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Study of LEACH Routing Protocol for Wireless Sensor Networks

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Abstract
Wireless sensor network (WSN) have great potential to support several important wireless applications including real-time multimedia communication, medical applications, surveillance using sensor networks. Industrial applications military surveillance and home networks applications. Wireless sensor network (WSN) is a network consists of large number of low power sensor nodes. LEACH is a less energy adaptive clustering hierarchy protocol. The main goal of cluster based sensor networks is to decrease system delay and reduce energy consumption. LEACH is a cluster based protocol for micro sensor networks which achieves energy efficient, scalable routing and fair media access for sensor nodes. Many improvements are done in wireless sensor network. Security is very essential in wireless sensor network. This paper describes LEACH protocol, their advantages, disadvantages etc. This paper depicts LEACH convention, their points of interest, disservices and so forth. The paper is composed as pursues: In segment I, contains presentation, segment II contains portrayal of LEACH Protocol, and segment III contains writing survey.

Keywords: Wireless Sensor Networks, LEACH Protocol, Cluster, Cluster Head, Attacks

1. Introduction
A Wireless Sensor Networks (WSNs) form a subset of Ad-hoc networks as shown in Fig.1.1. Wireless sensor networks have many restrictions compared to Ad-Hoc net- works in terms of its sensor nodes' capability of memory storage, processing and the available energy source. Wireless sensor networks are generally assumed to be energy restrained because sensor nodes operate with small capacity DC source or may be placed such that replacement of its energy source is not possible. Even though sensor networks are a subset of ad hoc networks, the protocols designed for ad hoc networks cannot be used as it is due to the reasons cited in [23].

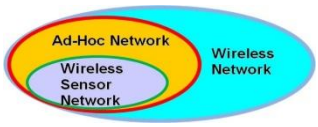


Fig 1.1: Wireless Sensor Network as Subset of Wireless Network

A WSN (see Fig.1.2) consists of spatially distributed autonomous sensors nodes to cooperatively monitor physical or environmental conditions. The nodes communicate wirelessly and often self-organize after being deployed in an ad-hoc fashion. A WSN may consist of hundreds or even thousands of nodes. Source nodes transmit their data to destination nodes through intermediate nodes. This destination node is connected to a central gateway, also known as base station. Central gateway provides a connection to the wired world where the data can be collected, processed, and analyzed.

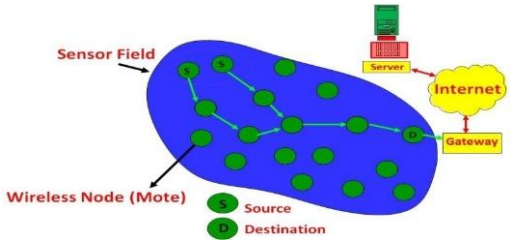


Fig 1.2: A Wireless sensor Network

The WSN consist of two main components

1. Sensor Nodes, and
2. Base Station (Central Gateway)

1.1 Application of Wireless Sensor Network

Wireless Sensor Networks (WSN) offers a rich, multi-disciplinary area of research, in which a number of tools and concepts can be applied to address a whole diverse set of applications. Sensor networks may consist of many deferent types of sensors such as magnetic, thermal, visual, seismic, infrared and radar, which are able to monitor a wide variety of conditions. These sensor nodes can be put for continuous sensing, location sensing, motion sensing and event detection. The idea of micro-sensing and wireless connection of these sensor nodes promises many new application areas. A few examples of their applications are as follows:

1. Area Monitoring Applications
2. Environmental Applications
3. Health Applications
4. Industrial Applications
5. Other Applications

Sensor networks now find huge application in our day-to-day appliances like vacuum cleaners, micro-wave ovens, VCRs and refrigerators. Other commercial applications in- cludes constructing smart oce spaces, monitoring product quality, managing inventory, factory instrumentation and many more.

2. LEACH Protocol

Filter convention is a TDMA based MAC convention. The primary point of this convention is to improve the life expectancy of remote sensor arranges by bringing down the vitality. Drain convention comprises of two phases protocol and after that in the third segment we will talk about the periods of LEACH convention. In the fourth area we characterize different conceivable assaults on it and in the fifth segment there are the favorable circumstances and disservices of LEACH. In the last area we contrast LEACH and different conventions.

1) Set-up phase
2) Steady phase

Operation of LEACH protocol consists of several rounds with two phases in each round. LEACH protocol is a typically representation of hierarchical routing protocol. It is self-adaptive and self-organized [2]. LEACH protocol uses round as unit, each round is made up of cluster set-up stage and steady state storage for the purpose of reducing unnecessary energy costs.

2.1. Set-up phase

In the set-up phase, the main goal is to make cluster and select the cluster head for each of the cluster by choosing the sensor node with maximum energy [3]. Set-up phase has three fundamental steps:

i. Cluster head advertisement
ii. Cluster set up
iii. Creation of transmission schedule

During the first step cluster head sends the advertisement packet to inform the cluster nodes that they have become a cluster head on the basis of the following formula:

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

Where n is a random number between 0 and 1
P is the cluster-head probability and
G is the set of nodes that weren't cluster-heads previous rounds
T (n) is the threshold

Node becomes cluster head for the current round if the number is less than threshold T (n). Once node is elected as a cluster head then it cannot become cluster head again until all the nodes of the cluster have become cluster head once. This is useful for balancing the energy consumption. In the second step, non-cluster head nodes receive the cluster head advertisement and then send join request to the cluster head informing that they are members of the cluster under that cluster head. All non-cluster head nodes save a lot of energy by turning off their transmitter all the time and turn it on only when they have something to transmit to the cluster head [2].

2.2. Steady phase

In steady phase, cluster nodes send their data to the cluster head. The member sensors in each cluster can communicate only with the cluster head via a single hop transmission. Cluster head aggregates all the collected data and forwards data to the base station either directly or via other cluster head along with the static route defined in the source code. After predefined time, the network again goes back to the set-up phase.

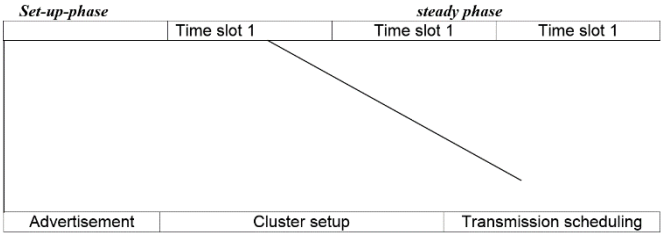


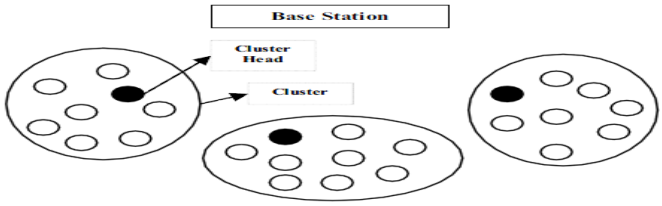
Fig 1: Time Line Operation of LEACH

3. Cluster Head Selection Algorithm in LEACH

Two phases are in LEACH protocol which is (i) the cluster formation and (ii) data receiving and transmission phase and round as defined the time slot gap between two phases. In the cluster head selection phase sensor node generates a random number which lies within 0 and 1, if that number is less than threshold value T (n) then in that round it selects that node to act as cluster head, and acknowledge that node to the other neighbor [11]. The formula for T (n) is given below:

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

r indicates the present round, selection of a node to be a cluster head with probability, p and those nodes are still not become cluster head in previous (r-1) round, will form another set G. We consider here N as the total number of nodes in the network, the approximate number of cluster head to be considered as k, where p =k/N. Each node has opportunity to become a cluster head once by this algorithm, if one node become cluster head in a particular round, it will lose to become another time cluster head in other round.



Cluster Formation in LEACH

Modified LEACH Protocol

3.1 Our Energy Model

In our protocol we consider energy for each round. We consider our energy model as given below:

$$Energy = Energy + S(i).E\frac{i-1}{r\ max - i} \quad (1)$$

Where i stands for number of iteration, r max is maximum number of rounds, Energy as our initial energy and S(i).E consider as energy level of each node after rounds.

3.2 Analysis of Modified LEACH

Energy consumption of the network under different number of rounds for LEACH and Modified LEACH protocol has been carried out and from simulated result it is observed using Eq. (1) our protocol reduces energy consumption than LEACH protocol, which has been shown in Fig. 2.

3.2.1 Simulation of Modified LEACH

In our simulation we consider 100 nodes randomly distribute within the square area of the 100m*100m, the base station is located in the centre of the region, the base station coordinates is (50, 50). It can be seen from the Fig. 1 that the nodes' are distributed randomly.

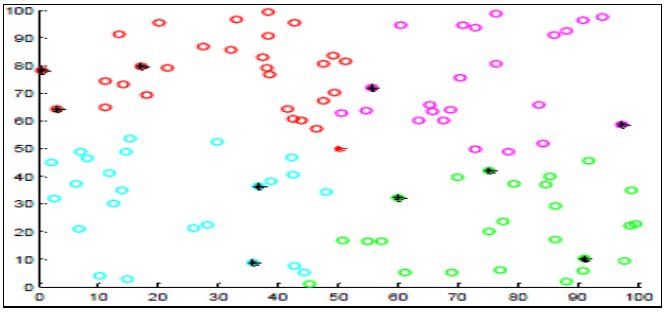


Fig 1: Randomly Distributed Nodes

In Fig. 1 cluster head are selecting from nodes and transmitting data to base station. Energy consumption is more in LEACH than Modified LEACH. We Consider 100 nodes for simulation LEACH and Modified.

3.3.2 Data Received by Base Station

Fig. 8 shows the comparison between the amounts of data received by base station with time. There are effective broadcast by cluster head, because of the effective data transmission fail means retransmission is needed that will send more data to the base station. Here the simulation has been done upto 500s and cluster head stop sending data until the transmitted data reached at destination. Our protocol, Modified LEACH protocol under optimum number of cluster head can improve efficiency of the wireless sensor networks.

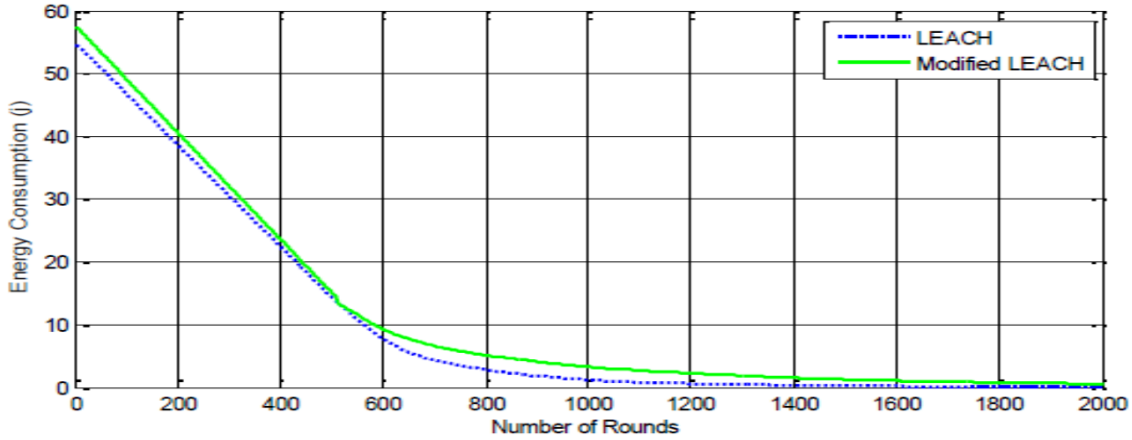


Fig 2: Comparison of energy Consumption between our protocol & LEACH

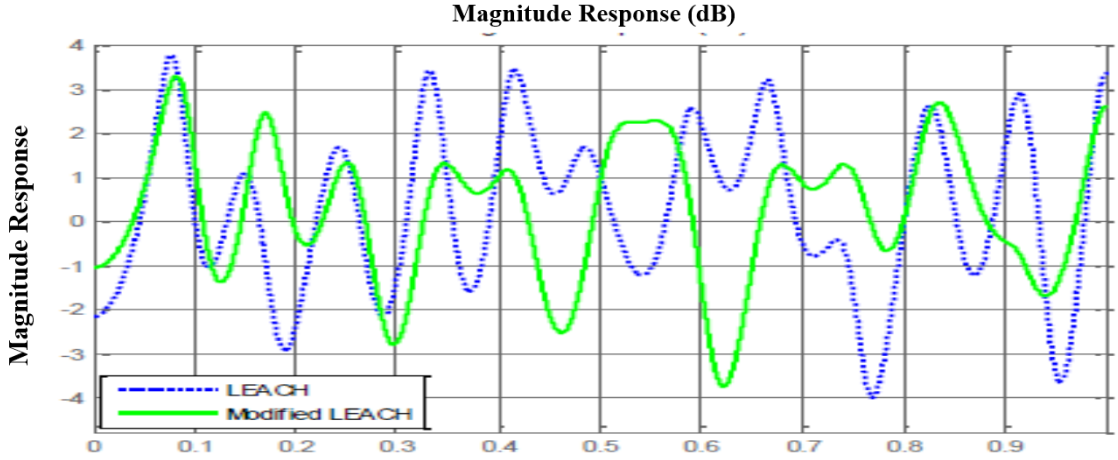


Fig 3: Comparison of magnitude of data transmission between our protocol and LEACH

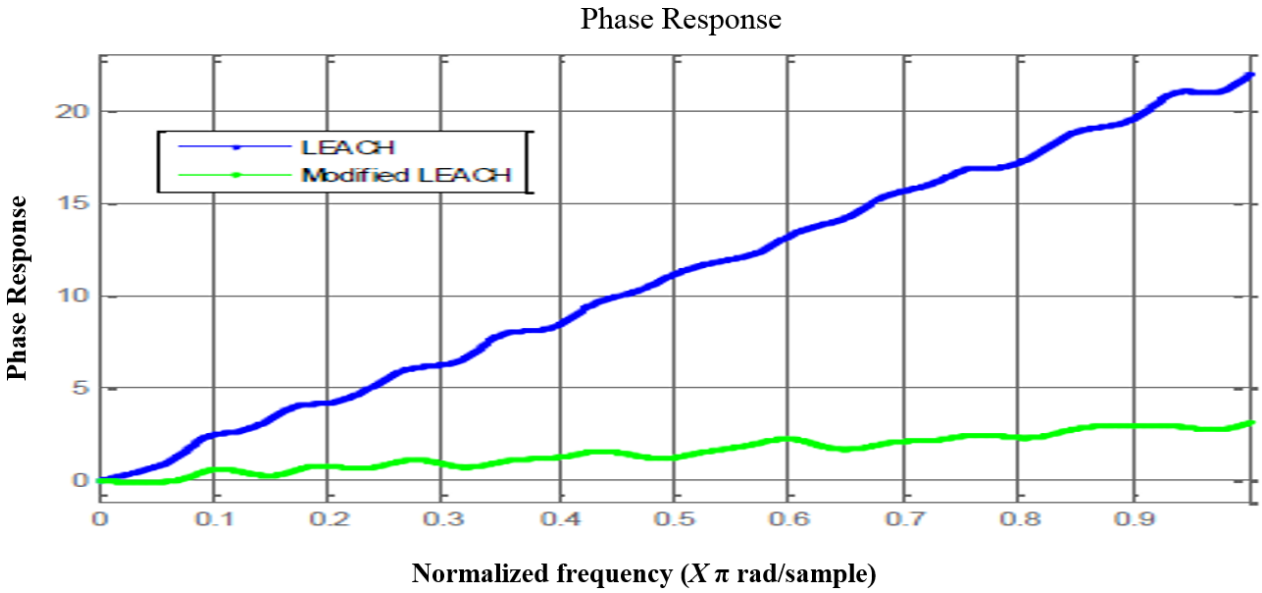


Fig 4: Phase recognition for Modified LEACH and LEACH

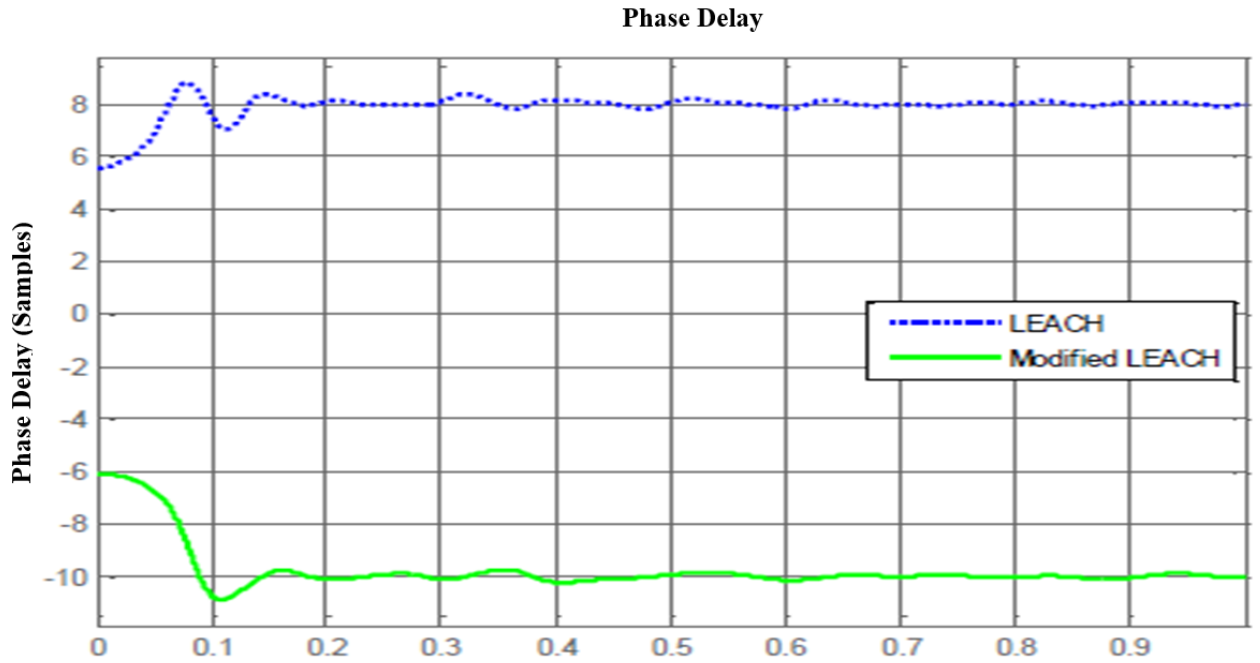


Fig 5: Phase delay between our protocol and LEACH

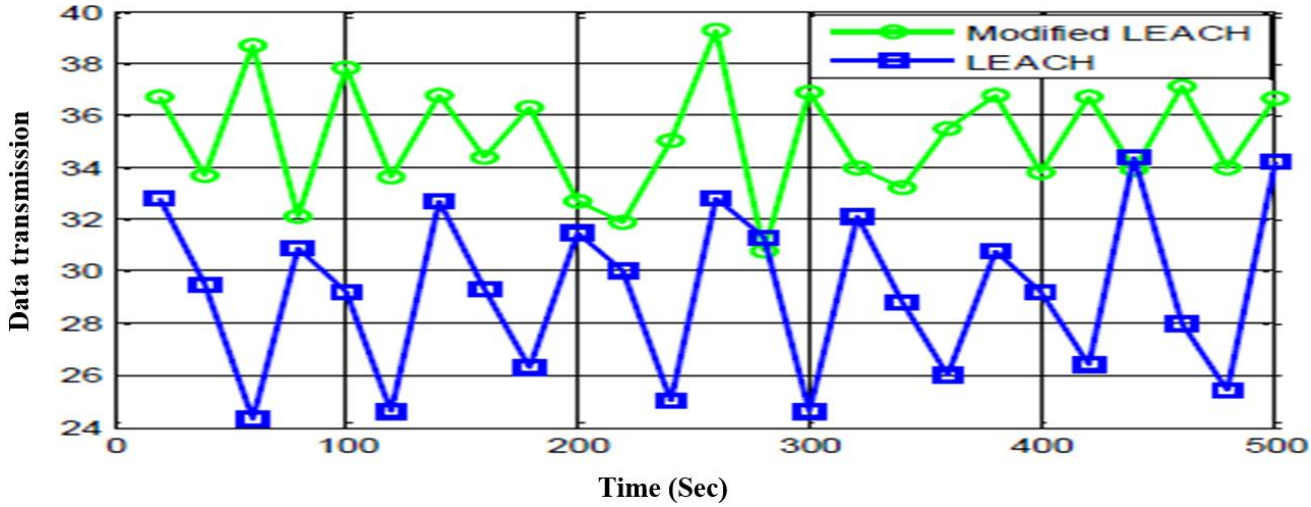


Fig 6: Data transmission of Modified LEACH and LEACH protocol

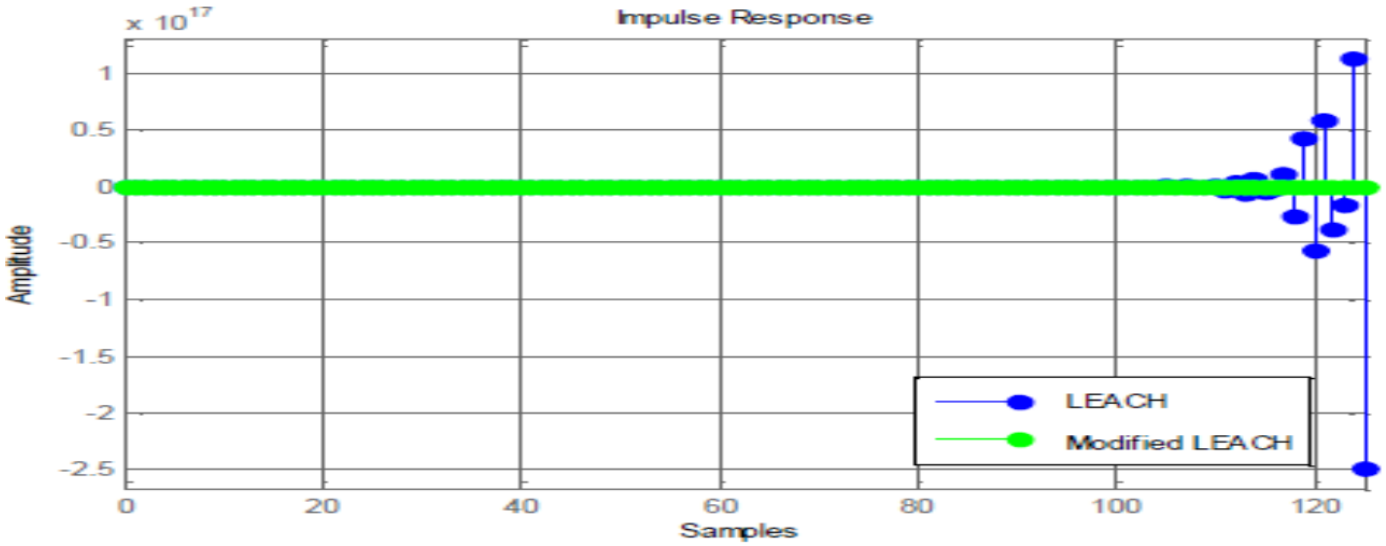


Fig 7: Amplitude of transmission of modified LEACH & LEACH

Parameters	Notations	Value
Number of nodes	N	100
Base Station location	(x_i, y_i)	(50,50)
The initial node energy	E_0	0.5J
Energy consumed by the amplifier to transmit at shortest distance	E_{amp}	120 pJ/bit/m^2
Energy consumed by the amplifier to transmit at longest distance	E_{fs}	10 pJ/bit/m^2
Energy consumed in the electronics circuit to transmit or receive the signal	E_{elec}	70pJ/bit
Data packet	K	4096 bits/frame
Data aggregation energy	E_{da}	5nJ/bit/report
The cluster probability of Modified LEACH	p	0.1
The Sensing area	M×M	100M×100M
Simulation time	T	3hours

Table 1: Transmission Parameters Value used for simulation

4. Performance Analysis

Heuristic simulation carried out by using MATLAB for both LEACH and Modified LEACH. In Fig.2 compares energy consumption with increasing on nodes in the network and shows Modified LEACH prolong system lifetime. Fig. 4 explains node broadcast with time is increasing than LEACH protocol. The result in Fig. 5 shows better perform of modified LEACH indicates for long run Modified LEACH will be much more applicable than LEACH.

5. Conclusion

LEACH and Modified LEACH protocols were implemented in Tiny OS with some degree of success. The basic evaluation of these protocols was carried out and different phase comparison has been made and showed by different graphs. During the design and implementation of the protocols it was clear that performance gains by Modified LEACH better than LEACH. The implemented protocols might prove to be more successful when used for routing packets in sensor networks.

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