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ENHANCED LEACH-C PROTOCOL FOR CLUSTER BASED ROUTING IN ENERGY EFFICIENT WIRELESS SENSOR NETWORKS

Neha[1], Sugandha Singh[2]

[1]Research Scholar, [2] Asso. Professor and Head, CSE Deptt., PDM College of Engineering, Bhadurgarh, MDU, Haryana, (India)

ABSTRACT

Energy is the main constraint in wireless sensor network. Hence to increase the lifetime of WSN, the requirement is to have an energy efficient routing protocol .For this purpose the hierarchical routing architecture is used wherein the whole network is divided into group of clusters and only cluster head is responsible for forwarding the data to base station directly. In hierarchical based architecture routing, cluster head is used to aggregate the data from other nodes and send the aggregated data to base station. Cluster head is chosen by the nodes of cluster according to the energy of node and the number of nodes in cluster. This paper presents the enhanced Leach-C protocol in which cluster head is chosen among the nodes, having energy more than the threshold level.

Keywords: Energy Efficiency, Flat Routing, Routing Protocols, Wireless Sensor Networks, Wireless Sensor Node.

I. INTRODUCTION

A sensor network is composed of tens to thousands of sensor nodes which are distributed in a wide area. These nodes form a network by communicating with each other either directly or through other nodes. One or more nodes among them serve as sink(s) which are capable of communicating with the user either directly or through the existing wired networks. According to nodes participation style, routing protocols can be classified into three categories, namely, direct communication protocols, flat protocols and clustering protocols [1].

a) In direct communication protocols, a sensor node sends data directly to the sink. Under this protocol, if the distance between the communicating nodes is large, more power would be required to establish a connection and they send the information and hence power would exhaust quickly.

b) In case of flat protocols, all nodes in the network are treated equally. When a node needs to send data, it may find a route consisting of several hops to the sink. Generally, the probability of participating in data transmission process is higher for the nodes around the sink than those nodes far away from the sink. So, the nodes around the sink could run out of their power soon. One of the most critical issue in wireless sensor networks is represented by the limited availability of energy with the nodes; thus, efficient use of energy is necessary to increase network lifetime. In hierarchical routing architecture, sensor nodes self-configure themselves for the formation of cluster heads [9].

c) In the clustered routing architecture, nodes are grouped to make cluster, and a dedicated node acting as a cluster head collects, processes, and forwards the data within its cluster. One of the most critical issues in wireless sensor networks is represented by the limited availability of energy on network nodes thus, making good use of energy is necessary to increase network lifetime.

This paper is organized as follows:

Section 2 includes the Literature survey on energy consumption in WSN. Section 3 explains the modified Leach-C algorithm. The implementation of algorithm is shown in section 4. Section 5 concentrates on the results. Finally section 6 concludes the paper.

II. LITERATURE SURVEY

2.1 Energy Consumption Model

Energy efficiency is one of the most important design constraints in wireless sensor network architectures [3]. The lifetime of each sensor node depends on its energy dissipation. In applications where the sensor nodes are totally dependent on no rechargeable batteries, sensor nodes with exhausted batteries will cease operation. A typical sensor node consists mainly of a sensing circuit for signal conditioning and conversion, a digital signal processor and radio links. Hence, during the life cycle of the sensor node each event or query will be followed by a sensing operation, performing necessary calculations to derive a data packet and send this packet to its destination[6].

Although energy is dissipated in all of the models of a sensor node, we mainly consider the energy dissipation associated with the communication energy consumption since the core objective of algorithm is to develop an energy-efficient network layer routing protocol to improve network lifetime.

The energy consumption costs for transfer of k-bit data message between two nodes separated by a distance of d meters is given by Eqs.1 and 2, respectively.

$$E_T(k,d) = E_{Tx}\,k + E_{amp}(d)\,k \quad (1)$$

$$E_R(k) = E_{Rx}k \quad (2)$$

Where $E_T(k,d)$ = the total energy dissipated by the transmitter of the source node

E_{Tx} = Per bit energy dissipation for transmission

E_{Rx} = the per bit energy dissipation at reception

$E_{amp}(d)$ = energy required to maintain an acceptable signal-to-noise ratio by amplifier

k = data bits

d = distance between two nodes

As is the case in [8], free-space propagation model and two ray ground propagation model both are used to approximate the path loss sustained due to wireless channel transmission. Given a threshold transmission distance of d_0, the free-space model is employed when $d \le d_0$, and the two-ray model is applied for cases where $d<d_0$. Using these two models, the energy required by the transmit amplifier $E_{amp}(d)$ is given by equation (3).

$$E_{amp}(d) = \begin{cases} \varepsilon_{FS} d^2 & ,d \le d_0 \\ \varepsilon_{TR} d^4 & ,d > d_0 \end{cases} \quad (3)$$

Where

ε_{FS} and ε_{TR} = Transmit amplifier parameters corresponding to the free-space and the two-ray models.

d = threshold distance

$$d_o = \sqrt{\frac{Efs}{Emp}} \quad (4)$$

III. CLUSTER BASED ROUTING PROTOCOL

One of the most critical issues in wireless sensor networks is represented by the limited availability of energy on network nodes; thus, making good use of energy is necessary to increase network lifetime. In hierarchical routing architecture, sensor nodes self-configure themselves for the formation of cluster heads [11].

In the clustered routing architecture, nodes are grouped into clusters, and a dedicated node as cluster head collects, processes, and forwards the data from all the sensor nodes within its cluster. A cluster head is chosen from the nodes. Each node decides whether it will become a cluster head or not. If a node become a cluster head for one time, it cannot become cluster head again for P rounds, where P is the desired percentage of cluster head.

3.1 Leach C

Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol proposed in [12] provides a balancing of energy usage by random rotation of cluster heads meanwhile assuring uniform load balancing in one-hop sensor networks.

In general LEACH-C works in rounds. There are two distinct operational phases in each round, namely Cluster Set up phase and Steady-State phases. Cluster Set up phase includes cluster head advertisements and Scheduling of nodes within each cluster by respective cluster heads. Steady-State phase involves transmission of data from nodes to their respective cluster heads at scheduled time intervals.

IV. PROPOSED ALGORITHM: MODIFIED LEACH-C PROTOCOL

According to the algorithm, clusters of nodes are made and the cluster head is chosen according to the energy of nodes. As the nodes send data to respective cluster heads energy dissipation for those nodes is calculated .Then cluster head aggregate the data and send it to the base station and energy consumption is calculated.

The following assumption are to be considered.

- A fixed base station is located far away from the sensor nodes.
- Initally all sensor nodes are assumed with uniform energy.
- The nodes are equipped with power control capabilities to vary their transmission power.
- Each node senses the environment at fixed interval and has data to send to the base station.
- The energy required to transmit a message from a source node to a destination node is same as the energy required to transmit the same message from the destination node back to the source node for a given SNR (Signal to Noise Ratio). Hence The radio channel is supposed to be symmetrical.
- Moreover, it is assumed that the communication environment is contention and error free. The need of retransmission is out of scope of this paper.

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4.1 Algorithm

This algorithm runs in two rounds.In round 1,cluster head is chosen and energy is calculated for each node on the basis of its transmission.In round 2,

1. Base station is set up at the center of region and each node will have equal energy.
2. In round 1, Cluster Head will be created according to energy of particular node and number of nodes in the cluster.
3. The decision of each node to become cluster head is taken based on the suggested percentage of cluster.
4. A sensor node chooses a random number, *r*, between 0 and 1. If this random number is less than a threshold value *T (n)*, the node becomes a cluster-head for the current round. The calculation of threshold value T(n) is shown in equation 5, that incorporates the desired percentage to become a cluster-head.

$$T(n) = \begin{cases} \dfrac{p}{1 - p * (r \bmod \frac{1}{p})} & if \;\; n \in G, \\ 0 & \text{otherwise} \end{cases} \qquad (5)$$

Where

T (n) = Threshold value of energy to become cluster head

p = percentage of cluster head nodes

n = number of nodes

G = set of nodes which has not been selected as cluster head

5. Then, Nodes send the data to their respective cluster heads and energy consumption will be calculated according to the Equ. 6

   $$E_{Tx} * k + (E_{Rx} * d^4 * k) \qquad (6)$$

   Where

   E_{Tx} = Per bit energy dissipation for transmission

   E_{Rx} = the per bit energy dissipation at reception

   K = packet size

6. Cluster Head will aggregate the data and send it to the base station and energy consumed will be calculated for each node and cluster heads according to following condition.

   $E_{Tx} + E_{DA} * k$

   Where

   E_{DA}= energy dissipation

7. In round 2, the nodes will become cluster heads according to probability condition [11] i.e. according to minimum distance from base station.
8. After selection of cluster heads, Nodes send the data to their respective cluster heads, that will be selected according to the minimum distance of a particular node from cluster heads and energy consumption will be calculated.
9. Cluster Head will aggregate the data and send it to the base station and energy consumption will be calculated.
10. This process will be repeated until the whole network gets down or number of rounds finished.

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11. Performance will be evaluated according to parameters like network lifetime, energy dissipation, and cluster head in each round.

V. IMPLEMENTATION AND RESULTS

Table 1 represents the parameters used to get the following results.

TABLE 1: Parameter Value

Network Field	300*300m
Number of nodes(N)	200
Initial energy	1 J
Eelec (E.Dissipation for ETx & ERx)	50nJ/bit
ε_{fs} (free space)	10 pJ/bit/m^2
ε_{mp} (Multipath fading)	0.0013 pJ/bit/m^4
E_{DA} (Energy Aggregation Data)	5 nJ/bit/signal
Data packet size	4000 bits

Figure 1 shows the performance of LEACH-C protocol and modified LEACH-C protocol. We can see from the graph that modified protocol has better network lifetime as the lesser number of nodes are dead in rounds in comparison to LEACH-C protocol.

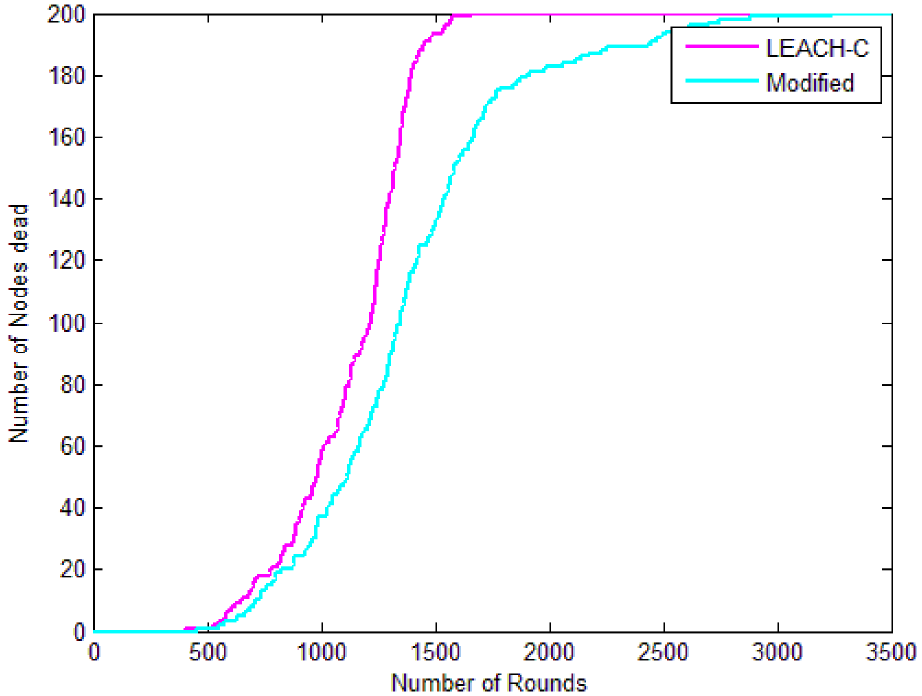

Figure 1 Number of Rounds vs Number of Dead Nodes

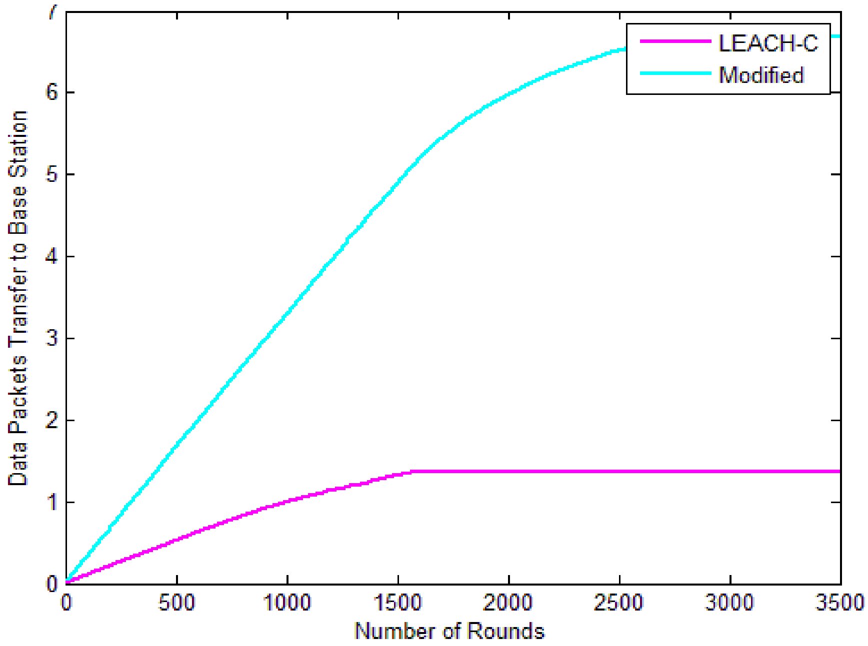

FIGURE 2 Number of Rounds vs Network Energy Consumption

Figure 2, shows that the number of packets transferred to the base station in modified protocol is much more as compared to LEACH-C.

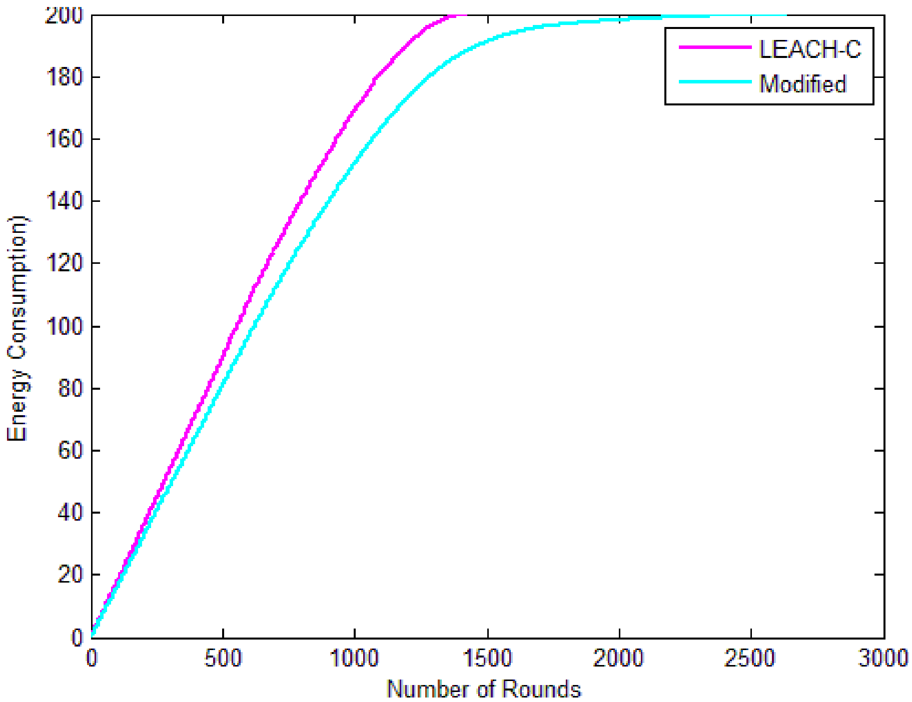

FIGURE 3 Number of Rounds vs Energy Consumption

Figure 3 shows the energy consumption in each round. The energy consumption of LEACH-C protocol is more in comparison to modified LEACH-C protocol. Hence the algorithm of modified LEACH-C protocol will enhance the network lifetime.

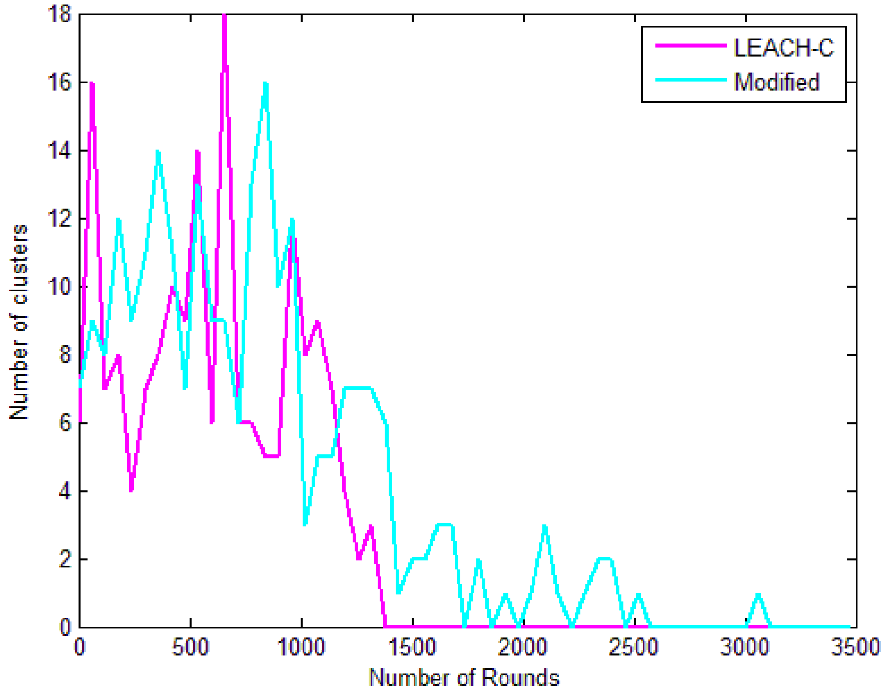

FIGURE 4 Number of Clusters vs Number of Rounds

Figure 4 shows the cluster head formation in each round. It can be observed that cluster head formation in each round of modified LEACH-C protocol is optimal and hence maximize the network lifetime.

VI. CONCLUSIONS AND FUTURE WORK

WSNs differ from traditional wireless communication networks in several of their characteristics. One of them is power awareness, due to the fact that the batteries of sensor nodes have limited lifetime and are difficult to be replaced. Therefore, the protocols must consume minimum energy and the longevity of the network must also be preserved. This is the reason that routing protocols in WSNs aim mainly to accomplish power conservation while the traditional networks focus primarily on the Quality of Service (QoS). The proposed modified Leach-C routing protocol is a hierarchical routing based protocol, wherein the control is with the base station. The sensor nodes self configure themselves for the cluster head selection in non centralized hierarchical routing. While self configuring them, the nodes are unaware of the whole logical structure of the network. But in the proposed modified Leach-C protocol, the base station first collects information about the logical structure of the network and residual energy of each node and then selects the cluster head. Hence the cluster formation leads to longevity of network also. Finally, modified protocol is compared with already developed routing protocol Low Energy Adaptive Clustering Hierarchy-Centralized (LEACH-C) using MATLAB. A comparison between two is done on the basis of energy consumption with rounds, data packet sent to base station and the system lifetime of network. System lifetime is basically for how long the system works. The results show that modified LEACH-C protocol works better than LEACH-C protocol.

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