Study of Wireless Sensor Network Using LEACH Protocol

Himanshi, Shruti Vashist, M.K.Soni

Abstract*— Wireless sensor networks (WSNs) have been identified as one of the most important technologies for the 21st century. A wireless sensor network with a large number of sensor nodes can be used as an effective tool for gathering data in various situations. This paper focuses on study of WSN using a communication protocol called LEACH protocol. LEACH is very effective in enhancing lifetime of the nodes

Index Terms- Energy efficiency, Wireless sensor network, LEACH, clustering

I. INTRODUCTION

Wireless sensor network (WSN) has attracted considerable attentions during the last few years. A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location named as sink or base station. Each node in the network is connected to each other. These sensors have the ability to communicate either amongst themselves or directly to an external base-station (BS). A greater number of sensors allows sensing over larger geographical regions with greater accuracy.. Data is collected at the wireless sensor node, compressed, and transmitted to the BS directly or, if required, uses other wireless sensor nodes to forward data to the BS [1]. LEACH (Low-Energy Adaptive Clustering Hierarchy) is a routing protocol for wireless sensor networks in which: the base station (sink) is fixed and sensor nodes are homogenous.

It is assumed that the BS is located at the center of the sensing region. The paper is organized as follows: Section II gives the characteristics of WSN and cluster organization in LEACH protocol. Section III gives details of energy model. Section IV introduces LEACH protocol. Section VI gives simulation result are analyzed. Section VI is the conclusion.

II. CHARACTERISTICS OF WIRELESS SENSOR NETWORK

- WSN consists of two kinds of nodes:
  - ***Sensor nodes*** whose function is to sense their own residual energy and have limited energy.
  - ***Base station*** to which aggregated data has to be transmitted and have no energy restriction

Manuscript Received on July, 2013.

Himanshi, M.Tech student, Department of Electronics & Communication Engineering, Faculty of Engineering and Technology, Manav Rachna International University Faculty of Engineering and Technology, Manav Rachna International University

Shruti Vashist, M.Tech student, Department of Electronics & Communication Engineering, Faculty of Engineering and Technology, Manav Rachna International University Faculty of Engineering and Technology, Manav Rachna International University

M.K.Soni, M.Tech student, Department of Electronics & Communication Engineering, Faculty of Engineering and Technology, Manav Rachna International University Faculty of Engineering and Technology, Manav Rachna International University

- All nodes are fixed. They use the direct transmission or multi-hop transmission to communicate with the BS.
- Cluster head perform data aggregation and BS receives compressed data.
- Sensor nodes sense environment at a fixed rate.
- Nodes have to sense the data and then send collected data to sink (base station) [2].

Fig 1 shows the WSN with sensor nodes and the base station.

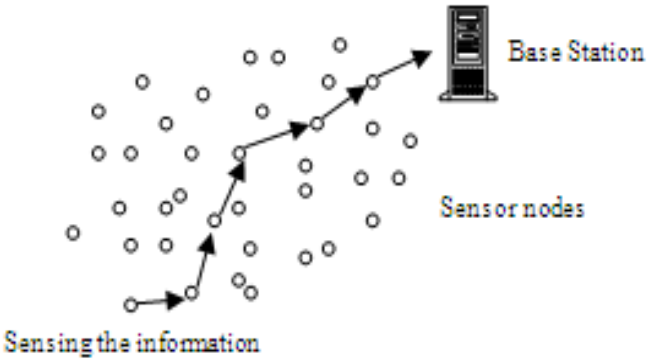

Fig 1: Wireless Sensor Network

Cluster:

Clustering is an effective technique that can greatly contribute to lifetime, and energy efficiency in wireless sensor networks (WSNs). A sensor network can be made scalable by assembling the sensor nodes into groups i.e. clusters. Every cluster has a leader, often referred to as the cluster head (CH).

An energy-efficient communication protocol LEACH, has been introduced which employs a hierarchical clustering done based on information received by the BS. The CH collects and aggregates information from sensors in its own cluster and passes on information to the BS [3]. By rotating the cluster-head randomly, energy consumption is expected to be uniformly distributed. In each round of the cluster formation, network needs to follow the following steps

- select cluster head
- transfer the aggregated data.

Data is collected at the wireless sensor node, compressed, and transmitted to the BS [1]. Since sensor nodes are energy constrained, it is inefficient for all the sensors to transmit the data directly to the BS. Data generated from neighboring sensors is often redundant and highly correlated.

To overcome the issue data aggregation is performed. Data aggregation involves the fusion of data at intermediate nodes and transmission of the aggregated data to the BS. Data aggregation can eliminate redundancy; minimize the number

of transmissions and thus save energy [4,7]. Fig 2 shows the organization of the cluster for sensor network.

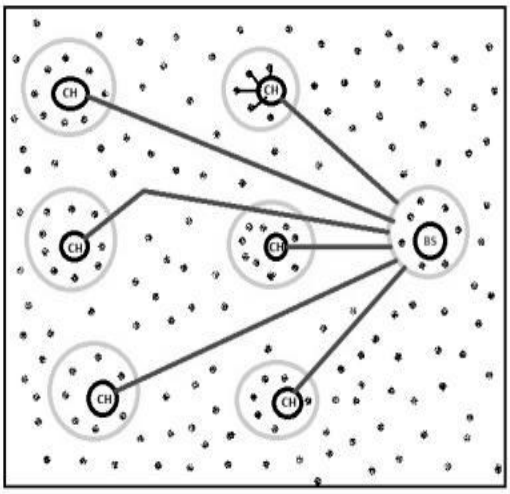

Fig 2. Cluster organization for sensor networks

III. ENERGY DISSIPATION MODEL

The radio hardware dissipation model assumed in LEACH [9] is a simple radio model as disused in [5,6]. In this model, when the distance of a node transmitting data to other nodes or the base station is greater than the threshold (Tn) , the multipath (mp) fading channel model is used. When the distance between a node transmitting data to other nodes or the base station is less than threshold the free space (fs) channel model is used (power loss).

Thus, to transmit a l-bit message at distance d, the radio transmission energy is given by:

$$E_{TX} = \begin{cases} L * E_{elec} + L * \varepsilon_{fs} * d^2 & d < d_{crossover} \\ L * E_{elec} + L * \varepsilon_{mp} * d^4 & d \geq d_{crossover} \end{cases}$$

- Where $d_{crossover} = \sqrt{\varepsilon_{fs} / \varepsilon_{mp}}$ denotes the threshold distance
- E_{elec} represents the energy consumption in the for sending or receiving one bit
- $\varepsilon_{fs}d^2$ and $\varepsilon_{mp}d^4$ is the amplifier energy that depends on the transmitter amplifier model.
- $E_{DA\ is}$ data aggregation

The energy consumption of receiving l-bit data is ERx (l) = $L*E_{elec}$

Fig 3 gives energy dissipation model [8].

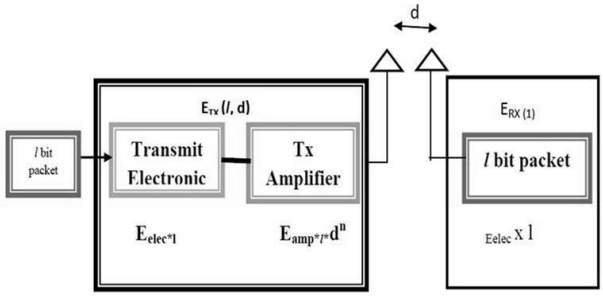

Fig 3: Radio energy dissipation model

Here we use the typical values E_{elec} = 70 nJ/bit, ε_{fs} = 10 pJ/bit/m2 and ε_{mp} = 120 pJ/bit/m2. The energy for data aggregation is set as E_{DA} = 5 nJ/bit/signal.

IV. LEACH PROTOCOL

Low Energy Adaptive Clustering Hierarchy (LEACH) proposed by Wendi B. Heinzelman, *et al.* [3] is the first hierarchical, self-organizing, adaptive cluster-based routing protocol for wireless sensor networks which partitions the nodes into clusters.

LEACH [3] is a hierarchical protocol in which most nodes transmits the data to cluster heads, and the cluster heads aggregate and compress the data and forward it to the base station. Node first senses its target and then sends the relevant information to its cluster-head. Then the cluster head aggregates and compresses the information received from all the nodes and sends it to the base station.

Nodes that have been cluster heads cannot become cluster heads again for P rounds, where P is the desired percentage of cluster heads. Thereafter, each node has a 1/P probability of becoming a cluster head in each round. At the end of each round, each node that is not a cluster head selects the closest cluster head and joins that cluster. The cluster head then creates a schedule for each node in its cluster to transmit its data.

Each sensor node n generates a random number such that 0< random < 1 and compares it to a pre-defined threshold T (n). If random < T (n), the sensor node becomes cluster-head in that round, otherwise it is cluster member.

The threshold is set

$$T(n) = \begin{cases} \dfrac{P}{1 - P * (r \bmod \frac{1}{P})} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

Where P is the desired percentage of cluster heads, r is the current round, and G is the set of nodes that have not been cluster head in the last 1/P rounds. After the cluster heads are selected, the cluster heads advertise to all sensor nodes in them network that they are the new cluster heads. Then, the other nodes organize themselves into local clusters by choosing the most appropriate cluster head (normally the closest cluster head). During the steady-state phase the cluster heads receive sensed data from cluster members, and transfer the aggregated data to the BS. This protocol is divided into rounds each round consists of two phases:

1. **SET UP PHASE:** Initially, when clusters are being created, each node decides whether or not to become a cluster-head for the current round. This decision is made by the node n choosing a random number between 0 and 1. If the number is less than a threshold, the node becomes a cluster-head for the current round. Each node that has elected itself a cluster-head for the current round broadcasts an advertisement message to the rest of the nodes. For this "cluster-head-advertisement" phase, the cluster-heads use a CSMA MAC protocol, and all cluster-heads transmit their advertisement using the same transmit energy. The non-cluster-head nodes must keep their receivers on during this phase of set-up to hear the advertisements of all the cluster-head nodes. After this phase is complete, each non-cluster-head node decides the cluster to which it will belong for this round. This decision is based on the received signal

strength of the advertisement.

2. **STEADY STATE PHASE:** The process of transferring aggregated data or sensed data from all the sensor nodes to the sink or base station is done under steady state phase. During this phase, nodes in each cluster sends data based on the allocated transmission time to their local cluster heads. To reduce the energy dissipation, the receiver of all non-cluster head nodes would be turned off until the nodes' defined allocated time. After receiving all the data from the nodes, the cluster head aggregates all the data sent from the member nodes into a single signal and transfers it to the base station. The duration of the steady state phase is longer than the duration of the set-up phase in order to minimize overhead

The flowchart of LEACH algorithm is presented in Figure.

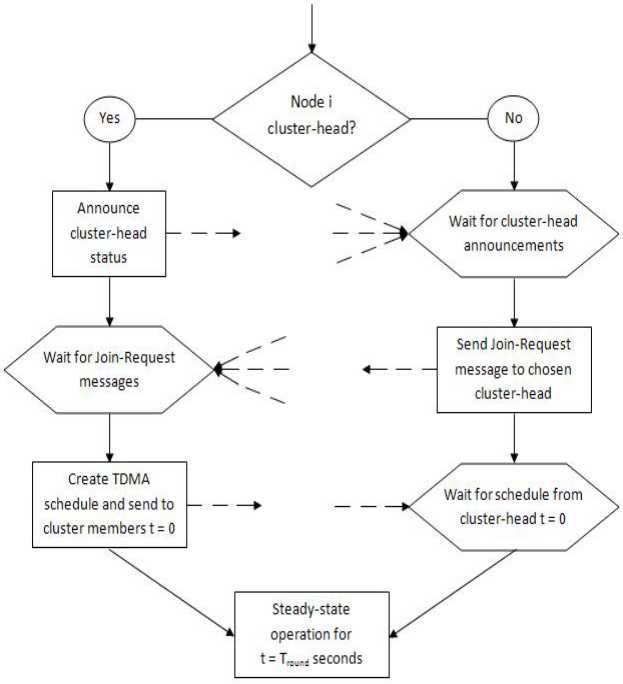

Fig 4: LEACH flow chart diagram

To complete the set-up phase, each node send a join-request message after they receive a broadcast from the elected cluster-heads using a non-persistent CSMA MAC protocol. The cluster-head creates a TDMA as shown in the LEACH flow chart and finally the nodes forming each cluster wait for their schedule before transmission. The steady phase starts immediately after the set-up phase. The cluster-heads gather all data from their respective cluster members and send the respected data to the base station. Fig 5 shows the Set up phase and Steady state phase.

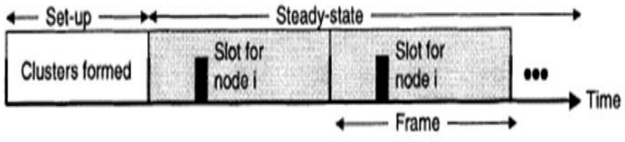

Fig 5. Set up and Steady state phase of LEACH

V. SIMULATION RESULT

The simulation is done using MATLAB. Let us assume the heterogeneous sensor network with 100 sensor nodes are randomly distributed in the 100m*100m area. The base station is located at the center (50, 50). We have set the minimum probability for becoming a cluster head (*pmin*) to 0.0001 and initially energy given to each node is 0.5. The desired parameters are shown in table 1.

TABLE 1: Simulation Parameters

Parameters	Value
No. of nodes	100
Sink(base station)	at(50,50)
Eelec	70 nJoul
Eamp	120 pJoul
Data Aggregation Energy, EDA	5 nJoul
Initial Energy, E0	0.5
No. of rounds, r	1000

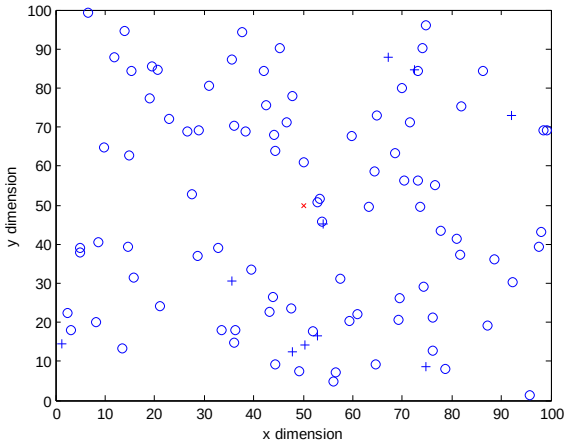

Fig 6: Normal and advanced nodes are shown by circle 'o' sign and '+' sign respectively

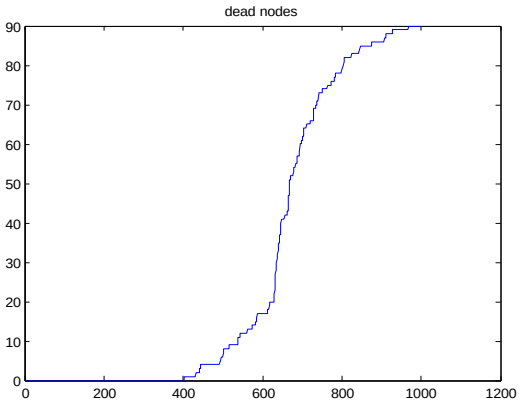

Fig 7.

In fig 7, the death of first node in the network appears at 400th round and death network completes at 980th round. The simulation is carried out with the location of the BS, at (x = 50; y = 50) inside the sensing field. As the number of rounds increases, number of alive nodes decreases due to power consumption.

VI. CONCLUSION

In this paper the simulation result shows the creation of dead and alive nodes ,its residual energy and the creation of normal and advanced node in 100mts*100 mts

environment using MATLAB.The simulation of all the parameters are based on a well-known energy efficient clustering algorithm for WSNs called LEACH algorithm. The calculation of energy of all the nodes are derived using threshold equation.

REFERENCES

1. Networks," International Journal of Soft Computing and Engineering (IJSCE), vol. 1, no. 1, pp. 33-42, 2011.
2. Jun Zheng and Abbas Jamalipour.New Jersey, John Wiley & Sons, 2009
3. W. Heinzelman, A. Chandrakasan and H. Balakrishnan, "Energy-efficient Communication Protocol for Wireless Microsensor Networks", Proceeding of the 33rd Hawaii International Conference on System Sciences, January 2000
4. B. Krishnamachari, D. Estrin, and S. Wicker, "The Impact of Data Aggregation in Wireless Sensor Networks," 22nd International Conference on Distributed Computing Systems Workshops, pp. 575-578, 2002.
5. M.Shankar, Dr.M.Sridar, Dr.M.Rajani, "Performance Evaluation of LEACH Protocol in Wireless Network ", International Journal of Scientific & Engineering Research, Volume 3, Issue 1, January-2012 1 ISSN 2229-5518.
6. W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, "An Application-Specific Algorithm Architecture for Wireless Microsensor Networks," IEEE Transactions on Wireless Communications, vol no.4, pp. 660-670, 2002.
7. R. Rajagopalan, and P. Varshney, "Data Aggregation Techniques in Sensor Networks: A Survey," IEEE Communications Surveys & Tutorials, vol. 8, no. 4, pp. 48-63, 2006.
8. W. B. Heinzelman, Application-Specific Protocol Architectures for Wireless Networks, PhD thesis, Massachusetts Institute of Technology, June 2000.
9. Panghal Amanjeet, Mittal Nitin, Singh D.P. & Chauhan R.S. (2010) Improved leach communication protocol for WSN ,National Conference on Computational Instrumentation CSIO Chandigarh, INDIA,177-181.