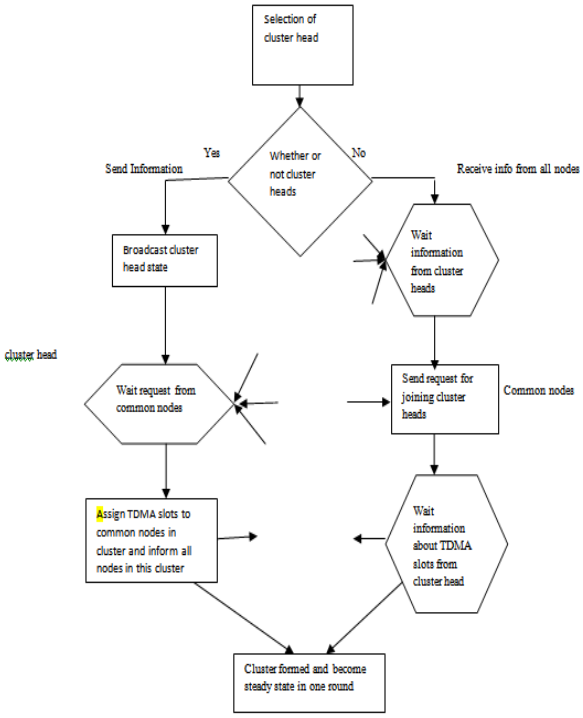

Figure 4. Cluster formation of LEACH protocol

The flow chart of different processes for these two kinds of node is shown in figure 5.

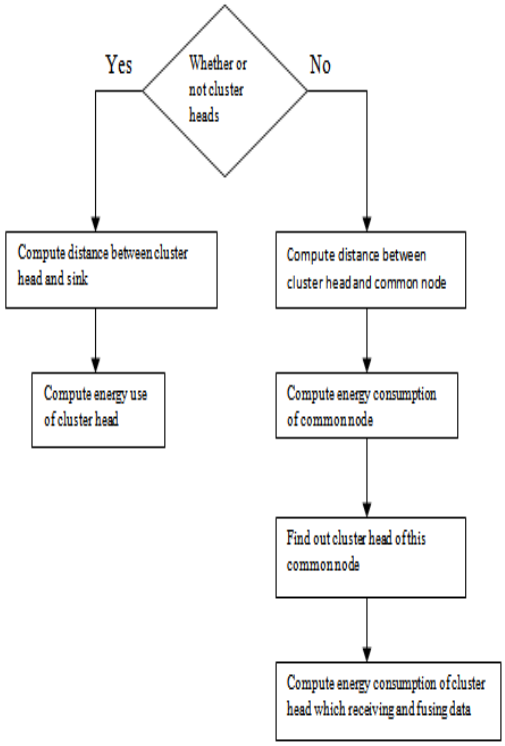

Figure 5. Different processes of nodes in LEACH protocol

C. Discussion of LEACH protocol:

Two ideas of LEACH protocol are given in this paper. Details will be presented in the following two sub-sections:-

a. The criterion of selecting cluster head node LEACH protocol randomly selects cluster head at each round. Therefore, some nodes maybe exhaust energy too quickly due to being selected as cluster head many times. In this paper, our modified protocol makes the nodes with more residual energy have more chance as cluster head and this will prevent the whole network to die too early.

b. Multi-hop communication among cluster heads, In the Cluster heads directly communicate with sink in LEACH protocol. The energy consumption between cluster head and sink are greater than energy consumption among cluster heads, so cluster head will exhaust energy soon. Multi-hop communication can avoid the whole network from dying quickly and prolong the network lifetime by balancing the energy consumption among the network [15],[17],[18].

III. KEY ISSUES IN ROUTING PROTOCOL

Different from traditional networks, a typical sensor network has a great number of nodes, which are scattered over a region of interest. All the sensor nodes sense and gather information in a coordinated manner, and then pass the sensed information to the BS over the path determined by the routing protocol. The sensor nodes have much smaller memories, constrained energy supply, limited computer ability and more redundant information.

In order to design a good protocol for wireless sensor networks, it is important to improve the following parameters:

a. System lifetime: these networks should function as long as possible
b. Timely: it is important to receive the data from a sensor in a timely manner
c. Quality: protocols should be designed to be the optimum manner of aggregate data.
d. Autonomy: routing should be determined by a distributed algorithm.

Because sensor nodes have irreplaceable batteries, it is essential that the network be energy efficient in order to maximize the life span of the network. Besides this, autonomy is an important issue for sometimes global information is hard or even impossible to achieve [5], [7], [8].

So, we mainly consider these two factors, the lifetime and autonomy in our paper.

A. LEACH Algorithm:

LEACH is a protocol based on clustering hierarchy architecture. In this protocol, nodes are organized into different clusters each of which has a cluster-head and each cluster-head fuses data from its members before transmitting them to the base station. Sensors elect themselves to be local cluster-heads at any given time with a certain probability. In order to avoid cluster-heads dissipating too much power, cluster-head election and network rebuilding run periodically. LEACH is built on the following two assumptions:

a. The base station is fixed and is far from the sensors.
b. All nodes in the network are homogeneous and energy-constrained.

The operation of LEACH is broken up into *rounds*, where each round begins with a set-up phase, when the clusters are organized, followed by a steady-state phase, when data transfers to the base station occur. In set-up phase, cluster-heads are selected randomly and the randomicity ensures the high energy-consumption for data transmitting between cluster-heads and the base station is distributed among all nodes in the network evenly. As a node is elected to be cluster-head, it broadcasts an advertisement message which contains the information qualifying for the cluster-head. The other non-cluster-head nodes decide which cluster to join according to the strength of the advertisement signal. And the cluster-head advertisement heard with the largest signal strength is the cluster-head to which it belongs. Then it transmits a message back to the cluster-head to inform that it will be a member of the cluster. Based on the number of nodes in the cluster, the cluster-head node creates a TDMA schedule telling each node when it can transmit [12],[14],[16],[19],[20]. In steady-state phase, cluster members gather data continuously and send these data to certain cluster-heads in certain slots. The cluster-head nodes fuse these data and forward them to the base station. Cluster-heads are elected again in next rounds.

IV. SELECTION OF CLUSTER-HEADS

In TB-LEACH, competition for cluster-heads (CHs) no longer depends on a random number as in LEACH, and a random time interval instead. Nodes which have the shortest time interval will win the competition and become cluster heads. In order to obtain a constant number of cluster-heads, we set a counter. When the number of the counter has reached specified value, nodes no longer continue competition for cluster-heads [9], [13].

For example, here, the nodes need to elect four CHs. Every node in the network produces a random timer at the beginning of a round. When the timer expires, and if the number which node has received of CHs' advertisement messages (CH_ADV) is less than four, the node broadcast a CHs advertisement message to announce its CH status by using a non-persistent carrier-sense multiple access (CSMA) MAC protocol. Else, it can't become a Cluster-head.

Once CHs are elected, the following processes are completely similar to LEACH. Of course, this algorithm is still a distributed algorithm, that is, nodes make autonomous decisions without any centralized control [8], [13], [14],[16], [18].

D. Flowchart and pseudo code:

To describe this cluster formation algorithm furthermore, a flowchart is given in Fig.6.

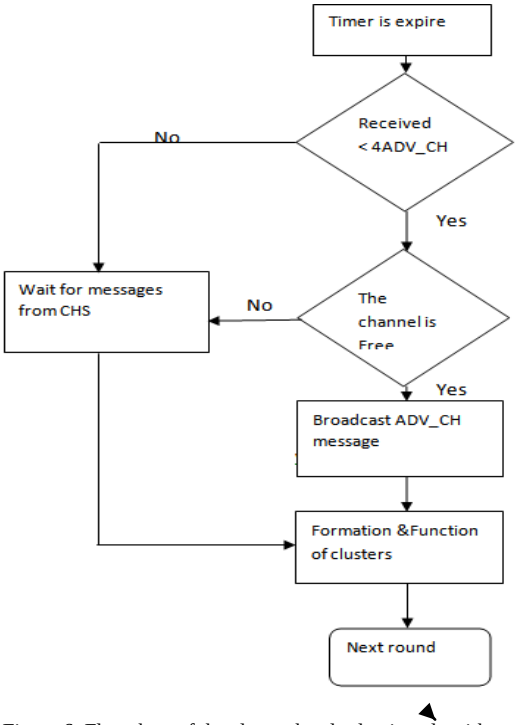

Figure 6. Flowchart of the cluster-head selection algorithm.

Here, we present the pseudo codes of the Cluster Head Selection Algorithm:

```
Networklnterface. ·: DecideCH (node i)
if  HasbeenCH = YES
then Random_timer = MAX_time
Else Random_timer =Random_timer_generator (MAX_time)
backoff (Random_Timer)
```

```
if ReceiveCH_ADV < 4
then send (CH_ADV)
set_CH ( )
HasbeenCH = YES
else HasbeenCH = NO
```

This abstract function contains the following members:
Random_timer-generator( ) schedule a timer to expire delay seconds in the future.
Backof( ) events following this method will be invoked upon timer expiration
Send ( ) broadcast a message

E. Simulation Parameters:

a. Sensor nodes contain two kinds of nodes: sink nodes (no energy restriction) and common nodes (with energy restriction);
b. Nodes are randomly distributed in a area within 80m×80m, and the efficient distance among nodes is 15m;
c. Suppose that every node knows its position, channels between sensor nodes are ideal, sending energy consumption is the same as receiving energy consumption, energy consumption in each round is 0.05J, and initial energy of each node is 10J;
d. Energy consumption between cluster head and sink is 59 times of the energy consumption among common nodes;
e. Probability of being cluster head equals 0.04;
f. Node sends data in every 0.5s, and sends data in every time interval at a random time by a TDMA slotted MAC (Medium Access Control) protocol;
g. Network with same number of nodes still may have different performance due to network structure. In our simulation, the network topology is randomly built each time, and simulation results are averaged for 3 different network topologies.

Our protocol is a routing protocol which based on LEACH described above with the introduction of related work. Such innovation can extend the lifetime of the whole network due to much less energy dissipation for data transmission to basic station. In this section, we will expatiate on the details of our protocol. The data transmission from sensor node to sink node may two-hop or multi-hops. In LEACH protocol sensor node transmit its data to sink node through two hops [5],[8],[11],[21]. After clustering, the typical LEACH work statement as follow figure7:

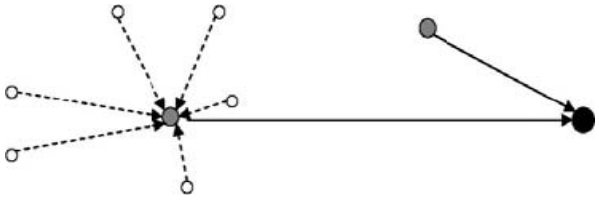

Figure 7. LEACH work statement

Considering the optimal routing, we can set up an optimal two-hop shortest path from sensor node to sink node. In our protocol, the initial hop is not selected from whole nodes, but randomly selected in some cluster heads. Therefore, the calculate complexity of optimal route is greatly reduced than the calculate complexity of overall route. In our new algorithm, we can get a new clustering based on Fig.7 as follow:

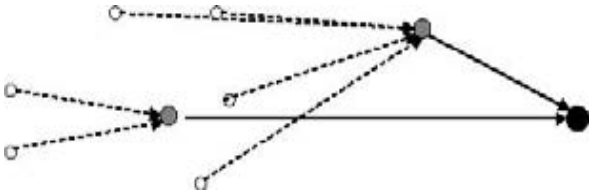

Figure.8 Improving protocol cluster

In our new protocol, it can make the cluster head closed to sink node as much as possible. The operation of the novel protocol is broken up into four steps:

a) Cluster heads are randomly selected in the sensor network;
b) Each cluster head broadcast its location information to sensor node by certain power and direction; In this phase, the certain power and direction for the sake of save energy. Figure7 shows clearly that the cluster head unnecessary send information to the node which is closer to sink. In a large scale and evenly distribute network, if the distance between cluster head and sink node is obvious father than the distance between all nodes and sink node, the cluster head is impossible selected to transmit information.
c) When nodes receive the information which are transmitted by cluster head, each node select a cluster node i. Then, the cluster node I has to satisfy the condition that the solution to KDi^{a} + KLi^{a} *is* minimum. (k is proportion coefficient, d_i is the distance between node and cluster head i, L_i *is* the distance between sink and cluster head i, a is path consumption factor)
d) After a certain period of time, nodes select the cluster head again, repeat the upper steps

Based on the upper process, we can get a typical cluster structure figure as follow:

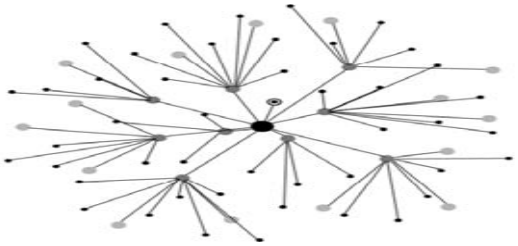

Figure.9. cluster structure

In Fig.9, the black solid dot in the centre of network is sink node; the small black dot is node. The deep gray dot is cluster head; the grayish is the cluster head which is randomly selected in the first step and blank out in the second step. In Fig.9 concentric round above the node is the node which is not receive data from cluster head in the second step, the node communicate with sink node directly or sleep.

Fig9 shows each cluster has difference, if the sink node locates in the centre of the roundness network, the cluster head which locate at 1/2 radius may has a lot of node as its member

node. This will lead the cluster size asymmetry, the size of cluster far from sink node bigger than the cluster close to the sink node. To solve this problem, we divide the big size cluster again. This solution is to ensure the lowest layer cluster has minimized overcast radius [5],[12],[19],[20].

V. CONCLUSION AND FUTURE SCOPE

In this paper, we analyzed the methods of reducing energy dissipation used in clustering-based routing protocol LEACH. We proposed a multi-hop routing protocol with LEACH (Low Energy Adaptive Cluster Hierarchy) to minimize the energy consumption of sensor nodes. According to principles mentioned in part4, the cluster heads will select new cluster heads in field of their own cluster for the followed rounds. LEACH achieves better performance and has good robustness and adaptability too. It is suitable for applications in the large-scale WSN .Such improvement consequently assure the improvement of the overall WSN lifetime.

The future scope of this paper is that we can establish the Homogeneous network and we also establish that network which have maximum live time.

VI. REFERENCES

[1]. M. Dong, K. Yung, and W. Kaiser. Low Power Signal Processing Architectures for Network Microsensors. In Proceedings 1997 International Symposium on Low Power Electronics and Design, Aug. 1997, pages 173– 177

[2]. Chandrakasan, Amirtharajah, Cho, Goodman, Konduri, Kulik,Rabiner and Wang. Design Considerations for Distributed Microsensor Systems. In IEEE 1999 Custom Integrated CircuitsConference (CICC), May1999, pages 279–286.

[3]. Clare, Pottie, and Agre. Self-Organizing Distributed Sensor Networks. In SPIE Conference on Unattended Ground Sensor Technologies and Applications, Apr. 1999, pages 229–237

[4]. Marcos, Diogenes. 2003. Survey on Wireless Sensor Network Devices. IEEE

[5]. L.V.Hosel, T. Nieber, Jian Wu, Prolonging the Lifetime of Wireless Sensor Networks by Cross-layer Design. In Proceedings IEEE Wireless Communications, December 2004, pages 80-86.

[6]. Wei Bo, Hu Han-ying, Fu Wen, A pseudo LEACH algorithm for wireless sensor networks. In proceeding IAENG, March,2007

[7]. Fan Xiangning," Improvement on LEACH Protocol of Wireless Sensor Network", 2007 International Conference on Sensor Technologies and Applications 0-7695-2988-7/07© 2007 IEEE.

[8]. Sohrabi K, Gao J, Ailawadhi V, Pottie GJ. Protocols for self organization of a wireless sensor network, IEEE Personal Comm.Mag. 2000, 7(5):16−27.

[9]. Haiming Yang, Biplab Sikdar," Optimal Cluster Head Selection in the LEACH Architecture",Performance, Computing, and Communications Conference, 2007. IPCCC 2007, IEEE International 2.

[10]. Wei Bo Hu Han," An Improved LEACH Protocol for Data Gathering and Aggregation in Wireless Sensor Networks", 2008 International Conference on Computer and Electrical Engineering 978-0-7695-3504-3/08© 2008 IEEE.

[11]. Wei Wang," Leach-H: An Improved Routing Protocol for Collaborative Sensing Networks",978-1-4244-5668-0/09© 2009 IEEE.

[12]. Hu Junping," A Time-based Cluster-Head Selection Algorithm for LEACH", 978-1-4244-2703-1/08 ©2008 IEEE 978-1-4244-3709-2/10/$25.00 ©2010 IEEE.

[13]. Deng Zhixiang," Three-layered Routing Protocol for WSN Based on LEACH Algorithm".

[14]. Haosong Gou," An Energy Balancing LEACH Algorithm for Wireless Sensor Networks", 2010 Seventh International Conference on Information Technology 978-0-7695-3984-3/10© 2010 IEEE.

[15]. Muhamnmad Omer Farooq," MR-LEACH: Multi-hop Routing with Low Energy Adaptive Clustering Hierarchy", 2010 Fourth International Conference on Sensor Technologies and Applications 978-0-7695-4096-2/10© 2010 IEEE.

[16]. Wu Xinhua," Performance Comparison of LEACH and LEACH-C Protocols by NS2",2010 Ninth International Symposium on Distributed Computing and Applications to Business, Engineering and Science 978-0-7695-4110-5/10© 2010 IEEE.

[17]. Li-Qing Guo," Improvement On LEACH By Combining Adaptive Cluster Head Election And Two-Hop Transmission", Proceedings of the Ninth International Conference on Machine Learning and Cybernetics 978-1-4244-6527 -9/10©2010 IEEE.

[18]. Mu Tong," LEACH-B:An Improved LEACH Protocol for Wireless Sensor Network", 978-1-4244-3709-2/10©2010 IEEE .

[19]. Bilal Abu Bakr," A Quantitative Comparison of Energy Consumption and WSN Lifetime for LEACH and LEACH-SM", 2011 31st International Conference on Distributed Computing Systems Workshops 1545-0678/11© 2011 IEEE.

[20]. Bilal Abu Bakr," Extending Wireless Sensor Network Lifetime in the LEACH-SM Protocol by Spare Selection",11 Fifth International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing 978-0-7695-4372-7/11© 2011 IEEE.

[21]. Ye W, Heidenmann J, Estrin D. An energy-efficient MAC protocol for wireless sensor networks. In: Proc. of the IEEE INFOCOM.2002.http://www.isi.edu/div7/publication_files/Ye02a.pdf.